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# Conference Paper Estimating the Impact of Chinese Foreign Direct Investment on Telecommunications Penetration Rates

24th Biennial Conference of the International Telecommunications Society (ITS): "New bottles for new wine: digital transformation demands new policies and strategies", Seoul, Korea, 23-26 June, 2024

# **Provided in Cooperation with:**

International Telecommunications Society (ITS)

*Suggested Citation:* Jiang, Peter (2024) : Estimating the Impact of Chinese Foreign Direct Investment on Telecommunications Penetration Rates, 24th Biennial Conference of the International Telecommunications Society (ITS): "New bottles for new wine: digital transformation demands new policies and strategies", Seoul, Korea, 23-26 June, 2024, International Telecommunications Society (ITS), Calgary

This Version is available at: https://hdl.handle.net/10419/302525

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# Estimating the Impact of Chinese Foreign Direct Investment on Telecommunications Penetration Rates

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Keywords: Foreign direct investment, China, Telecommunications, Broadband, Cellular, Panel data

# Abstract

This research examines the effects of Chinese Foreign Direct Investment (CFDI) on fixed broadband and mobile cellular penetration rates using panel data from the "China Global Investment Tracker," a dataset of publicly available CFDI transactions from 2005 to 2023. As CFDI grows to pre-COVID-19 levels, its impact on penetration rates may be influenced by the Chinese government's preferential treatment for its stateowned enterprises (SOE) and telecommunications companies. Policy makers interested in FDI liberalization would benefit from understanding the distinct consequences of FDI from different sources. Through panel data analysis, this paper estimates that CFDI has a positive relationship with fixed broadband subscriptions and a negative relationship with mobile cellular subscriptions. This paper also explores potential explanations for these trends and their policy implications.

# Introduction

Although research has been conducted on the effect of China's Belt and Road Initiative (BRI) as well as the effect of FDI on specific telecommunications markets and factors like economic growth, there is currently little literature that specifically explores how CFDI may differ from FDI other countries. This preliminary exploration of the effect of CFDI on the telecommunications industry seeks to address this gap.

Liberalization of FDI policies and the opening of infrastructure sectors to private

investment and competition have been major drivers of growth in the telecommunications industry. However, liberalization has not been universal, and some countries have maintained stringent regulatory restrictions on foreign investment and ownership, citing concerns for national sovereignty and economic growth. Although studies suggest that FDI can bring capital, technology, enhanced infrastructure, and increased competition that benefits consumers and providers, it may also cause market distortion and loss of control over key industries.

China has itself protected its internal telecommunications market while also making substantial investments all around the world in strategic telecommunications infrastructure. CFDI in telecommunications has grown significantly over the past two decades, driven by China's strategic interests and the global expansion of its major telecommunications companies like Huawei Technologies and Zhongxing Telecom Ltd. (ZTE). A recent April 2024 report from the European Commission found significant state-induced distortions in how China operates across more than dozen industries. including the a telecommunications equipment sector. These distortions include preferential state subsidies and grants, as well as forced technology transfers from foreign firms to Chinese firms. China's inconsistent intellectual property rights enforcement may also leave foreign firms vulnerable to involuntary knowledge transfers. Governments interested in liberalizing FDI restrictions would benefit from having an empirical understanding of the potential

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benefits and costs of receiving CFDI, and therefore be able to design policies to attract, manage, and review CFDI.

This paper applies panel data estimation techniques on CFDI data collected by an American think tank, the American Enterprise Institute, as well as datasets from the World Bank, the Organisation for Economic Co-operation and Development (OECD), and the International Telecommunication Union (ITU). Although preliminary estimates are significant and suggest that CFDI has negative effects on mobile subscriptions and positive effects on broadband subscriptions, there are shortcomings inherent to the data that make further research necessary to build a complete picture of the impact of CFDI on telecommunications penetration rates.

# Literature Review

The BRI is a key component of China's foreign policy that focuses on infrastructure development and digital connectivity in an effort to expand soft power (Shen, 2018). its Telecommunications operators in China play a crucial role in implementing these strategies, all while receiving myriad benefits from the government that allow them to undercut and outcompete foreign operators (European Commission, Studies that articulate 2024). quantifiable harms of the BRI mostly relate to the environment and macroeconomic debt issues. Relatively few studies have been able to quantify harms of especially the CFDI, in the telecommunications industry. One such recent study by Arnold finds that African countries tend to lose autonomy in ICT infrastructure if they are linked to Chinese ICT financing (2024).

Other studies have explored the effect of CFDI invested through the BRI, finding that participation in the BRI is associated with higher economic growth (Sun et al., 2019). Studies into specific industries like transportation also conclude that participation is associated with economic growth (Want et al., 2020). The most notable research in this particular area is a 2023 study by Ho et al. that uses a difference-in-differences model to see how participation in the BRI and Digital Silk Road (DSR) affects ICT development indicators, including penetration rates. Ho et al. find that participating economies experience a significant rise in ICT development. This paper seeks to expand on their findings by including observations from non-BRI countries who also receive telecommunications CFDI, non-BRI countries who receive telecommunications FDI from the world at large, and by using dollar figures of FDI rather than a dummy variable for BRI participation.

The broader literature surrounding FDI is largely characterized by the balance between economic growth and national security that comes with liberalization or restriction. Some countries that have shifted towards FDI liberalization have substantial within realized growth the telecommunications industry, especially in developing nations like India and Nigeria (Mahajan, 2014; Izuchukwu, 2011). However, whether or not FDI is a necessary mechanism for developing countries to promote economic growth is still debated, particularly in strategic industries like telecommunications (Lin, 2008).

Outside of CFDI, the literature for FDI in the telecommunications industry tends to suggest a positive relationship between the two. Lestage et al. find that FDI can boost infrastructure investment by state-owned companies but may decrease investment by private firms (2013). Others like Meidavati have found that foreign direct investment in recent years has created a positive impact for ASEAN (2017). Some of these impacts include spillover effects from technology transfers, market access to other countries, also skills and managerial transfers. In more developed markets like the United States, scholars like Sidak argue that the restrictions that existed prior to the Telecommunications Act of 1996 harmed both consumers and investors, denying them lower prices, higher quality services, and valuable investment opportunities (1997).

Conversely, Lin raises concerns about losing control over strategic industries, including

telecommunications, due to FDI (2008). Although Lin largely discusses this from the perspective of a developing country, the issue of security in key industries is also widely discussed in developed countries. According to the OECD's FDI restrictiveness index, Canada ranks the fifth highest across all nations (2024). Its particularly stringent foreign ownership and investment restrictions have prevented foreign entrants from entering its market, and has even banned Chinese firms. Huawei and ZTE, from its 5G networks (Innovation, Science and Economic Development Canada, 2022). Other countries like Australia and New Zealand have similarly restrictive regulations against foreign ownership of telecommunications companies. For ownership example, aggregate foreign of Australia's largest telecommunications company, Telstra, is limited to 35% and individual foreign investors are only allowed a maximum of 5%. In cases where foreign governments do not invest at "a fully arm's length and commercial basis", Australia administers a test mitigate national security concerns and block investments that would grant unreasonable control over an industry or company (Australian Government, 2022).

Some studies have also explored the inverse relationship between the telecommunications industry and FDI in terms of how to attract FDI through better telecommunications infrastructure. Tiong et al. (2022) and Shah and Khan (2019) emphasize that robust ICT infrastructure plays a crucial role in attracting FDI in Asia. These studies suggest that FDI in telecommunications is driven by technological innovation, market dynamics, and institutional factors. FDI that is attracted this way may then be reinvested in ICT infrastructure, creating a feedback cycle that promotes more FDI in the long-term.

The existing literature on the relationship between CFDI and telecommunications outcomes is limited by a lack of empirical evidence. Few studies examine how FDI from specific state actors affect telecommunications. While several studies have examined the effect of FDI overall on telecommunications development and economic growth, additional research on a country-bycountry basis will only be possible through improved data collection and publishing. Governmental organizations like the OECD that maintain a public database on FDI financial inflows and positions would enable significant research in this space by publishing more granular data by sector and by counterpart area.

### Methodology

# Data Description of CFDI Data

Data on CFDI transactions come from the American Enterprise Institute's "China Global Investment Tracker", a public dataset that has documented over 4,300 transactions across different industries since 2005. In the interest of transparency, it would be important to recognize that the American Enterprise Institute is generally recognized as a right-leaning, conservative organization. Recognizing that its ideological stance may bias the data, some cross-verification of the data was conducted to ensure accuracy.

Observations categorized under telecommunications amount to approximately 46.6 billion USD as of the datasets last update in the fall of 2023. Telecommunications investments since the formation of the BRI in 2013 amount to approximately 9.63 billion USD. Greenfield investments amount to 8.42 billion USD.





since 2006, peaking in 2014 at approximately 6 billion USD. The COVID-19 pandemic and its related restrictions saw annual CFDI decreasing to its lowest observed value of 180 million USD in 2020. Since then, it has increased every year to about 1.7 billion in 2023. Given that this trend may likely continue, it would be valuable to understand how to manage increasing inflows of CFDI.

There were varying levels of CFDI across the regions that were recorded in the dataset. Europe was the largest recipient region at more than 21 billion USD, with the bulk of CFDI going to the United Kingdom and Italy. This is followed by more than 8 billion USD of investments in sub-Saharan Africa, a region that is a major priority of BRI infrastructure investments.





After filtering only for observations related to the BRI, East Asia becomes the largest recipient region of CFDI at approximately 3.8 billion USD. In comparison to the overall regional distribution, there are far fewer BRI projects in Europe, now amounting to 940 million USD. These projects still amount to 9.63 billion USD, accounting for roughly 28.8% of all CFDI transactions since 2013. SOEs also make up the majority of BRI transactions at 6.7 billion USD.



Figure 3: BRI-related CFDI value by region

In terms of specific investors, Huawei is the largest investor at more than 13 billion USD in total CFDI. This accounts for approximately 28.4% of all CFDI transaction volume. ZTE is the second largest investor at roughly 5.5 billion USD and also represents the largest SOE. Figure 4 depicts the top 10 largest investors.



# Figure 4: Top 10 investors

Figure 5 characterizes the largest private investors. A private investor in this sense can be publicly traded as long as it is not an SOE or mainly controlled by an SOE. Huawei business activity comprises the majority of private business activity, with the remaining investors coming from a variety of investment and technology firms.



#### Figure 5: Top 10 largest private investors

Figure 6 characterizes the largest SOE investors. Behind ZTE are a variety of other state actors that include telecommunications firms (e.g., China Telecom, China Unicom, China Mobile), infrastructure firms (e.g., Sinomach, Railway, Aerospace), as well as other SOEs whose primary objectives are investment-related like China's State Administration of Foreign Exchange (SAFE) and China Investment Corporation (CIC).



Name of state-owned enterprise



# Data Description of World FDI Data and Controls

Data on world FDI activity is sourced from an OECD dataset titled, "FDI by counterpart area and by economic activity" which uses the 4<sup>th</sup> edition of the OECD's Benchmark Definitions of FDI, BMD4. With the counterpart area set as the world and the directional principle as inward, all 38 available reference areas and periods from 2005 to 2022 were selected under the economic activity category of telecommunications. During this period, the sum of world FDI amounted to about 120 billion USD. The unit of measurement selected for FDI was total financial flows as it was most comparable to the data from the "China Global Investment Tracker."

Figure 7 depicts the top 10 countries that receive world FDI. The OECD dataset is mostly comprised of European and North American countries, with the only exceptions being Israel and South Korea.



### Figure 7: Top 10 recipients of world FDI

Other variables of interest like telecommunications penetration rates, economic indicators, and FDI restrictiveness indices are sourced from the World Bank, the International Telecommunications Union, and the OECD.

Dependent variables:

• Fixed broadband subscriptions per 100 people (FBS)

• Mobile cellular subscriptions per 100 people (MCS)

Independent variables:

- CFDI in telecommunications measured in billions of USD (CFDI)
- World FDI in telecommunications measured in billions of USD (WFDI)
- Log transformed GDP per capita (GDP)
- Percentage of the population living in urban population centres (URBAN)
- Domestic credit to the private sector as a percentage of GDP (DC)
- Exports of goods and services as a percentage of GDP (EGS)
- Net inflows of FDI as a percentage of GDP (FDIGDP)
- Fixed broadband FDI restrictiveness index measured on a scale from 0 to 1 (FBSRRI)
- Mobile cellular FDI restrictiveness index measured on a scale from 0 to 1 (MCSRRI)

The definition for fixed broadband also includes satellite broadband and fixed wireless services. Control variables were selected based on research conducted by Ho et al. on the effect of participation in the BRI and DSR (2023). These largely account for omitted variable biases and approximate trade openness through EGS, FDI receptiveness through FDIGDP, and general ICT capacity through URBAN and GDP. Table 1 depicts summary statistics of these variables for 940 observations across 60 countries and 17 years.

Variable	Mean	SD	Min	Max
FBS	17.9	14.9	0.000327	49.4
MCS	105	37.3	0.445	221
CFDI	0.414	0.949	0	7.81
WFDI	10.3	20.5	-0.989	125
GDP	24,000	25,300	192	134,000
URBAN	63.3%	23.2%	12.9%	100%
DC	75.7%	49.0%	2.66%	305%
EGS	48.1%	36.0%	5.12%	229%

FDIGDP	4.11%	17.9%	-394%	234%	
FBSRRI	0.095	0.188	0.00	0.675	
MCSRRI	0.0873	0.171	0.00	0.0675	
Table 1: Summary Statistics for Panel Variables					

# Estimation Approach

Given the nature of the data, I employed panel data methods using the following models:

- 1) Pooled OLS Estimator
- 2) Fixed Effects Estimator
- 3) Random Effects Estimator

Each model was regressed using an unadjusted model, that only included FDI variables as the independent variables, as well as a fully specified model that included all control variables. FDI values were transformed to billions of USD to provide more meaningful and easily interpretable coefficients, given the tendency for some models to produce weak effects that were close to zero. Regulatory restrictiveness indices were necessarily dropped in fixed effects regressions because they did not vary throughout time.

The models are therefore specified as follows, where the variable "FDI value" represents either CFDI, world FDI, or both:

Unadjusted model:

 $FBS = \alpha + \beta 1 \cdot FDI \ value + \epsilon it$ 

 $MCS = \alpha + \beta 1 \cdot FDI \ value + \epsilon it$ 

Fully specified model:

 $FBS = \alpha + \beta 1 \cdot FDI \ value + \beta 2 \cdot GDP + \beta 3$  $\cdot URBAN + \beta 4 \cdot DC + \beta 5 \cdot EGS$  $+ \beta 6 \cdot FDIGDP + \beta 7 \cdot FBSRRI$  $+ \epsilon it$  $MCS = \alpha + \beta 1 \cdot FDI \ value + \beta 2 \cdot GDP + \beta 3$ 

$$\cdot URBAN + \beta 4 \cdot DC + \beta 5 \cdot EGS$$
$$+ \beta 6 \cdot FDIGDP + \beta 7 \cdot MCSRRI$$
$$+ \epsilon it$$

# Statistical Tests

To determine which of the four previously outlined models was most appropriate, I conducted

the following statistical tests:

- Lagrange Multiplier Test—to decide between the random effects model and the pooled OLS model.
- pF Test—to decide between the fixed effects mode and the pooled OLS model.
- Hausman Test—to decide between the fixed effects and random effects model.

No pooled models proved to be a better fit than random or fixed effect models. Hausman Test outputs suggested however that for certain models, the random effect models were more appropriate than fixed effect models. The specification of each regression is indicated in dedicated rows of Tables 2 and 3.

# Results

# Mobile Cellular Subscription Rates

Six regression models were used to estimate the effect of different sources of FDI on mobile cellular subscriptions rates. They are as follows:

- 1) Unadjusted fixed effects model regressed on Chinese FD
- 2) Fully specified fixed effects model regressed on Chinese FD
- 3) Unadjusted random effects model regressed on world FDI
- 4) Fully specified fixed effects model regressed on world FDI
- 5) Unadjusted random effects model regressed on both Chinese and world FDI
- 6) Fully specified fixed effects model regressed on both Chinese and world FDI.

Model 1 suggests that CFDI had a significant positive effect on mobile penetration rates with a coefficient of 6.454 (p<0.01), indicating an additional 6.454 subscriptions per 100 people for every billion USD in FDI. After adding controls, model 2 suggests a negative coefficient of -1.363 (p<0.1). The remaining models produced insignificant results for the dependent variables. This suggests that while CFDI may initially appear beneficial, its effect diminishes or reverses when considering other economic and demographic factors.

With respect to world FDI, coefficients were insignificant in all models, indicating no clear impact on mobile penetration rates. This consistent insignificance indicates that general FDI from the rest of the world might not be a major driver for mobile cellular penetration in this context.

Several control variables observed significant relationships with cellular subscription rates. Of note, model 2 indicates that GDP per capita and urbanization are strongly correlated with more cellular subscriptions with coefficients of 42.768 (p<0.01) and 5.595 (p<0.01), respectively. This is expected, as these two variables were selected based off of their ability to approximate a country's capacity for ICT.

The models show varying levels of explanatory power, with model 2 having the highest adjusted R-squared value (0.588), indicating a better fit under the fully specified model with multiple controls. The F-statistics in the fixed effects models suggest that the overall models are highly significant. Although model 1 indicates that CFDI has a coefficient of 6.454 (p<0.01), the adjusted R-squared value is negative (-0.031), indicating an exceptionally poor model fit.

While CFDI initially appears to boost mobile cellular subscriptions, this effect appears to reverse when considering broader economic factors. World FDI does not show a significant impact on mobile cellular penetration. Other economic indicators such as GDP per capita, urbanization, and fixed broadband subscriptions play significant roles in the overall penetration rate of a country over time. Table 2 displays the full regression output.

	Dependent variable:					
	Mobile cellular subscriptions per 100 people					
	(1)	(2)	(3)	(4)	(5)	(6)
Chinese FDI	6.454***	-1.363*			-0.687	-0.753
	(1.219)	(0.807)			(0.876)	(0.936)
World FDI			-0.026	0.032	-0.021	0.044
			(0.046)	(0.047)	(0.047)	(0.047)

FBS		-0.193		1.269***		1.476***
		(0.145)		(0.243)		(0.271)
GDP per capita		42.768***		-0.689		2.482
		(2.840)		(4.238)		(4.453)
URBAN		5.595***		-4.838***		-6.157***
		(0.410)		(1.013)		(1.136)
DC		0.084***		0.043		$0.088^{*}$
		(0.030)		(0.043)		(0.045)
EGS		-0.447***		0.071		0.043
		(0.084)		(0.097)		(0.103)
FDIGDP		0.024		-0.014		-0.016
		(0.038)		(0.023)		(0.023)
MCS RRI		-9.623				
		(22.111)				
Constant			121.459* **		121.108*	
			(2.648)		(3.121)	
Fixed effects	Yes	Yes	No	Yes	No	Yes
Random effects	No	No	Yes	No	Yes	No
Ν	944	792	294	285	251	242
$\mathbb{R}^2$	0.031	0.618	0.077	0.117	0.065	0.169
Adj. R <sup>2</sup>	-0.031	0.588	0.074	0.001	0.058	0.051
F statistic	28.030*** (df = 1; 887)	148.335* ** (df = 8; 732)	0.316	4.741*** (df = 7; 251)	0.890	5.381*** (df = 8; 211)
Note:	*p<0.1; **p<0.05; ***p<0.01					

Table 2: Regression results for mobile cellularpenetration rates

# Fixed Broadband Penetration Rates

Using the same methodology, the following six regression models were identified to be the most appropriate models to estimate the effect of different sources of FDI on fixed broadband subscriptions rates. They are as follows:

- 1) Unadjusted random effects model regressed on CFDI
- 2) Fully specified fixed effects model regressed on CFDI
- 3) Unadjusted random effects model regressed on world FDI
- 4) Fully specified fixed effects model regressed on world FDI
- 5) Unadjusted random effects model regressed on both Chinese and world FDI

6) Fully specified fixed effects model regressed on both Chinese and world FDI.

Coefficients for the impact of CFDI were positive and statistically significant across all models where it was included. This includes a significant positive effect in model 1 with a coefficient of 2.538 (p<0.01), a significant positive effect in model 2 with a coefficient of 1.415 (p<0.01), a significant positive effect in model 4 with a coefficient of 1.996 (p<0.01), and a positive but marginally significant in model 6 with a coefficient of 0.378 (p<0.1). The results suggest that CFDI is associated with increased fixed broadband penetration.

In contrast, coefficients for world FDI were less consistent. Significant results include weakly negative coefficient in models 4 and 6 with coefficients of -0.034 and -0.035 respectively (p<0.01). This seems to suggest that other forms of FDI might not have the same positive effect as CFDI.

The models show varying levels of explanatory power, with model (6) having the highest adjusted R-squared value (0.712), indicating a good fit when multiple controls and fixed effects are included. The F-statistics in the fixed effects models suggest that the overall models are highly significant.

Results indicate that CFDI does not uniformly affect mobile cellular subscriptions and fixed broadband subscriptions in the same way. The fact that the effects work in opposing directions suggest that there may be some substitution effect between the two. Counterintuitively, world FDI is associated with a negative impact in fixed broadband. CFDI may play a unique role in enhancing broadband infrastructure compared to an average transaction from the rest of the world. Similar to mobile, other factors such as GDP per capita and urbanization play significant roles in driving broadband penetration-FDI is by no means the sole determinant of a country's telecommunications penetration rate. Table 3 displays the full regression output.

	Dependent variable:					
	Fixed broadband subscriptions per 100 people					
	(1)	(2)	(3)	(4)	(5)	(6)
Chinese FDI	2.538***	1.415***			1.996***	$0.378^{*}$
	(0.237)	(0.199)			(0.406)	(0.221)
World FDI			0.002	-0.034***	-0.009	-0.035****
			(0.022)	(0.011)	(0.022)	(0.011)
MCS		-0.012		0.077***		0.084***
		(0.009)		(0.015)		(0.015)
GDP per capita		1.576*		6.145***		5.095***
		(0.825)		(0.970)		(1.001)
URBAN		1.264***		3.147***		3.178***
		(0.108)		(0.169)		(0.188)
DC		-0.007		-0.005		-0.017
		(0.008)		(0.011)		(0.011)
EGS		0.147***		-0.014		-0.014
		(0.021)		(0.024)		(0.024)
FDIGDP		-0.006		0.006		0.006
		(0.010)		(0.006)		(0.005)
FBS		1 1 ( 4		()		(
RRI		1.104				
		(5.039)				
Constant	16.177***		32.169***		31.866***	
	(1.951)		(1.394)		(1.555)	
Fixed effects	No	Yes	No	Yes	No	Yes
Random effects	Yes	No	Yes	No	Yes	No
Ν	940	792	295	285	252	242
$\mathbb{R}^2$	0.108	0.452	0.079	0.716	0.152	0.748
Adj. R <sup>2</sup>	0.107	0.408	0.076	0.679	0.145	0.712
F		75.408***		90.500***		78.211***
statistic	114.570***	(df = 8; 732)	0.005	(df = 7; 251)	24.123***	(df = 8; 211)
Note:	*p<0.1; **p<0.05; ***p<0.01					

Table 3: Regression results for fixed broadbandpenetration rates

The coefficients of FBS and MCS as control variables for their corresponding dependent variables also provide insights on whether or not cellular and broadband are substitutes or complements. For both dependent variables, models 4 and 6 indicate positive coefficients for the effect of broadband penetration on mobile and vice versa. Although this effect is not significant for all models, it does lend some confirmation for existing research on the direction of this effect. For example, Wulf et al. finds that this effect is complementary in OECD countries (2013). Quaglione et al. also find a complementary relationship using data from Italy (2020). Notably, these studies both looked specifically at OECD countries, which were also the primary observations of the world FDI dataset in this paper. However, the negative coefficients produced by model 2 were likely influenced by the inclusion of more observations outside of the OECD. Despite this coefficient not being significant, whether the relationship between fixed and mobile is complementary is likely heavily context dependent.

# Discussion

Early insights into this dataset suggest that CFDI uniquely affects telecommunications penetration rates compared to world FDI. This paper offers potential explanations for this effect.

The impact of FDI from different countries varies in a way that measuring the aggregate effect from world FDI leads to insignificant or weakly significant results. It is possible that the effectiveness of a particular FDI transaction is heavily dependent on its specific sender and recipient, technology transfers, and access to unique assets and key markets, such that measuring them this way leads to its impact being washed out. The telecommunications industry is diverse, widereaching and contains a large range of technologies beyond mobile cellular and fixed broadband services. Companies are increasingly branching out into industries like media, broadcasting, and even health care and agriculture solutions. Additional capital may be allocated towards projects that do not directly affect penetration rates, especially in markets that are already well connected and competitive.

FDI may be entering markets that are close to saturation and additional capital goes towards improving the quality of services provided rather than increasing access. This added capital may go towards upgrading infrastructure to support 5G networks or repairs and upkeep costs that do not necessarily lead to a rise in subscriptions. If not to improve quality or increase quantity, increases in investment may be necessary in mature and highly competitive markets to simply retain an operator's existing customer base. Even where access to services does increase, this typically occurs in rural and sparsely populated population areas, where increased penetration rates would be more apparent geographically but not in a subscription rate measured for every 100 people. This can lead to a scenario where an increase in investment leads to greater qualitative, rather than quantitative, changes. For example, this is somewhat reflected in measuring the Canadian government's effort towards expanding high-speed broadband coverage in rural areas. According to data from the Canadian Radio-television and Telecommunications Commission Facilities Survey and Statistics Canada 2021 census from 2017 to 2022, the percentage of homes and businesses in rural areas that have access to high-speed broadband coverage has increased from 37.2% to 67.4%. In contrast, fixed broadband subscriptions per 100 people saw relatively modest growth of roughly 4.1 subscriptions from 39.0 to 43.1.

As for why CFDI seems to have a more positive relationship with broadband over cellular, it is possible that these transactions place a strategic emphasis on broadband in recipient countries. Large urban population centres that tend to be more favourable investment opportunities also tend to favour broadband use. Internet intensive activities like education, data hosting, cloud services, overthe-top streaming, gaming all tend to be supported by broadband. In comparison, rural areas that rely on cellular networks are likely less favourable investment opportunities. This favourability may also be attributable to recipient country regulations that favour broadband investments over cellular. Future research would be necessary to review the transactions and analyze public data on where capital was allocated.

In recent years, fixed wireless access has become an increasingly efficient way to increase market penetration, accounting for nearly all of broadband subscription growth in the US market since mid-2022 (Wyrzykowski, 2024). Although its growth in fixed wireless adoption is categorized under fixed broadband, it employs 5G technologies and telecommunications equipment that mobile cellular operators like Huawei specialize in. To some extent, there may be some spillover in the ensuing analysis of mobile operators on the fixed broadband and wireless markets.

The market distortions present in the wireless industry as a result of interventions from the Chinese government may provide an explanation for this paper's estimates on the effect of CFDI. As depicted in Figures 4 through 6, Huawei and ZTE are the largest investors by a large margin of billions of USD. These two companies also made up almost 40% of the global market and 90% of China's domestic market for telecommunications equipment in 2021 (Pongratz, 2022). Although Huawei is a private company in name, the Chinese government is capable of interfering in Huawei's business decisions through regulatory frameworks outlined in China's Trade Union's Charter (European Commission, 2024). Similarly, ZTE is partially privately owned and describes itself as state-owned. The benefits that have been made available to Huawei and ZTE include below market lending, preferential tax treatment, grants, and as well as aggressive export financing to encourage international expansion (Balding, 2020). These highly favourable loans have been instrumental in the ability of Huawei and ZTE to undercut other firms abroad and win major contracts in other states. By 2021, Huawei had been responsible for the construction of 70% of Africa's 4G network. These market distortions may provide a partial explanation for the negative relationship present in mobile cellular penetration rates. Countries that award contracts to firms like Huawei and ZTE may not necessarily be achieving better value for their money. In some cases, they might be lower quality or less receiving effective infrastructure despite lower procurement and suggests This contract costs. that these arrangements may not provide the expected market

benefits or efficiencies, compared to other telecommunications operators.

This paper identifies two policy implications for jurisdictions interested in pursuing CFDI in telecommunications for the purposes of increasing penetration. Firstly, consider liberalizing FDI restrictions for cellular and broadband services at different levels. Some jurisdictions already do this, like Israel, Japan, the United States, China, Kazakhstan, Lebanon, Myanmar, Thailand, and Fixed wireless access somewhat Tunisia. complicates this separation, as many of its benefits come from the economies of scale that come with operating 5G networks. Mixed liberalization can come in numerous forms-different thresholds for national security review, different allowable levels of foreign ownership, and different definitions for sensitive sectors and foreign government investors. For example, the definition for foreign government investors can be expanded to include companies like Huawei that are nominally private and not substantially government owned, but receive significant government financing, has deep ties with the government and military, and serves to execute government foreign policy directives. Restrictions that only measure government ownership of a company would not capture this dynamic. Conversely, jurisdictions interested in specifically expanding fixed broadband FDI may consider selectively liberalizing restrictions that allow for greater CFDI.

Given that different sources of FDI are likely to have dynamic, context-dependent impacts on penetration rates, the second policy implication is that policy makers should design FDI restrictions with more discretion to allow for strategic choice in investments. Rather than creating hard limits through barriers like legislation, other barriers through FDI screening and approval burdens on investors can create comparable levels of FDI restriction while still attracting investors and competitiveness. increasing Discretionary measures will also allow for greater flexibility as economic relationships and telecommunications technologies evolve. In contrast, countries like

Canada that have their foreign ownership restrictions enshrined in legislation have to go through time-consuming political channels to amend these restrictions. FDI liberalization in combination with robust FDI review can help attract the desired types of CFDI, more competitive foreign entrants, and promote competitive bidding for contracts and spectrum licenses.

# **Limitations and Future Research**

There are numerous considerations to be made in interpreting the causal nature of CFDI. Although regression results can be helpful, there are limitations inherent within the dataset and the extent to which the results can be interpreted for practical policy. Firstly, the data on CFDI and world FDI do not come from the same source and have different methodologies for publishing, recording, and definitions for transactions. Their datasets include different, with only a minority of them overlapping. This means that the number of observations available to regressions that examine both Chinese and world FDI variables (models 5 and 6) are necessarily fewer and therefore have less explanatory power. For example, model 2 has 792 observations for analysis while model 6 only has 242. This is reflected in the adjusted R-squared scores for mobile of 0.588 and 0.051 respectively. Interestingly, the fully specified model 6 for broadband does not reflect this and boasts a higher adjusted R-squared score. The number of observations of world FDI available for analysis were also limited by confidential information that the OECD was not able to publish. These data restrictions often occurred in the middle of a series for multiple periods which made interpolation difficult, especially with so few observations for a country to begin with. This paper opted to input the average of the two adjacent observations only in cases where one value in a series between two observations relatively close in value was missing. Otherwise, the data was analyzed as is. This phenomenon also occurred at times for control variables, with many countries not yet having published the latest data for 2022. In these instances, the data was also left as is.

Another major difference is that the "China Global Investment Tracker" only tracks inflows of CFDI, while the OECD data will also record negative inflows from withdrawal or repatriation of funds. A satisfactory method or alternative data source to account for this could not be found at this time. Certain transactions included within the "China Global Investment Tracker" also raised they technically counted concerns. as as transactions related to telecommunications but would not have had a direct effect on the market. One example of this is the 210 million USD invested by Huawei from 2014 to 2018 in Canada to create its Canadian division, Huawei Canada. Huawei Canada does not provide mobile cellular or fixed broadband services and was banned from operating on Canadian telecommunications networks in 2022. Relying solely on author knowledge to go through all transactions could have introduced additional bias and was unrealistic given the number of transactions. Developing a way to systematically filter the data for transactions that directly affect penetration rates is an opportunity for future research.

If these data concerns were addressed, another opportunity for future research would be to introduce lagged variables for FDI. Large-scale FDI transactions may take years to take effect and are often subject to legal reviews that delay the availability of funds. Future research could also estimate the impact of the FDI of another major country like the United States. A comparison of China against the world may provide some value, but a comparison on a country-by-country basis would be more appropriate. The OECD publishes FDI data by sector and by counterpart area but does not publish the intersection of the two. Data on telecommunications FDI for each country's interaction with another is also not available.

# Conclusion

This research explores the distinct impacts of CFDI on telecommunications penetration rates, specifically on fixed broadband and mobile cellular subscriptions. The findings suggest that CFDI has a positive relationship with fixed broadband subscriptions and a negative relationship for mobile cellular subscriptions. These results reflect the complex and context-dependent nature of FDI impacts, suggesting that the source and strategic objectives of the FDI play a crucial role in determining its effectiveness.

The variability in the impact of CFDI compared to world FDI highlights the importance of considering the origin and nature of investment when formulating policy. While world FDI showed insignificant or weakly significant effects, the distinct outcomes of CFDI emphasize the need for targeted and strategic investment policies. This paper suggests that policy makers adopt a more discretionary approach to FDI regulation, enabling strategic choices that align with national objectives and market needs. CFDI has grown significantly in recent years and is on track to ramp up to pre-COVID-19 levels. In light of market distortions caused by interventions from the Chinese government, particularly through companies like Huawei and ZTE, discretionary treatment of CFDI would allow policy makers to better access the benefits of CFDI and mitigate its potential harms.

These findings are necessarily limited by the telecommunications industry's diversification into other industries, indicating that FDI may not always directly influence traditional penetration rates. Instead, investments may contribute to service quality, technological advancement, and overall infrastructure without increasing market penetration. Policy makers ought to consider both qualitative and quantitative outcomes when assessing the impact of FDI.

Overall, this research contributes to the scholarly conversation by quantitatively estimating how different sources of FDI influence telecommunications development. Future research should aim to address data limitations, explore the long-term effects of FDI, and consider the impact of other major investing countries to provide a more comprehensive understanding of FDI dynamics in the telecommunications sector.

### References

American Enterprise Institute for Public Policy Research. (n.d.). China Global Investment Tracker. Retrieved from China Global Investment Tracker: <u>https://www.aei.org/china-global-investment-tracker/</u>

Arnold, S. (2024). African agency in ICT infrastructure provider choice: Navigating access to foreign finance and technology. *Telecommunications Policy*, 102713.

Australian Government. (2022, January 14). Australia's foreign investment policy. Retrieved from <u>https://foreigninvestment.gov.au/sites/firb.gov.</u> <u>au/files/2022-</u> <u>01/Australias\_Foreign\_Investment\_Policy-</u> <u>20220114.pdf</u>

Balding, C. (2020). Financing 5G Rollout in the Face of Nation State Security Threats and Non-Market Subsidies: Policy Options for States to Address Cost Concerns. *Available at SSRN* 3537463.

European Commission. (2024, April 10). Commission staff working document on significant distortions in the economy of the People's Republic of China for the purposes of trade defence investigations (SWD(2024) 91 final). *Brussels: Author*. Retrieved from https://policy.trade.ec.europa.eu/news/commiss ion-updates-report-state-induced-distortionschinas-economy-2024-04-10\_en

Ho, C. Y., Narins, T. P., & Sung, W. (2023).
Developing information and communication technology with the belt and road initiative and the digital silk road. *Telecommunications Policy*, *47*(10), 102672.

Innovation, Science and Economic Development Canada. (2022, May). Policy statement: Securing Canada's telecommunications system. Retrieved from <u>https://www.canada.ca/en/innovation-science-</u> acconomic\_daualopment/pows/2022/05/policy

economic-development/news/2022/05/policystatement--securing-canadastelecommunications-system.html

Izuchukwu, O. O. (2011). Relationship between FDI and telecommunication growth in Nigeria. In *Proceedings of the 7th International Conference on Innovation & Management* (Vol. 1892).

Lestage, R., Flacher, D., Kim, Y., Kim, J., & Kim, Y. (2013). Competition and investment in telecommunications: Does competition have the same impact on investment by private and state-owned firms?. Information Economics and Policy, 25(1), 41-50.

Lin, C. H. (2008). Role of foreign direct investment in telecommunication industries: a developing countries' perspective. *Contemporary Management Research*, 4(1).

Mahajan, D. (2014). Telecommunication Sector and Foreign Direct Investment: An Indian Perspective. *Journal of Commerce and Trade*, 9(2), 77-87.

Meidayati, A. W. (2017). Impact of telecommunication infrastructure, market size, trade openness and labor force on foreign direct investment in ASEAN. *Journal of Developing Economies*, 2(2), 76-86.

OECD (2024), FDI restrictiveness (indicator).

doi:10.1787/c176b7fa-en (Accessed on 24 May 2024)

- Pongratz, S. (2022). Key takeaways 2021 total telecom equipment market. Dell'Oro Group; available at: <u>https://www.delloro.com/key-</u> <u>takeaways-2021-total-telecom-equipment-</u> <u>market/</u> (accessed on 8 June 2024)
- Quaglione, D., Matteucci, N., Furia, D., Marra, A., & Pozzi, C. (2020). Are mobile and fixed broadband substitutes or complements? New empirical evidence from Italy and implications for the digital divide policies. *Socio-Economic Planning Sciences*, *71*, 100823.

Shah, M. H., & Khan, F. (2019).

Telecommunication infrastructure development and FDI into Asian developing nations. *Shah*, *MH*, & *Khan*, *F*.(2019). *Telecommunication Infrastructure Development and FDI into Asian Developing Nations. Journal of Business and Tourism*, 5(1), 91-102.

- Shen, H. (2018). Building a digital silk road? Situating the internet in China's belt and road initiative. *International Journal of Communication*, 12, 19.
- Sidak, J. G. (2008). Foreign investment in American telecommunications. *University of Chicago Press.*
- Sun, Q., Zhang, X., Xu, X., Yang, Q., & Wang, S. (2019). Does the "belt and road initiative" promote the economic growth of participating countries?. *Sustainability*, 11(19), 5240.

Tiong, K. M., Cheng, M. Y., & Choong, C. K.

(2022). The roles of ICT telecommunication infrastructure on foreign direct investment in Malaysia. *Asian Academy of Management Journal*, 27(2).

- Wang, C., Lim, M. K., Zhang, X., Zhao, L., & Lee, P. T. W. (2020). Railway and road infrastructure in the Belt and Road Initiative countries: Estimating the impact of transport infrastructure on economic growth. *Transportation Research Part A: Policy and Practice*, 134, 288-307.
- Wulf, J., Zelt, S., & Brenner, W. (2013, January).
  Fixed and mobile broadband substitution in the OECD Countries--A quantitative analysis of competitive effects. In 2013 46th Hawaii International Conference on System Sciences (pp. 1454-1463). IEEE.
- Wyrzykowski, R. (2024, June 6). 5G fixed wireless access (FWA) success in the US: A roadmap for broadband success elsewhere. *OpenSignal*. <u>https://www.opensignal.com/2024/06/06/5g-</u> <u>fixed-wireless-access-fwa-success-in-the-us-a-</u> <u>roadmap-for-broadband-success-elsewhere</u>