Digital Development

Working Paper Series

The Digital Development working paper series discusses the broad issues surrounding digital data, information, knowledge, information systems, and information and communication technologies in the process of socio-economic development

Paper No. 98

Learning Along the Digital Silk Road? Technology Transfer, Power, and Chinese ICT Corporations in North Africa

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2023

A working paper from the "China's Digital Expansion in the Global South" project

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Abstract

While much attention has been paid to how China's rise as a digital superpower could threaten US hegemony over cyberspace, much less has been written on what the Digital Silk Road, or the presence of Chinese tech firms in developing countries more broadly, means for technological upgrading and development. This paper contributes to filling this gap by investigating the technology spillovers emanating from two Chinese tech giants – Huawei and ZTE – in Algeria and Egypt.

Using a political economy framework that combines insights from structuralist economic development and techno-politics and drawing on over 70 semi-structured interviews and field-observations, the paper argues that despite localising activities that bear the promise of generating significant linkages, the two Chinese tech firms created no meaningful learning opportunities that contribute to technological upgrading. What could at first seem like developmental connections that promote technology transfers are found to be linkages diffusing Chinese infrastructures, hardware, software, processes and standards that shape distinct digital systems. Without pro-active policies from host governments, the Digital Silk Road risks creating new technological dependencies, locking local ICT actors into activities and relationships captured and defined by Chinese tech giants.

A. Introduction

Over 2,200 years ago, the movement of people and goods across the Silk Roads facilitated the diffusion of Chinese inventions and technologies to Eurasia, the Middle East and North Africa. This trade network constituted a channel for Chinese innovations such as papermaking and woodblock printing, which enabled large-scale printing for the first time and transformed information dissemination in Europe (Hernandez 2019). The movement of medicine and pharmaceutical knowledge across the Silk Roads encouraged translations of medicinal writings from Chinese into Arabic, making a broad array of scholarship accessible to local polymaths, with profound effects on medical practices in the Middle East and elsewhere (UNESCO 2022). In the 21st century, Beijing's Digital Silk Road (DSR), the digital component of the Belt and Road Initiative (BRI), could potentially play a similar role in spreading new technologies and practices.

There is a dearth of empirical studies looking at China's contribution to technology transfer in developing nations' ICT (information and communication technology) sectors. The nascent literature has either argued that Chinese ICT multinational companies (MNCs) create significant opportunities for technology transfer (Tsui 2016; Agbebi 2019; Li 2020) or, conversely, that there is weak evidence of such opportunities (Tugendhat 2021; Rwehumbiza 2021), depending on the cases and methodologies used. However, emerging research has tended to use a simple diffusionist technology transfer lens, focusing more on the quantum of linkages rather than a qualitative investigation of their content. By narrowly focusing on the *existence* or *lack* thereof of spillovers, existing scholarly work tends to obscure the bargains around technology and the politics upheld in the transferred technologies and training programmes. What is perhaps as significant as the question of whether or not Chinese digital companies engage in technology transfer in host developing countries is the role played by spillovers in diffusing specific technologicalprocesses, practices and standards and what this means for structural transformation.[1]

Using a novel political economy framework that combines insights from structuralist economic development and techno-politics, this article examines the technological spillovers emanating from the interaction of two Chinese telecommunication giants – Huawei and ZTE – with local configurations of power and skills in North Africa and their grounded effects. North Africa is an interesting case to analyse the developmental implications of Chinese digital MNCs. While North African countries have different political economies, they all share middle-income status and have in common growing numbers of tech-savvy young people, a relatively high rate of internet penetration, and proximity to the EU market, making the region a strategic hub for the DSR. One of the first high-level references made to the DSR was in the 13th Five Year Plan published by the Central Committee of the Communist Party of China (CCCPC) in 2016, which stated the aim to "develop an online Silk Road with the Arab countries and others through high-speed fibre optic networks" (CCCPC 2016, 71). Algeria and Egypt, in particular, have emerged as two significant markets for Chinese original equipment manufacturers (OEMs) like Huawei and ZTE, the most prominent Chinese digital firms in North Africa. Unlike platform-based

[1] Structural transformation is defined as the move from low-productivity, labour-intensive economic activities to high-productivity, technology- and skill-intensive activities.

businesses, the OEM sub-sector is a high-linkage sector that can theoretically generate significant technology spillovers.

Based on extensive and triangulated field evidence, drawing on over 70 interviews in Algeria and Egypt, this research finds that Huawei and ZTE, like their Western competitors, limit meaningful technology transfers to protect their knowledge premiums. What could at first seem like developmental connections that promote technological learning and upgrading are found to be linkages diffusing Chinese infrastructures, hardware, software, processes and standards that shape distinct digital systems designed around the consumption of Chinese technologies. Without pro-active policies from host governments, the DSR risks creating new technological dependencies, locking local ICT actors into activities and relationships captured and defined by Chinese digital giants.

As ICTs have become multifunctional and pervasive technologies and as China has become an ever-more-important player in this sector, understanding the interplay between China and the digital economy is of critical importance. However, to date, what the dynamic intersection of these two poles means for technological upgrading, is far from clear and thus requires further investigation. By providing an empirically rich account of the multifaceted forces shaping technological spillovers from Chinese digital MNCs and their implications, this work aims to contribute to ongoing debates on China's growing role in the global digital economy, the Belt and Road Initiative, foreign direct investment (FDI) and technology transfer, and South-South investments.

The article is structured as follows. After this introduction, the second section starts by reviewing the literature on technology transfer. It suggests an analytical framework that departs from standard diffusionist models of technology transfer which focus on the occurrence of spillovers while marginalising the *hidden* politics behind seemingly technical linkages. The next section discusses the paper's methodology, and this is followed by the findings, which analyse the channels of knowledge spillovers from digital MNCs in terms of three types of linkages: horizontal linkages, vertical linkages and linkages with local universities and research institutions. The final section concludes and provides policy recommendations to help countries maximise gains from Chinese tech firms for their own digital transformations.

B. Literature Review and Theoretical Framework

B1. FDI and technology transfer

Technology transfer – the dissemination of technical knowledge and know-how embodied in products, processes, and management (Wahab et al. 2011, 62) – through FDI has long been regarded as a major engine of technological upgrading and structural transformation (Globerman 1979; Markusen and Venables 1999; Amsden 2001; Saggi 2002; Blalocka and Gertlerbc 2008; Fu et al. 2011). The basic premise underlying the existence of technology

spillovers[2] is that foreign-invested firms are technologically superior to local ones; thus, their interaction with local economies is assumed to lead to technology transfers which, in turn, lead to productivity gains (Saggi 2002). Given the lower technology base within developing economies, these spillovers may help local industries build up their domestic technological capabilities and catch up with the international technology frontier (Lall 1992; Ning and Wang 2018).

The theoretical literature identifies two main channels through which foreign firms can generate technology transfer. Horizontally, skills and knowledge transfer can occur through labour mobility across firms, including when local firms 'poach' skilled workers from foreign firms (Liu 2008; Iršová and Havranek 2013). Vertically, backward and forward linkages help the diffusion of skills, knowledge, and technology as they provide demonstration effects and training to local firms (Blomstrom and Kokko 2001; Liu et al. 2009; Rojec and Knell 2017). Based on Albert Hirschman's work, the theory of linkages refers to the way in which a factory generates demand for primary materials like sand mining in a cement factory (backward linkage), while its outputs, cinder blocks, might be an input for the local construction industry downstream (forward linkage) (Hirschman 1988 [2013], 103). Backward linkages are the most critical mechanism for learning and achieving productivity gains (Hirschman 1988; Javorcik 2004; Blalock and Gertler 2008).

There are also significant sectoral variations in the potential for technology spillovers. Manufacturing and infrastructure building are recognised as high linkage sectors in the literature (Hirschman 1988 [2013]; Lean 2010). For instance, building digital infrastructure can foster inter-firm spillovers by encouraging industrial clustering and generating a broader supply chain in equipment and component manufacturing and services. Most fundamentally, installing new ICT infrastructure requires the transfer of know-how and skills to operate and maintain advanced technologies (Ockwell et al. 2008, 4107). Digital MNCs can thus theoretically provide technical artefacts and managerial skills transfers that contribute to technological upgrading and the building of competitive ICT industries in host countries.

However, the empirical evidence on the transfer of technology through FDI is, at best, mixed. In their seminal study of technology spillovers in Morocco, Haddad and Harrison (1993) found that if domestic and foreign firms compete to capture the same market, the latter does not have the incentive to promote technology linkages. In some instances, foreign firms operated as enclaves with little connection to the local economy (Aitken and Harrison 1999). Measures adopted by foreign companies to limit technology transfer include protecting their intellectual property, trade secrecy, hiring mainly foreign workers, and preventing labour turnover by offering significantly higher wages than local industry averages (Liu et al. 2009, 1114). In other instances, research showed that foreign subsidiaries did more harm than good to the local economy by capturing the domestic market and crowding out local competitors without engaging in any meaningful technology transfer (Amendolagine et al. 2013). Any discussion on the developmental potential of foreign subsidiaries needs to tackle the difficult but pragmatic question of whether it is

[2] Technology spillovers reflect the unintended transfer of technology, while technology transfer has a more intentional/deliberate connotation (Smeets 2008). Similarly, knowledge transfer implies a broader, more general type of knowledge, while technology transfer is narrower and more targeted (Holm et al. 2020).

sound to expect technology transfer to occur in the first place, as corporations would naturally be expected to preserve their technological edge.

B2. Chinese digital firms and the techno-politics of linkages

With the world's largest online population and a booming digital industry, China has expanded its global digital footprint. Chinese digital MNCs have built the backbone infrastructure used by billions of internet users across the developing world. One estimate suggests that Huawei built 70 per cent of Africa's 4G network (Mackinnon 2019). While the internationalisation of Chinese tech firms in developing countries has undoubtedly promoted local economies' catch-up efforts in terms of ICT infrastructure, the role played by these corporations in diffusing knowledge and technology remains under-researched.

One of the few fieldwork-based studies looking at technology transfer from Chinese tech corporations is Agbebi's (2018, 2019) research on Huawei's presence in Nigeria. Drawing on 29 interviews with staff and beneficiaries of Huawei's training programmes in Nigeria, Agbebi points to the existence of dynamic horizontal linkages as she finds several instances of trained Huawei staff leaving the firm to join other ventures (Agbebi 2019, 198). She also indicates "considerable backward vertical linkages with local suppliers" (ibid, 201), with Huawei Nigeria counting over 500 local partners in its supply chain, many of which receive training from the Chinese tech giant. In a similar vein, Li and Cheong (2017, 764) argue that ZTE and Huawei contribute to technology transfer in Malaysia through partnerships established with Malaysian universities and research centres, through which the Chinese firms have been found to provide courses for local students that led to ZTE and Huawei certifications.

A somewhat different take emerges from the more critical work of Tugendhat (2020), who finds from his fieldwork in Kenya and Nigeria that Huawei, like Ericsson, Nokia, Cisco and other competitors, treads a fine line between training local engineers and keeping control of its intellectual property. In a subsequent publication, he argues that the Chinese tech giant offers no significant opportunity for technology transfers that could contribute to technological upgrading and stresses that the firm has a "limited impact on knowledge transfer by design" (Tugendhat 2021, 19). Likewise, based on fieldwork in Tanzania, Rwehumbiza (2021) finds that while there is some evidence of local staff and suppliers' training, Huawei Tanzania does not seem to build significant backward linkages with local firms.

These studies bring valuable insights into understanding the developmental implications of Chinese investments in the ICT sector of some developing countries. Yet, the emerging literature adopts a simple diffusionist technology transfer model, which measures technology transfer by the existence or absence of linkages. This framework conceals the idiosyncratic norms, standards and politics conveyed in the transferred technologies and training programmes. Analysing technology spillovers requires not only observing their occurrence through vertical and horizontal linkages but also scrutinising what these linkages actually *do* on the ground. In the same way that we cannot expect high-tech firms to willingly share their cutting-edge technology with poorer countries, neither can we assume

that the transfer of technology is devoid of political content and consequences. To date, however, there is still a need for a more effective theorisation of technology transfer processes to untangle both its technical and political aspects.

In this regard, the techno-politics framework can bring valuable insights into the analysis. From a conceptual perspective, techno-politics unpacks the oftentimes *hidden* political work of technological artefacts and infrastructures (Mitchell 2002; Larkin 2013; Anand 2015). One strand of this intellectual tradition leads back to the work of Langdon Winner (1980), who argued that all technologies, from forks to nuclear power stations, have "politics" embedded into them. In its basic form, techno-politics refers to “the strategic practice of designing or using technology to constitute, embody, or enact political goals” (Hecht 2001, 256). Here technology is defined as both “artefacts and nonphysical, systematic means of making or doing things” (ibid, 257).

This analytical lens shifts attention from individual innovations to the system of relations in which technology is embedded, emphasising that the “same” technology can uphold different types of politics as it is negotiated, adopted, and reshaped by various actors to advance their own interests (Edwards and Hecht 2010). Seen from this perspective, power and politics stem from both the social and the technical, with different stakeholders competing over authority by ensuring that some technologies and standards prevail over alternative ones (Hecht 2001, 2). The question of technology standards – the underlying regulations that define how telecommunication networks operate and interwork – is particularly significant in the debate on the role of Chinese digital MNCs in transferring technology to host middle-income countries. Competition over who gets to set technological standards has become intense between China and the US, with China trying to challenge the US-centric cyberspace (Beattie 2019).

Against the backdrop of Chinese tech firms taking a more active role in developing, supplying, and maintaining the physical components upon which future digital infrastructures will rely, a conceivable consequence is that this will speed up the dissemination of Chinese technological standards. Recently, Chinese representatives have been calling for a new standard, which they called "New IP", arguing that the current, US-set protocol of TCP/IP is unable to support the speed of package transfers needed in the upcoming 5G revolution (Smith et al. 2021). Behind this technical jargon lies a fierce fight over who gets to set the standards of the next technological wave. The ability to define standards has long been understood as a tool of power, enabling those who set the rules to shape them to their own advantage (Mattli and Buthe 2003; Lee and Oh 2006; Yao et al. 2009). Although international technological standards are approved by multilateral institutions such as the International Telecommunication Union (ITU), the increased number of countries and actors integrated into digital systems built by Chinese tech firms helps amplify China’s voice in international standard-setting bodies.

In a study of China’s digital presence in Africa, Gagliardone (2019) uses techno-politics to answer the question of whether China is imposing its internet model on African countries. He finds that China’s intervention in Africa’s information societies has been driven by the preferences of different African states rather than those of Beijing. In this paper, I extend techno-politics to analyse technology spillovers emanating from Chinese tech giants. What

we see being opened with the techno-politics framework is a different angle on the transfer of technology from foreign subsidiaries, as it no longer becomes a straightforward binary between the existence or absence of vertical and horizontal spillovers, which diffuse (or not) know-how and technology in ways that are predominantly seen as developmental and unproblematic, but instead questions the more profound and uncertain implications of transferred technologies.

Several possibilities emerge when looking at the issue of technology transfer through this lens. What if horizontal and vertical spillovers are observed, as argued by Agbebi (2019, 201), but tech firms are building through these linkages markets for staff and subcontractors that revolve around the consumption and use of their products, processes, and standards? In other words, what if emerging linkages are creating 'closed-loop systems' that lock local ICT actors into activities and relationships captured and defined by foreign digital giants? As technological latecomers, could it be that Chinese ICT firms are engaging more in training employees, students, and suppliers than their Western counterparts to promote their own brands? Is the technology transferred by Chinese digital firms creating a separate Sino-centric Internet among BRI countries?

To help answer some of these questions and to keep the technical and the political together, this paper adopts a conceptual framework that brings together insights from structuralist economic development – to trace the occurrence of vertical and horizontal linkages – as well as from techno-politics – to understand the *hidden* politics conveyed through these channels. This framework recognises that only a deeper, empirical engagement with technical processes – rather than assumptions based on preconceived ideas – can allow an adequate understanding of the extent and implications of technology transfer. Thus, by zooming in on the actual process of technology transfer through traceable socio-technical linkages, this conceptual lens enables us to go beyond both depoliticised and over-politicised debates about the developmental role of Chinese tech giants.

C. Methods

How can we capture technology spillovers and their effects, given the complexity and layers that make up the ICT industry? There is a lack of quantitative data on the contribution of Chinese digital firms to technology transfer. But even with rigorous and fine-grained data, quantitative methods fail to capture the nuances and rich insights that can be gathered through fieldwork (Pack 2006, 30). There is a growing recognition that technology transfer is subject to contextual influences and power dynamics, making qualitative tools appropriate (Autio et al. 2014; Auffray and Fu 2015; Cunningham et al. 2017; Demena and Bergeijk 2018). Furthermore, the conceptual framework of this paper, which conceptualises technology transfer as a complex process emerging from power bargains between different actors, calls for thicker descriptions (Denzin 2001, 83).

In order to deliver this density of evidence, this study relies on a broad set of both interview and field observation data drawn from two countries. Algeria and Egypt were selected because, from Mao Zedong's Three World theory to Xi Jinping's Belt and Road Initiative, the two North African countries have developed and sustained strong relations with Beijing

rooted in a shared experience of colonial domination (Pairlaut 2017, 8). Algeria and Egypt are also the two most important recipients of Chinese FDI in the region, and the two most lucrative markets for Chinese OEMs, like Huawei and ZTE, which specialise in building backbone ICT infrastructure. The two firms have played a key role in setting up 3G and 4G networks and will likely continue playing a significant role in the upgrade towards 5G. Furthermore, Algeria is the only African country counting a Huawei manufacturing plant (Agence Ecofin 2019a), and Telecom Egypt signed a rare contract with ZTE to create a joint technology training centre and innovation laboratory (Agence Ecofin 2019b).

This study draws on 71 semi-structured interviews conducted in Egypt and Algeria between October 2021 and March 2022. As summarised in Table 1, interviews included employees, subcontractors, customers of Huawei and ZTE, students and start-ups receiving training and support from Chinese tech-giants, ICT policymakers, government officials, university faculty/researchers, as well as Western ICT equipment manufacturers including Cisco, Ericsson, and Nokia (see Annex 1 for full interview table). The choice of including other foreign firms in data collection and analysis was taken to avoid falling into the trap of "Chinese exceptionalism", which often leads to accounts picturing Chinese firms as unique and somehow detached from broader sectoral practices (Oya and Schaefer 2019).

Table 1. Breakdown of respondents by category

Interviewee' category	**Code**	**Number of Interviewees**
Local subcontractors, suppliers, and customers of Huawei and ZTE	S	11
Current and former Huawei and ZTE engineers and managers	W	21
ICT experts and researchers	E	12
Students and instructors of Huawei and ZTE training programmes	U	11
Engineers and managers of Western competitors	C	11
Policymakers	G	5
Total		**71**

Interviewees were selected using purposive sampling in the first stage. Having worked in the Algiers office of Huawei Technologies North Africa, regionally headquartered in Egypt, I have developed a large network within the ICT industry in the two countries, which facilitated my access to key informants during my fieldwork. This work experience allowed me to gather first-hand observations on the nature and intensity of the training provided to local workers and dynamics between Chinese and non-Chinese staff members. LinkedIn further allowed me to reach out to engineers working for Huawei and ZTE and beneficiaries of training programmes offered by the Chinese firms in Algeria and Egypt. Snowballing from different entry points was used to achieve a large enough sample until knowledge saturation was reached. Being a native Arabic and French speaker and an advanced Mandarin speaker, I

was able to conduct interviews with local, Chinese and other foreign actors in Egypt and Algeria.

Data analysis was not separated from data collection but rather conducted simultaneously. A theory-driven coding strategy was used to identify technology spillovers with codes indicating the mechanisms accounting for horizontal and vertical spillovers and linkages between ICT firms and local universities. Codes were later grouped into themes representing different channels of technology transfer. I followed an inductive approach to analyse the power dynamics between different actors and the content conveyed in linkages. In addition to interviews and field observations, data was collected during and after the fieldwork from financial and business newspapers and the companies' annual reports. Quantitative data was sometimes also collected via interviewees.

D. Findings and Analysis

D1. Overview of the ICT sector in Algeria and Egypt

Before assessing the main channels of technology spillovers from Chinese ICT multinationals in Algeria and Egypt, some remarks are needed to understand the political economies in which Huawei and ZTE are operating. The Algerian and Egyptian economies are concentrated in low-value-added sectors and suffer from sluggish growth. High chronic youth unemployment, estimated at 30 per cent as of 2017, is a distinctive feature of the Middle East and North Africa region (Kabbani 2019). Remarkably, about 40 per cent of the region's university graduates are unemployed (World Economic Forum 2017). More than ten years after the mass revolt against authoritarianism, poverty and lack of economic opportunities, no notable change has materialised in the region. For countries in the region to produce and sustain economic growth and create high-quality jobs for the millions of unemployed workers, they need to undergo structural transformation, the process of moving from low-productivity, labour-intensive economic activities to high-productivity, technology-intensive activities that require advanced skills.

Recognising the potential of the digital economy to help this transition, Egypt and Algeria adopted national ICT plans designed to expand internet connectivity, upgrade workers' skills, and create flourishing knowledge economies. Egypt's ICT 2030 plan prioritises developing ICT infrastructure, fostering digital inclusion, building domestic capacity, and encouraging innovation (MCIT 2016). Egypt has positioned itself as a regional leader in exporting information technology services and is home to a vibrant start-up scene. In 2017, Egypt passed an investment law that promotes inbound FDI by easing barriers to entry and supporting foreign multinational firms' localisation efforts (Egyptian Investment Law 2017). Algeria was slower to start its digital transformation but has made significant strides in terms of ICT infrastructure, with bandwidth capacity increasing more than twenty times since 2014 (APS 2021). By creating the Ministry of Microenterprise, Knowledge-Economy, and Start-ups in 2020, the government is attempting to break away from the current hydrocarbon-dependent model towards a knowledge-based model.

The two North African governments are investing heavily in upgrading network infrastructure. Egypt witnessed significant growth in internet usage, increasing from 29 per cent of the population in 2009 to 72 per cent as of January 2020 (World Bank 2022a). In Algeria, internet penetration rates were estimated at 63 per cent by the same year (ibid). Growth in mobile broadband access is correlated with a surge in mobile-cellular subscriptions and the expansion of 3G and 4G network coverage. Mobile penetration in Egypt stands at 110 per cent (World Bank 2022b) and is covered by four operators, Orange, Vodafone, Etisalat, and Telecom Egypt. Algeria's mobile penetration reached 105.8 per cent (ibid), distributed between three core operators, Mobilis, Djezzy and Ooredoo. While these rates represent an important growth, the region's internet penetration remains just slightly above the world's average, estimated at 60 per cent (World Bank 2022a). This creates significant demand for ICT infrastructure provided by equipment manufacturers like ZTE and Huawei.

D2. Chinese tech firms and technology transfer

> "Information technology advances rapidly. I hope that Chinese enterprises not only observe local laws, operate credibly and have sound management but also disseminate their advanced technologies and experience to the local enterprises and employees. We always say that give a man a fish, and you feed him for a day; teach a man to fish, and you feed him for a lifetime. Do you agree with me?"
> Premier Wen Jiabao on a visit to Huawei's Training Center in Cairo in 2009 (MFA 2009)

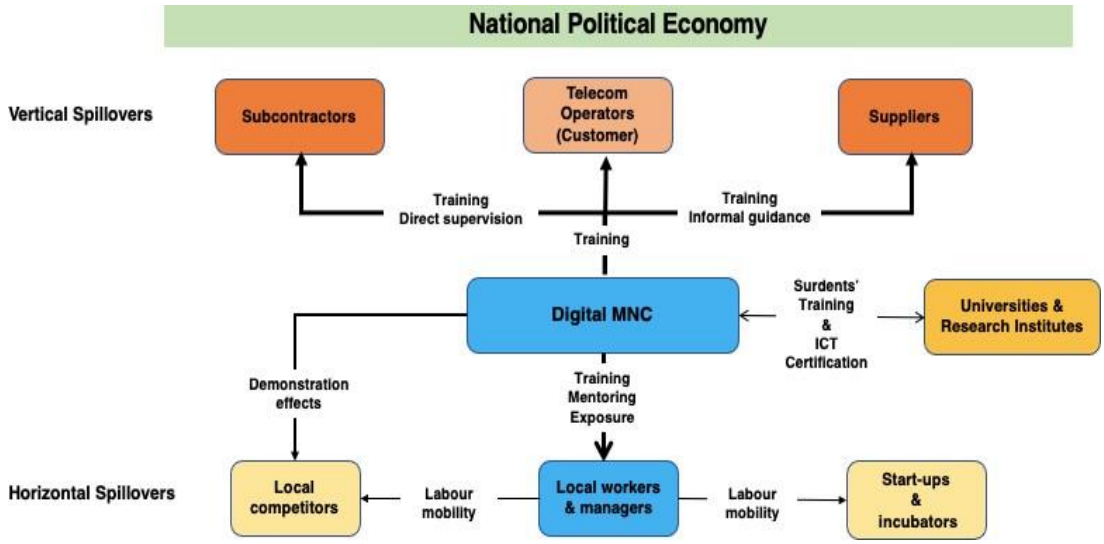
The above quote by Premier Wen encapsulates well the importance attributed to technology transfer in the localisation strategy of Chinese tech firms abroad before and after the launch of the DSR in 2015[3]. But do Chinese ICT firms contribute to bridging the digital divide by providing opportunities for technology transfer? Drawing on the theoretical framework discussed above, this section identifies and assesses the intensity and grounded effects of three core types of linkages: horizontal linkages, vertical linkages and linkages with universities and research institutes (see Figure 1). It argues that while Huawei and ZTE have localised activities that can theoretically generate significant linkages, the two Chinese tech firms created no meaningful learning opportunities that contribute to technological upgrading. Instead, emerging linkages are creating a distinct techno-political regime that risks locking local ICT actors into new forms of dependencies as they reconfigure ICT ecosystems around the use and consumption of Chinese infrastructures, processes and standards.

Notably, the Chinese state was not explicitly included in the framework. Dominant accounts tend to assume that the Chinese state holds a tight rein over its tech champions, which in turn strictly align with large policy plans such as the DSR (Hilman 2021; Chen 2021). Fieldwork evidence indicated that the presence of Huawei and ZTE, including their engagement in knowledge transfer initiatives, is shaped by a much wider variety of Chinese and non-Chinese economic and political forces. Although the Chinese state, through the DSR, has supported the presence of Chinese tech firms via access to preferential loans (Shen

[3] Following China's adoption of its "going out" policy in the late 1990s, Chinese ICT OEMs started venturing out. Both Huawei and ZTE set up subsidiaries in Cairo and Algiers by the early 2000s.

2018), the need to meet commercial imperatives was guiding firms much more strongly than Chinese state political priorities. In terms of policy, Algerian and Egyptian government ICT agendas were more important in shaping Huawei and ZTE strategies to capture markets and increase profits.

Figure 1 – Channels of technology spillovers in the ICT sector



Source: Author's elaboration

D2.1 Horizontal linkages

As trained workers and managers at multinationals move to domestic firms or start their own businesses, knowledge may be disseminated from MNCs to other firms within the same industry (Kneller and Pisu 2007; Iršová and Havranek 2013). Due to growing labour costs in China, ZTE and Huawei have in recent years localised a bigger share of their labour in North Africa. Huawei employs an estimated 1,000 workers in Egypt, counting both in-house and outsourced contracts and about half as many in Algeria, with about 70 per cent of the staff made up of local employees and the remaining 30 per cent consisting of Chinese and other foreign engineers. ZTE Algeria counts about 200 employees in-house, 70 per cent of whom are locals and 500 outsourced workers, most of whom are local Algerians (W6).[4]

Local engineers and managers at the two Chinese firms, both on in-house and leased contracts, reported going through training programmes when they were first hired. The training covered technical and soft skills and continued throughout their employment period, with mandatory tests undertaken at different stages of their careers. International OEMs also send their local employees abroad for further training. A key motive driving many young engineers to work with Chinese MNCs, and Huawei in particular, is the learning opportunities provided by the companies (W1, W3, W4, W19, W20). When asked to attribute a grade from 1 to 5 assessing the quality of the training received by the Chinese

[4] The exact number of employees at ZTE Egypt remains unknown. A senior ZTE manager refused to divulge the number of employees in the Egyptian subsidiary, stating that the information was confidential (W12).

tech firms, with 1 indicating low levels of satisfaction and 5 indicating high levels of satisfaction, respondents converged towards a grade of 4. These responses differ from the results of a 2019 survey, in which African workers viewed Chinese firms' training efforts as underwhelming (Oya 2019). One possible explanation accounting for this divergence could be the nature of the ICT industry, a knowledge-intensive sector in which training staff is paramount for firms' operations and profits (te Velde 2002; King 2013).

The distribution of local managers followed a pyramidal structure in both countries, with local employees well represented at the bottom of the pyramid and Chinese nationals dominating top managerial positions. Similarly to other studies (Auffray and Fu 2015; Oya and Schaefer 2019), this researcher's findings suggest the existence of a glass ceiling for local employees. At the time fieldwork was conducted, acting CEOs of Huawei and ZTE in Egypt and Algeria were Chinese nationals, while CEOs of Ericsson, Cisco and Nokia were host country nationals. When questioned about the lack of locals in top-managerial positions, Chinese managers explained that Chinese nationals were more familiar with the firm's work culture, ethos, and processes, giving them an edge in operating projects effectively and in short timeframes (W16).

In the two countries, limited evidence of horizontal spillovers emerged. While, as highlighted by Agbebi (2019, 200), the ICT sector is characterised by high turnover rates, labour mobility tends to occur between foreign multinationals and not towards local firms and institutions. Like Tugendhat (2021), I found that Algerian and Egyptian OEMs employees were more likely to move around between Huawei, Nokia, ZTE, Ericsson, and Cisco, among others (W4, W10, W12, C2, C4, C7). About 80 per cent of local workers and managers at Huawei and ZTE responded that they would leave the company for another foreign competitor or to go work abroad. The high salaries offered by international OEMs created a disincentive for local engineers to join local firms or set up their own ventures and constrained the capacity of most local companies to poach talent working for multinationals. This finding is in line with studies that show that MNCs use high wages as a mechanism for labour (and knowledge) retention (Aitken et al. 1996; Liu et al. 2009). Most of the younger respondents at Chinese and non-Chinese tech multinationals said that they would go abroad if they were to take up another employment opportunity. Policymakers in both countries expressed concerns about the high rate of locally trained ICT engineers who were poached by big tech firms in Europe and the US (G1, G2, G4).

There were few instances of horizontal spillovers, i.e. of respondents indicating the possibility of leaving multinationals to join local firms in the same sector or launch their own firms. In the limited cases found, two main factors account for labour turnover towards national companies: local employees at OEM multinationals leaving to take up higher responsibilities in large national telecommunication firms such as Mobilis in Algeria and Etissalet in Egypt, and those who join smaller local firms and institutions to break away from the hectic workload of international OEMs, especially Chinese ones which are renowned for operating long hours. Additionally, the small number of surveyed subcontractors operating in ICTs were established by former employees of foreign OEMs, including Huawei and ZTE. Managers of these subcontractor firms reported taking with them useful Chinese work culture and management ethos that helped them better operate their businesses (S1).

D2.2 Vertical linkages

Technology transfer occurs via backward linkages from foreign firms to local suppliers and forward linkages from foreign firms to local buyers (Javorcik 2004; Liu et al. 2009). In Algeria and Egypt, foreign companies undertake the biggest ICT infrastructure contracts. In doing so, they often rely on local subcontractors – to install fibre optic cables, towers, and other infrastructure across various regions of the country and suppliers – who provide subsidiary equipment, components, administrative and management services, technical assistance and expertise, logistics, etc. This creates potential for backward linkages, alongside potential forward linkages to the customers who use this ICT infrastructure.

Fieldwork findings in Algeria and Egypt suggest this potential was realised, with the existence of both backward and forward linkages. For instance, interviewed suppliers, subcontractors and customers indicated that Huawei and ZTE provided them with training similarly to other foreign ICT OEMs (S1-S11). The training covered a few different areas, including the operation of machinery and equipment, technical training on the technologies used, and health and safety measures. Local subcontractors, suppliers and customers also reported having well-established and long-term relations with the two Chinese tech firms and highlighted no notable differences between foreign companies. The length and intensity of the business relationship are important for technology spillovers because frequent and lasting links create greater training and supervision opportunities and pressure the supplier or subcontractor to learn and upgrade to preserve the business relationship (Auffry and Fu 2015, 293). However, there is a need to look beyond the quantum of linkages to scrutinise their actual content and deeper effects, and I will here analyse two cases: Huawei's mobile phone factory in Algeria and the provision of digital infrastructure by ZTE and Huawei in the two countries.

The case of Huawei's phone factory in Algiers, one of the flagship Digital Silk Road initiatives in North Africa, illustrates how even linkage-intensive activities like manufacturing can be scarce in knowledge transfer opportunities. The factory opened in the Algiers neighbourhood of Oued Smar in 2019 after lengthy negotiations between the Algerian government and mobile phone manufacturers for the localisation of production, following the rapid decline in the country's foreign reserves due to dwindling oil prices. The manufacturing plant was the first of its sort in Africa and one of the few outside of China and was set up as a joint venture between Huawei and Algerian firm AFGO-Tech (Agence Ecofin 2019). The plant has a monthly production capacity of 15,000 smartphones and started operating with about 40 workers, among which 18 local engineers were sent to China to observe Huawei's factories and learn about production processes. Later the factory expanded to 140 workers as extra production lines were added (W7). Commenting on Huawei's manufacturing endeavours in Algeria, one of the Chinese firm's representatives stated that: "The Oued Smar plant is equipped with the latest generation equipment and uses the most innovative technologies and all of Huawei's know-how" (Djazairess 2019).

This rhetoric tied to developmental imaginaries of seamless spillovers and unhindered knowledge flows tells us little about how mechanisms of technology transfer operate on the ground. A closer examination of the factory's embeddedness with local production networks raises concerns about its rate of technological integration. Strong backward linkages would

involve important supply inputs from local firms, a mechanism that would help upgrade local suppliers' technical and managerial capabilities (Javorcik 2004; Rojec and Knell 2017). Yet, Huawei's phone production relied on imported SKD (Semi Knocked Down) and CKD (Completely Knocked Down) kits, which are built in China and then exported to Algeria for the final stages of assembly. According to an Algerian line manager working at the factory: "Every component of the phone was imported from China. Even the phones' boxes and the tape used to close the boxes were purchased directly from China" (W7). Local suppliers consisted of Algerian firms turned into import companies focussing on the purchase of Chinese electronic and non-electronic components. Forward linkages, in this case, consisted of phone distribution and retail companies aimed at boosting the sales of Huawei devices.

While manufacturing activities are assumed to generate considerable spillovers, the nature of the emerging linkages around Huawei's factory resulted in flooding the market with Chinese artefacts without much technology transfer. When asked about the reasons behind the factory's low rate of local integration, a manager at Huawei Device explained that the firm had the plan to increase local integration to 40 per cent by localising the supply of the phone's batteries and chargers, but that they had challenges finding suitable firms and start-ups to partner with (W11). Low levels of local supply seem to be a pattern in Chinese investments in Africa, with other research indicating that Chinese investors tended to prefer having Chinese suppliers along the value chain rather than sourcing locally (Tang 2021; Rwehumbiza 2021). The Algerian government described the practice, which had become the norm across manufacturers from different countries, as "fictitious production" and "disguised import". In January 2021, the factory's activities were suspended due to the government's ban on the import of CKD and SKD kits, and its workers were laid off for an undetermined period (W7).

The picture is similar when analysing spillovers emanating from digital infrastructure building, Huawei and ZTE's core activity. Effective forward linkages, in this case, would involve the transfer of knowledge to enable customers (e.g., mobile operators) to learn how to use the technologies and to operate them independently, ultimately allowing technological appropriation and customisation. While contracts between mobile carriers and foreign ICT equipment producers in Algeria and Egypt include clauses stating that the equipment's seller transfers know-how on how to operate and maintain the equipment, local engineers working for Huawei and ZTE highlighted that they *intentionally* provided minimal levels of details to customers. As explained by a ZTE engineer in the Algiers office: "We probably give our customers just about 50 or 60 per cent of information. ZTE wants to keep control over its technology and sustain the customers' need for its maintenance services" (W10). Customers of Chinese ICT equipment highlighted that the user guide accompanying the purchased technologies would often come in Mandarin only to constrain the extent of knowledge diffusion.

Likewise, effective backward linkages promoting technology transfer would entail significant local provision of infrastructure components, training, and involvement in equipment installation. But, as with the phone factory, fieldwork interviews and observations indicated that the bulk of components used in digital infrastructure built by Chinese OEMs were imported from China. This practice was also observed among non-Chinese OEMs. Unlike Auffray and Fu (2015), who find that the weak absorptive capacity of Ghanian firms plays a

major role in hindering knowledge transfer from Chinese firms, Egyptian and Algerian subcontracting firms responded that the training received by Chinese OEMs fell short of meeting their perceived absorptive capacity. The lion's share of training focused on health and safety procedures, while the more technical content entailed learning how to install, maintain and troubleshoot the equipment of specific ICT equipment manufacturers (S3, S4, S5, S11). In this sense, training provided by Chinese tech MNCs could not be the basis for effective local appropriation or of movement up the value chain. Instead, it primarily serves as socio-technical links creating ecosystems of identifiable local firms that support value retention by the Chinese firms.

Chinese technology companies are emerging as important infrastructure agents with the power to shape digital ecosystems and keep a tight rein over their maintenance, undermining other actors in the process. Local ICT firms reported being marginalised from public infrastructural bids and highlighted that even when they had the technical capacity to conduct the work (e.g., providing and installing data centres, fibre optic cables, antennas, etc.), governments would issue public bids with such high requirements that only large foreign ICT OEMs could bid. These OEMs would win large, attractive contracts and then subcontract only limited parts of them to local firms, keeping most of the value (S1, S7, S11).

With developing countries like Algeria and Egypt showing an appetite for digital infrastructure provided by Huawei and ZTE, these companies are increasingly defining the conditions under which countries transition towards digital economies. The rapid construction of digital infrastructure without concurrently establishing meaningful backward and forward linkages with the local economy raises serious concerns about a new kind of technological dependency. While Chinese tech firms are helping developing countries catch up in terms of infrastructure for digital connectivity (Cisse 2012; Rwehumbiza 2021), they are concurrently capturing lucrative markets, excluding potential local competitors, and consolidating dominant positions. Without effective learning opportunities that could lead to technology and skill transfers and ultimately usher in structural transformation, the DSR may only strengthen the global position of Chinese tech multinationals while exacerbating cross-country inequalities.

D2.3 Linkages with universities

If there is limited evidence of vertical and horizontal linkages emanating from Huawei and ZTE in Egypt and Algeria that are leading to technological upgrading, what about the emerging linkages between these two firms and local universities? University-FDI linkages can support the cross-fertilisation of ideas and develop the national innovation base by embedding the existing R&D activity of MNC subsidiaries (Heidenreich 2012, Guimon et al. 2018). Through partnerships with universities, foreign firms can provide training, internships, and certifications to local students, exposing them to cutting-edge technologies and helping them improve their technical and managerial capabilities to match industry practices (Vaaland and Ishengoma 2016).

Although ZTE has several partnerships with educational and research institutions in the region, no other foreign OEM's engagement with universities compares with Huawei. In 2019, the tech firm signed an extensive partnership with the Egyptian government to launch

the ICT Talent Bank, its flagship capacity-building programme to boost university-industry linkages. The programme's ambitions are to create 100 Huawei ICT academies in Egypt, train 200 instructors and 1200 ICT engineers and certify over 4000 trainees (Huawei ICT Academy 2019). Huawei certifications cover several themes like 5G, cloud, artificial intelligence, big data, switches, and routers. Trainees are selected on a competitive basis from a dozen Egyptian universities, such as Port Said University and the University of Suez, among others. Interviewed Egyptian graduates from Huawei's ICT academy who obtained the training stated that it covered high-quality technical and theoretical content that would facilitate their job hunt after graduating (U9, U10, U11).

While university-FDI linkages are often perceived to be beneficial *per se*, shifting to a techno-politics framework, these training initiatives stop being benevolent capacity-building endeavours but become politically charged artefacts embodying power and creating winners and losers on the way. Traditionally, the ICT OEM enterprise subsector has been dominated by Cisco certifications. Cisco Systems' technologies would be the standard taught in university curriculums worldwide. Until today, most Cisco certifications remain the gold standard among ICT engineers who recognise that Huawei's certifications are a copy of Cisco's with different codes and nominations. As a technological latecomer, Huawei has been actively trying to reverse Cisco's hegemony through its ICT academies. The Shenzhen-headquartered firm created several incentives to raise the rate of students certified in Huawei technologies, one of which consisted of gifting costly technological equipment to universities that succeed in achieving a significant number of Huawei-certified students per year (U1, U9).

Another strategy to promote the number of ICT engineers certified in Huawei technologies entailed providing significant discounts on the certification fees, which tend to be paid directly by students. These certifications can cost between 200 and 600 USD for Cisco certifications and 100 to 500 USD for Huawei certifications (U3, U4, U9). During the COVID-19 pandemic, Huawei made all its certifications free, while Cisco only introduced a 50 per cent discount. With free certifications, many interviewed students in Algeria and Egypt opted for Huawei certifications instead of Cisco's. The director of an ICT department in Algeria explained that OEM certifications are not mandatory in the curriculum but that they are highly recommended electives that make graduates more employable. She highlighted the tense competition between big ICT manufacturers on campus and noted that Algerian curriculums avoid training students on a unique system to avoid creating dependencies (U1, U2). Nonetheless, the fee waivers provided by Huawei to students, along with the free training in its ICT academies, made it an easy choice for university students.

In the race to dominate the ICT enterprise business, Huawei has reached out to local channel partners that are already Cisco qualified and financed their conversion to become Huawei partners (S5, S11). Due to the interrelated and interlocking nature of technological regimes, more engineers trained to install, maintain, and troubleshoot Huawei technologies, and more channel partners selling Huawei products, means that governments, mobile carriers, and local companies increasingly decide to buy Huawei equipment. Chinese firms have thus adjusted national visions for the development of the ICT industry while mapping out and structuring digital communities revolving around the consumption of their artefacts and standards. This finding corroborates Tugendhat (2021), who finds that Huawei's training

centres in Kenya and Nigeria serve to establish a network of trained technicians, distributors, and salespeople qualified in Huawei technologies.

Yet Tugendhat's analysis neglects the important macro ramifications of these micro-level restructurings. Training programmes, digital infrastructure projects and the emanating linkages at the micro-level are closely intertwined with digital technology standard-setting at the macro-level. China's strategy of increasing its weight in digital technology standardisation relies on the use and diffusion of its own technical and industrial standards in the physical infrastructure it builds overseas (Peyrat 2012). In practice, technology standards spread from the top through adoption in international standard-setting bodies and from the bottom when MNCs build infrastructures that gravitate towards a common standard to ensure interoperability (Erie and Streinz 2021). Access to and use of digital infrastructures, and the applications that run over them, are regulated by frameworks that are, in turn, shaped by those who design and operate these infrastructures on the ground (Triolo and Sherlock 2020).

Against the backdrop of the technological competition between the United States and China, emerging linkages from Chinese tech firms are diffusing a mixture of infrastructures, hardware, software, certifications, and processes that are reordering digital systems on various scales and shaping new digital geographies. The experience of a final year student in ICT engineering sums up the situation well: "During my first year's internship at a large Algerian state-owned company, there was equipment from different vendors. But during my final year's internship at the same firm, I realised that most of the equipment had changed to become Huawei's" (U7). Thus, what may seem to be developmental endeavours are found to be connections that end up merely diversifying sources of technological dependency.

E. Conclusion and Policy Recommendations

E1. Conclusion

If much attention has been paid to the political, geopolitical and security implications of China's global digital expansion (Gagliardone 2019; Fannin 2019; Ma 2021; Feldstein 2021), what this expansion means for technological upgrading in other developing countries has been underexplored. This research contributes to filling this gap by investigating the technology spillovers emanating from Chinese tech firms by looking at Huawei and ZTE's presence in Algeria and Egypt. To do so, this paper assessed three different types of linkages: horizontal linkages, vertical linkages, and linkages with local universities, through a conceptual framework that combines insights from development economics and techno-politics to examine the quality of linkages and their deeper effects – what linkages *do* on the ground, *how* they work and for *whom.*

The paper finds that despite localising seemingly developmental activities that can produce considerable linkages, the two Chinese tech firms created no meaningful learning opportunities that contribute to technological upgrading. Instead, the technologies

disseminated by Chinese digital corporations, from codes to the hardware making up network infrastructures, as well as the know-how embedded in training programmes provided to local employees, suppliers, and students, are reconfiguring ICT ecosystems in ways that render the use of Chinese firms' products, processes, and standards ubiquitous. In this sense, Chinese ICT giants are diffusing, both intentionally and non-intentionally, a distinct techno-political regime that risks locking local ICT actors into new dependencies that resemble those with Western powers.

The comparison between tech firms headquartered in different countries reveals that keeping a tight rein over intellectual property is by no means a Chinese specificity. In Algeria and Egypt, both Chinese and non-Chinese firms are found to limit knowledge transfer by design to protect their technological edge (Tugendhat 2021). This being said, as technological latecomers, Chinese ICT firms, and Huawei in particular, engage in more public relations activities and training for employees, students, and suppliers than their Western counterparts in order to promote their own brands and take market space that was previously occupied by US and European firms. Although not yet conclusive the preliminary findings suggest that with its energetic efforts in organising ICT competitions, providing scholarships to students and grants to promising start-ups, Huawei may have a greater footprint in skill building than its competitors.

By highlighting the salience of power in technology transfer and connecting micro-processes with broader geopolitical struggles over global digital infrastructure, this paper echoes findings made by communication, development, political economy and Internet governance scholars, among others, and responds to calls to examine China's global digital presence in the global South from an interdisciplinary perspective. This research provides further evidence that on-the-ground field-based research is critical for grasping the complex dynamics shaping the internationalisation of Chinese digital capital (Li and Cheong 2017; Agbebi 2018, 2019; Gagliardone 2019; Erie and Streinz 2021; Tugendhat 2021). The combination of theoretical and empirical work is significant because "global digital China" is notoriously difficult to study due to the inaccessibility of key documents, including memorandums of understanding, contracts, and loan agreements.

It is important to note that this study's findings are limited by the scope of the research and the fieldwork undertaken. This paper has focused on specific types of knowledge spillovers that may have marginalised more tacit and informal channels of transmission, such as the interpersonal relationships between Chinese and local workers and managers. Another important limitation has to do with the restricted access to private tech MNCs (both Chinese and non-Chinese), which made it challenging to collect more high-level management data and systematically compare practices across firms. Ultimately, further research is needed to better grasp the opportunities and challenges created by localisation strategies of Chinese MNCs in different regions and settings. One potential future research would look at the question of digital data control in Chinese engagement with other developing countries. While technology transfer that could promote structural transformation is constrained by ICT MNCs, knowledge transfer from North African internet users to these firms is booming, with Chinese MNCs building much of the region's data centres and cloud systems.

E2. Policy recommendations

This study has a number of policy implications that could be applicable to other countries beyond Algeria and Egypt. The increasingly intricate linkages via which knowledge is diffused and absorbed raise concerns regarding the distributive effects of these linkages. Without pro-active policies, the DSR risks exacerbating existing digital inequalities. To reverse current trends, BRI countries ought to adopt a set of digital industrial policies that supports technology localisation and productive linkages. What follows provides some policy recommendations to improve the three types of linkages assessed in the paper:

First, as the wage premiums offered by MNCs were found to hinder labour turnover, strengthening horizontal linkages may require host governments to introduce financial incentives to help local private and public tech firms align with the salaries and remuneration packages offered by tech MNCs. Such policies would promote labour turnover and poaching, especially of managers, a mechanism long recognised as powerful in promoting domestic innovation and increasing productivity (Beaudry and Francois 2010). Learning from China's own development experience, policies could ensure that emerging tech champions have sufficient financial resources to hire top talents and adopt cutting-edge technical and managerial practices.

Second, to promote vertical linkages – and backward linkages in particular – policies should seek to include local firms in large ICT infrastructure projects to boost learning from foreign digital firms. One way of achieving this would be by requiring consortium bidding between local and foreign firms. Tender winners would have to divide the tasks between them with well-defined compensations for each party and clearly set terms for technology transfers. Furthermore, while joint venture requirements, when feasible, have proven to be powerful vehicles for technology transfer (Blomström and Sjöholm 1999), the case of Huawei's factory in Algiers indicates that without broader local content requirements, these are unlikely to yield significant learning opportunities.

Third, governments ought to move beyond the idea that business-university linkages are inherently valuable and create dedicated bodies to examine and improve the quality of business-university partnerships. These bodies would ensure that cooperation is leading to effective knowledge transfer and that traineeships and certifications provided to students by tech-MNCs do not simply serve to create future users and repairers of the firms' technologies. Importantly, policies should support universities to improve their internal scientific base, develop indigenous R&D capabilities and adopt curricula that are in phase with technological innovations, rather than leaving them to become fighting grounds between large foreign tech firms.

Ultimately, greater regional collaboration could help smaller economies maximise the gains from global digital initiatives like the Digital Silk Road. The idea of a regional digital policy, such as the one regulating the European Digital Single Market, may be useful for smaller developing countries (Azmeh, Foster & Echavarri 2020). Moving beyond fragmented bilateral commercial agreements with China and its tech giants would help to level the playing field for all African nations and ultimately enhance opportunities for local agencies to sculpt structures that support inclusive digital development.

Acknowledgements

This working paper is part of a series from the project, "China's Digital Expansion in the Global South", funded by the Faculty of Humanities, University of Manchester, UK. Richard Heeks and Qingna Zhou of the Global Development Institute, University of Manchester, and Xia Han of the Alliance Manchester Business School, University of Manchester, were the facilitating editors.

References

Agbebi, M. 2018. China in Africa's telecom sector: Opportunities for human capital development? A case of Huawei in Nigeria. *Human Resource Development International*, *21*(5), 532–551. https://doi.org/10.1080/13678868.2018.1512232

Agbebi, M. 2019. Exploring the Human Capital Development Dimensions of Chinese Investments in Africa: Opportunities, Implications and Directions for Further Research. *Journal of Asian and African Studies*, *54*(2), 189–210. https://doi.org/10.1177/0021909618801381

Agence Ecofin. 2019a. *Telecom Egypt signs new deal with Huawei, ZTE and China Telecom*. Ecofin Agency. Accessed May 22, 2022 https://www.ecofinagency.com/telecom/0908-40385-telecom-egypt-signs-new-deal-with-huawei-zte-and-china-telecom

Agence Ecofin. 2019b. L'Algérie abrite la toute première usine africaine de Huawei, opérationnelle depuis le 22 janvier 2019 [Algeria hosts Huawei's very first African factory, operational since January 22, 2019]. *Agence Ecofin*. Accessed May 22, 2022. https://www.agenceecofin.com/investissement/2801-63550-l-algerie-abrite-la-toute-premiere-usine-africaine-de-huawei-operationnelle-depuis-le-22-janvier-2019

Aitken, B. J., & Harrison, A. E. 1999. Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela. *American Economic Review*, *89*(3), 605–618. https://doi.org/10.1257/aer.89.3.605

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. https://doi.org/10.1016/j.worlddev.2013.05.001

Amsden, A. H. 2001. *The Rise of 'the Rest': Challenges to the West from Late-industrializing Economies*. Oxford University Press.

Anand, N. 2015. Leaky States: Water Audits, Ignorance, and the Politics of Infrastructure. *Public Culture*, *27*(2 (76)), 305–330. https://doi.org/10.1215/08992363-2841880

APS. 2021. L'augmentation du débit Internet Minimum Réalisée Grâce à "d'Énormes" Investissements. [The increase in the minimum internet speed achieved thanks to "huge" investments]. *Algérie Presse Service*. Accessed May 22, 2022. https://www.aps.dz/sante-science-technologie/128654-l-augmentation-du-debit-internet-minimum-realisee-grace-a-d-enormes-investissements#:~:text=ALGER%20%2D%20L'augmentation%20du%20d%C3%A9bit,dimanche%20aupr%C3%A8s%20d'Alg%C3%A9rie%20T%C3%A9l%C3%A9com.

Auffray, C., & Fu, X. 2015. Chinese MNEs and managerial knowledge transfer in Africa: The case of the construction sector in Ghana. *Journal of Chinese Economic and Business Studies*, *13*(4), 285–310. https://doi.org/10.1080/14765284.2015.1092415

Autio, E., Kenney, M., Mustar, P., Siegel, D., & Wright, M. 2014. Entrepreneurial innovation: The importance of context. *Research Policy*, *43*(7), 1097–1108. https://doi.org/10.1016/j.respol.2014.01.015

Azmeh, S., Foster, C., & Echavarri, J. 2020. The International Trade Regime and the Quest for Free Digital Trade. *International Studies Review*, *22*(3), 671–692. https://doi.org/10.1093/isr/viz033

Beattie, A. 2019. Technology: How the US, EU and China compete to set industry standards. *Financial Times*. Accessed June 02, 2022. https://www.ft.com/content/0c91b884-92bb-11e9-aea1-2b1d33ac3271

Beaudry, P., & Francois, P. 2010. Managerial Skills Acquisition and the Theory of Economic Development. *The Review of Economic Studies*, *77*(1), 90–126. https://doi.org/10.1111/j.1467-937X.2009.00571.x

Blalock, G., & Gertler, P. J. 2008. Welfare gains from Foreign Direct Investment through technology transfer to local suppliers. *Journal of International Economics*, *74*(2), 402–421. https://doi.org/10.1016/j.jinteco.2007.05.011

Blomstrom, M., & Kokko, A. 2001. Foreign direct investment and spillovers of technology. *International Journal of Technology Management*, *22*(5–6), 435–454. https://doi.org/10.1504/IJTM.2001.002972

Blomström, M., & Sjöholm, F. 1999. Technology transfer and spillovers: Does local participation with multinationals matter? *European Economic Review*, *43*(4), 915–923. https://doi.org/10.1016/S0014-2921(98)00104-4

CCCPC. 2016. *The 13th Five-Year Plan for Economic and Social Development of the People's Republic of China—2016–2020*. https://en.ndrc.gov.cn/newsrelease_8232/201612/P020191101481868235378.pdf

Chen, B.-M. 2021. *Digital Leninism: The Complex, Dangerous Relationship Between Tech Giants and the Chinese Communist Party*. Center for International Private Enterprise. https://www.cipe.org/resources/digital-leninism-the-complex-dangerous-relationship-between-tech-giants-and-the-chinese-communist-party/

Chenley, C. 2019. *China's Digital Aid: The Risks and Rewards*. https://www.cfr.org/china-digital-silk-road

Cissé, D. 2012. Chinese Telecom Companies Foray into Africa. *African East-Asian Affairs*, *69*(0), Article 0. https://doi.org/10.7552/69-0-94

Cunningham, J. A., Menter, M., & Young, C. 2017. A review of qualitative case methods trends and themes used in technology transfer research. *The Journal of Technology Transfer*, *42*(4), 923–956. https://doi.org/10.1007/s10961-016-9491-6

Demena, B. A., & Bergeijk, P. A. G. van. 2019. Observing FDI spillover transmission channels : Evidence from firms in Uganda. *Third World Quarterly*, *40*(9), 1708–1729. https://doi.org/10.1080/01436597.2019.1596022

Denzin, N. K. 2001. *Interpretive Interactionism*. SAGE.

Djazairess. 2019. Huawei se lance dans le 'Made in bladi'. *Djazairess*. https://www.djazairess.com/fr/lexpression/308334

Edwards, P. N., & Hecht, G. 2010. History and the Technopolitics of Identity: The Case of Apartheid South Africa. *Journal of Southern African Studies*, *36*(3), 619–639. https://doi.org/10.1080/03057070.2010.507568

Egypt Independent. 2019. Egypt, Huawei sign MoU for cloud computing, AI networks. *Egypt Independent*. Accessed May 18, 2022. https://egyptindependent.com/egypt-huawei-sign-mou-for-cloud-computing-ai-networks/

Egyptian Investment Law. 2017. *Law No. 72 of 2017: Promulgating the Investment Law*. https://www.gafi.gov.eg/english/startabusiness/laws- and-regulations/publishingimages/pages/business laws/investment%20law%20english%20ban.pdf

Erie, M. S., & Streinz, T. 2021. *The Beijing Effect: China's 'Digital Silk Road' as Transnational Data Governance* (SSRN Scholarly Paper No. 3810256). https://papers.ssrn.com/abstract=3810256

Fannin, R. A. 2019. *Tech Titans of China: How China's Tech Sector is challenging the world by innovating faster, working harder, and going global*. Nicholas Brealey.

Feldstein, S. 2021. *The Rise of Digital Repression: How Technology is Reshaping Power, Politics, and Resistance* (1st edition). Oxford University Press.

Fu, X., Pietrobelli, C., & Soete, L. 2011. The Role of Foreign Technology and Indigenous Innovation in the Emerging Economies: Technological Change and Catching-up. *World Development*, *39*(7), 1204–1212. https://doi.org/10.1016/j.worlddev.2010.05.009

Globerman, S. 1979. Foreign Direct Investment and 'Spillover' Efficiency Benefits in Canadian Manufacturing Industries. *The Canadian Journal of Economics / Revue Canadienne d'Economique*, *12*(1), 42–56. https://doi.org/10.2307/134570

Guimón, J., Chaminade, C., Maggi, C., & Salazar-Elena, J. C. 2018. Policies to Attract R&D-related FDI in Small Emerging Countries: Aligning Incentives with Local Linkages and Absorptive Capacities in Chile. *Journal of International Management*, *24*(2), 165–178. https://doi.org/10.1016/j.intman.

Haddad, M., & Harrison, A. 1993. Are there positive spillovers from direct foreign investment?: Evidence from panel data for Morocco. *Journal of Development Economics*, *42*(1), 51–74. https://doi.org/10.1016/0304-3878(93)90072-U

Hecht, G. 2001. Technology, politics, and national identity in France. In *Technologies of power: Essays in honor of Thomas Parke Hughes and Agatha Chipley Hughes* (M. Allen & G. Hecht, pp. 253–294). Cambridge, MA: MIT Press.

Heidenreich, M. 2012. *Innovation and Institutional Embeddedness of Multinational Companies*. Edward Elgar Publishing.

Hernandez, K. 2019. *Achieving Complex Development Goals Along China's Digital Silk Road*. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/14396

Hillman, J. E. 2021. *The Digital Silk Road: China's Quest to Wire the World and Win the Future*. Harper Business.

Hirschman, A. O. H. 2013. A Generalized Linkage Approach to Development, with Special Reference to Staples. In *The Essential Hirschman* (pp. 155–194). Princeton University Press. https://www.degruyter.com/document/doi/10.1515/9781400848409-008/html

Holm, J. R., Timmermans, B., Østergaard, C. R., Coad, A., Grassano, N., & Vezzani, A. 2020. Labor mobility from R&D-intensive multinational companies: Implications for knowledge and technology transfer. *The Journal of Technology Transfer*, *45*(5), 1562–1584. https://doi.org/10.1007/s10961-020-09776-8

Huawei. 2017. *Huawei Announces New OpenLab in Cairo to Build ICT Ecosystem in Northern Africa—Huawei Press Center*. Huawei. Accessed June 09, 2022. https://www.huawei.com/en/news/2017/12/Huawei-New-OpenLab-Cairo

Iršová, Z., & Havránek, T. 2013. Determinants of Horizontal Spillovers from FDI: Evidence from a Large Meta-Analysis. *World Development*, *42*, 1–15. https://doi.org/10.1016/j.worlddev.2012.07.001

Javorcik, B. S. 2004. Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers Through Backward Linkages. *American Economic Review*, *94*(3), 605–627. https://doi.org/10.1257/0002828041464605

Kabbani, N. 2019. *Youth Employment in the Middle East and North Africa: Revisiting and Reframing the Challenge*. Brookings Institution. https://www.brookings.edu/research/youth-employment-in-the-middle-east-and-north-africa-revisiting-and-reframing-the-challenge/

King, K. 2013. *China's Aid and Soft Power in Africa*. Boydell & Brewer.

Kneller, R., & Pisu, M. 2007. Industrial Linkages and Export Spillovers from FDI. *The World Economy*, *30*(1), 105–134. https://doi.org/10.1111/j.1467-9701.2007.00874.x

Lall, S. 1992. Technological capabilities and industrialization. *World Development*, *20*(2), 165–186. https://doi.org/10.1016/0305-750X(92)90097-F

Larkin, B. 2013. The Politics and Poetics of Infrastructure. *Annual Review of Anthropology*, *42*(1), 327–343. https://doi.org/10.1146/annurev-anthro-092412-155522

Le, H. Q., & Pomfret, R. 2011. Technology spillovers from foreign direct investment in Vietnam: Horizontal or vertical spillovers? *Journal of the Asia Pacific Economy*, *16*(2), 183–201. https://doi.org/10.1080/13547860.2011.564746

Lean, C. S. 2001. Empirical tests to discern linkages between construction and other economic sectors in Singapore. *Construction Management and Economics*, *19*(4), 355–363. https://doi.org/10.1080/01446190010022686

Lee, H., & Oh, S. 2006. A standards war waged by a developing country: Understanding international standard setting from the actor-network perspective. *The Journal of Strategic Information Systems*, *15*(3), 177–195. https://doi.org/10.1016/j.jsis.2005.10.002

Li, R., & Cheong, K.-C. 2017. Huawei and ZTE in Malaysia: The Localisation of Chinese Transnational Enterprises. *Journal of Contemporary Asia*, *47*(5), 752–773. https://doi.org/10.1080/00472336.2017.1346697

Liu, X., Wang, C., & Wei, Y. 2009. Do local manufacturing firms benefit from transactional linkages with multinational enterprises in China? *Journal of International Business Studies*, *40*(7), 1113–1130. https://doi.org/10.1057/jibs.2008.97

Liu, Z. 2008. Foreign direct investment and technology spillovers: Theory and evidence. *Journal of Development Economics*, *85*(1), 176–193. https://doi.org/10.1016/j.jdeveco.2006.07.001

Ma, W. 2021. *The Digital War: How China's Tech Power Shapes the Future of AI, Blockchain and Cyberspace* (1st edition). Wiley.

Mackinnon, A. 2019. For Africa, Chinese-Built Internet Is Better Than No Internet at All, *Foreign Policy*. https://foreignpolicy.com/2019/03/19/for-africa-chinese-built-internet-is-better-than-no-internet-at-all/

Markusen, J., & Venables, A. 1999. Foreign direct investment as a catalyst for industrial development. *European Economic Review*, *43*(2), 335–356.

Mattli, W., & Büthe, T. 2003. Setting International Standards: Technological Rationality or Primacy of Power? *World Politics*, *56*(1), 1–42.

MCIT - Ministry of Communications and Information Technology. (2016). *Egypt's ICT 2030 Strategy*. https://mcit.gov.eg/en/ICT_Strategy

MFA (Ministry of Foreign Affairs of the PRC). 2009. *Premier Wen Jiabao Talks with Trainees of Huawei Training Center in Egypt*. https://www.mfa.gov.cn/ce/cedk/eng/TourChina/t626256.htm

Mitchell, T.2002. *Rule of Experts: Egypt, Techno-politics, modernity*. University of California Press.

Ning, L., & Wang, F. 2018. Does FDI Bring Environmental Knowledge Spillovers to Developing Countries? The Role of the Local Industrial Structure. *Environmental and Resource Economics*, *71*(2), 381–405. https://doi.org/10.1007/s10640-017-0159-y

Ockwell, D. G., Watson, J., MacKerron, G., Pal, P., & Yamin, F. 2008. Key policy considerations for facilitating low carbon technology transfer to developing countries. *Energy Policy*, *36*(11), 4104–4115.

Oya, C. and Schaefer, F., 2019. Chinese firms and employment dynamics in Africa: A comparative analysis. IDCEA Research Synthesis Report, SOAS, University of London.

Pairault, T. 2017. La Chine au Maghreb: De l'esprit de Bandung à l'esprit du capitalisme. *Revue de la régulation. Capitalisme, institutions, pouvoirs*, *21*, Article 21. https://doi.org/10.4000/regulation.12230

Peyrat, O. 2012. Normes: Un outil caché de la stratégie économique chinoise [Standards: A Hidden Tool of Chinese Economic Strategy]. *Le Journal de l'ecole de Paris du Management*, *30*. https://www.ecole.org/fr/seance/961-normes-un-outil-cache-de-la-strategie-economique-chinoise

Rojec, M., & Knell, M. 2018. Why Is There a Lack of Evidence on Knowledge Spillovers from Foreign Direct Investment? *Journal of Economic Surveys*, *32*(3), 579–612. https://doi.org/10.1111/joes.12207

Rwehumbiza, D. A. 2021. Huawei's linkages with local firms in Tanzania: Idiosyncratic benefits and risks. *Global Business and Organizational Excellence*, *40*(3), 20–35. https://doi.org/10.1002/joe.22076

Saggi, K. 2002. Trade, Foreign Direct Investment, and International Technology Transfer: A Survey. *The World Bank Research Observer*, *17*(2), 191–235. https://doi.org/10.1093/wbro/17.2.191

Shen, H. 2017. *Across the Great (Fire) Wall: China and the Global Internet: Vol. PhD Dissertation*. University of Illinois. https://www.ideals.illinois.edu/handle/2142/97589

Smith, J., Cummins, C., & Krasodomski-Jones, A. 2021. *Why Democracies should care about the wiring of the internet*. Demos. Accessed 14 June 2022. https://demos.co.uk/wp-content/uploads/2021/03/Good-Foundations-Report-.pdf

Takii, S. 2005. Productivity spillovers and characteristics of foreign multinational plants in Indonesian manufacturing 1990-1995. *Journal of Development Economics*, *76*(2), 521–542.

Tang, X. 2021. Adaptation, innovation, and industrialization: The impact of Chinese investments on skill development in the Zambian and Malawian cotton sectors. *Journal of Chinese Economic and Business Studies*, *19*(4), 295–313. https://doi.org/10.1080/14765284.2021.1943734

Te Velde, D. W. 2002. *Government Policies for Inward Foreign Direct Investment in Developing Countries: Implications for Human Capital Formation and Income Inequality*. Working Paper No. 193. Paris, OECD.

Triolo, P., & Sherlock, A. 2020. 'New infrastructure'—China's race for 5G and networked everything has a new catchphrase. *SupChina*. https://supchina.com/2020/07/01/new-infrastructure-chinas-race-for-5g-and-networked-everything-has-a-new-catchphrase/

Tsui, B. 2016. Do Huawei's Training Programs and Centers Transfer Skills to Africa? *China-Africa Research Initiative: Johns Hopkins SAIS.*, *Policy Brief 14.*

Tugendhat, H. 2020. How Huawei Succeeds in Africa: Training and Knowledge Transfers in Kenya and Nigeria. *China Africa Research Initiative - SAIS Hopkins*, 31.

Tugendhat, H. 2021. Connection issues: A study on the limitations of knowledge transfer in Huawei's African training centres. *Journal of Chinese Economic and Business Studies*, (0), 1–27. https://doi.org/10.1080/14765284.2021.1943194

UNCTAD. 2012. *Technology and innovation report 2012: Innovation, technology and south–south collaboration.* New York and Geneva: United Nations.

Vaaland, T. I., & Ishengoma, E. 2016. University-industry linkages in developing countries: Perceived effect on innovation. *Education + Training*, *58*(9), 1014–1040. https://doi.org/10.1108/ET-07-2015-0067

Wahab, S. A., Rose, R. C., & Osman, S. I. W. 2011. Defining the Concepts of Technology and Technology Transfer: A Literature Analysis. *International Business Research*, *5*(1), p61. https://doi.org/10.5539/ibr.v5n1p6 1

Winner, L. Do Artifacts Have Politics? *Daedalus*, *109*(1), 121–136.

World Bank. 2022a. *Individuals using the Internet (% of population)*. https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=DZ

World Bank. 2022b. *Mobile Penetration per country*. https://databank.worldbank.org/Mobile-penetration-/id/5494af8e

World Economic Forum. 2017. *The Future of Jobs and Skills in the Middle East and North Africa: Preparing the Region for the Fourth Industrial Revolution*. https://www3.weforum.org/docs/WEF_EGW_FOJ_MENA.pdf

Yao, X., Tan, A., & Suttmeier, R. 2009. Standards of power? Technology, Institutions, and Politics in the Development of China's National Standards Strategy. *Geopolitics, History, and International Relations*, *1*(1), 46–84.

Annex 1: List of Interviewees

Affiliation	Code	Date	Place
Subcontractors, Suppliers, and Customers of Huawei and ZTE			
CEO of subcontracting firm for major ICT OEM	S1	17/10/2021	Algiers
CEO of subcontracting firm for major ICT OEM	S2	18/10/2021	Algiers
CEO of subcontracting firm for major ICT OEM	S3	22/10/2021	Algiers
CEO of subcontracting firm for major ICT OEM	S4	13/12/2021	Algiers
CEO of subcontracting firm for major ICT OEM	S5	20/12/2021	Algiers
Start-up	S6	09/12/2021	Algiers
CEO of subcontracting firm for major ICT OEM	S7	13/12/2021	Algiers
Mobile operator	S8	08/01/2022	Algiers
CEO of subcontracting firm for major ICT OEM	S9	02/03/2022	Cairo
Start-up	S10	02/03/2022	Cairo
Subcontractor to Major ICT vendors	S11	15/03/2022	Cairo
Huawei and ZTE Engineers and Managers			
ICT engineer at ZTE	W1	28/10/2021	Algiers
ICT engineer at ZTE	W2	06/11/2021	Algiers
Engineer at Ooredoo with Huawei certification	W3	28/11/2021	Zoom call
Former Huawei engineer	W4	05/12/2021	Algiers
Engineer at Huawei	W5	07/12/2021	Algiers
ZTE manager	W6	22/12/2021	Algiers
Assembly line manager at Afgotech (Algerian Huawei's partner for the factory)	W7	20/01/2022	Phone call
Former Huawei engineer who set up his own business	W8	03/01/2022	Algiers
Engineer at Huawei, the Oran Institute of Telecommunication	W9	06/01/2022	Zoom call
Engineer at ZTE	W10	18/01/2022	Algiers
Manager at Huawei's device – coordinator of phone manufacturing	W11	01/02/2022	Algiers
A senior manager at ZTE Egypt	W12	16/02/2022	Cairo
Junior network engineer at Huawei	W13	17/02/2022	Zoom call
Senior network engineer at Huawei	W14	21/02/2022	Cairo
Training and development manager at Huawei customer	W15	24/02/2022	Phone call
Huawei public relations manager	W16	27/02/2022	Zoom call
Telecom engineer at Huawei	W17	02/03/2022	Cairo
Telecom engineer at Huawei	W18	02/03/2022	Cairo
Telecom engineer at Huawei	W19	02/03/2022	Cairo
Computer engineer at ZTE Egypt	W20	04/03/2022	Phone call
Computer engineer at Huawei's OpenLab	W21	16/03/2022	Cairo
Experts and Researchers			
Economic expert	E1	30/11/2021	Algiers
IT engineer and digital economy expert	E2	30/11/2021	Algiers
Professor of ICTs at the University of Bab Ezzouar	E3	17/11/2021	Algiers
Responsible for the US-Algeria Trade Chamber	E4	20/11/2021	Algiers
Digital economy expert	E5	15/12/2021	Algiers
Digital economy Expert	E6	19/01/2022	Algiers

Professor of economic innovation	E7	07/02/2022	Oran
Device factory	E8	23/02/2022	Cairo
Researcher focusing on China-Egypt Relations	E9	27/02/2022	Zoom call
Professor of political economy at the American University in Cairo	E10	28/02/2022	Cairo
Professor of economics at the University of Cairo	E11	01/03/2022	Cairo
Senior digital development specialist at the World Bank	E12	10/03/2022	Cairo
Students and Instructors of Huawei and ZTE Training Programmes			
Director of the national institute of ICTs, Ucalypthus, Algiers	U1	07/12/2021	Algiers
Pedagogical coordinator at the national institute of ICTs, Ucalypthus, Algiers	U2	07/12/2021	Algiers
Student at the national institute of ICTs	U3	07/12/2021	Algiers
Student at the national institute of ICTs	U4	07/12/2021	Algiers
Student at the national institute of ICTs	U5	07/12/2021	Algiers
Student at the national institute of ICTs	U6	07/12/2021	Algiers
ICT student and coordinator of Huawei ICT academies at the University of Saad Dahleb, Blida	U7	12/21/2021	Zoom call
Director of the National School of Computer Science (ESI)	U8	27/12/2021	Algiers
University student and graduate of Huawei ICT Academy	U9	27/02/2022	Cairo
ICT Academy graduate	U10	09/03/2022	Cairo
ICT Academy graduate	U11	04/03/2022	Cairo
Engineers and Managers of Western Competitors			
Managing director at Ericsson Algeria	C1	21/12/2021	Zoom call
Ericsson engineer	C2	23/12/2021	Algiers
Managing director at Cisco Algeria	C3	17/01/2022	Algiers
Engineer at Ericsson	C4	29/01/2022	Zoom call
Foreign tech incubator	C5	28/02/2022	Cairo
Foreign tech incubator	C6	28/02/2022	Cairo
ICT engineer at Nokia	C7	08/03/2022	Cairo
Engineer at the Orange Innovation Lab	C8	08/03/2022	Cairo
Engineer at the Orange Innovation Lab	C9	08/03/2022	Cairo
Managing director of the Orange Innovation Lab	C10	08/03/2022	Cairo
ICT engineer at Ericsson	C11	15/03/2022	Cairo
Policymakers			
Algerian minister with responsibilities for the knowledge economy and start-ups	G1	28/11/2021	Algiers
Adviser to the Algerian minister of the knowledge economy	G2	28/11/2021	Algiers
Manager at the Egyptian Agency of Investment and Free Zones	G3	22/02/2022	Cairo
Policy Maker at ITIDA – Egyptian agency for informatics and telecommunication development	G4	01/03/2022	Phone call
Former finance minister of Egypt	G5	09/03/2022	Cairo