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AI export and digital silk road: a comparative analysis of China's influences on digital economies and geopolitics across Southeast Asia

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Introduction: There is a lack of original research investigating the relationships between China's artificial intelligence (AI) exports and their possible impacts on strengthening Digital Silk Road (DSR) co-operation. This paper addresses this gap by studying the distribution of China's AI export projects to Southeast Asian countries and examining whether larger Southeast Asian AI importers were more active DSR partners.

Methods: The analysis employs a robust panel data methodology incorporating lagged explanatory variables and clustered standard errors to mitigate issues of heteroscedasticity and auto-correlation. Data for China's AI export projects were drawn from the China's AI Exports Database (CAIED) for the period 2006–2017, while DSR partner activity (2018–2020) and economic variables were sourced from the IISS China Connects and the World Bank Open Data, respectively.

Results: Findings suggest that Southeast Asian countries importing AI technologies from China between 2006 and 2017 had not been statistically more DSR active between 2018 and 2020. Instead, the analysis reveals a positive and highly significant impact of country-level economic freedom as a contributing factor to being an active DSR partner.

Discussion: This study enhances transparency in the dynamics of China's digital geopolitics by highlighting economic competitiveness as the primary driver of DSR partnerships, rather than prior AI import history. This suggests DSR engagement is driven more by intrinsic economic factors than by direct technological pre-conditioning through Chinese AI exports.

KEYWORDS

belt-and-road initiative, digital silk road initiative, China, digital economy, digital geopolitics

Overview

China's Belt and Road Initiative (BRI), launched in 2013, aims to foster development and investment partnerships across Asia, Europe, Africa, Oceania, and Latin America. This global initiative has facilitated China's expansion of economic and political influence (McBride et al., 2023). In Southeast Asia, China has emerged as a dominant investor, signing infrastructure deals worth billions annually (Dayant and Stanhope, 2024). A core dimension for China to build global connectivity is through trade. China's supply chain connectivity has risen across BRI regions, with Southeast Asian countries (both richer and poorer economies) remaining the most connected (LSE Ideas, 2018). Within the region, Singapore, Vietnam, Thailand, Malaysia, Cambodia, and Myanmar are ranked among the world's most connected economies to China via trade (LSE Ideas, 2018).

Since BRI partnerships between the two parties are extensively researched and addressed in existing scholarship, this paper will instead examine the Digital Silk Road (DSR) relationships between China and Southeast Asia. The DSR, first officially mentioned in China's *13th Five-Year Plan (2016–20)*, has become a key pillar of the BRI. In recent years, given the intensified United States-China technological and artificial intelligence (AI) rivalry, expanding the DSR's influence on Southeast Asian markets has become crucial for China (Zheng, 2024). China's DSR prioritisation as a national strategy is shaped by two factors. The push factor is the rapid growth of China's digital economy in recent years. The pull factor is China's perception of the digital gap in many developing countries, including Southeast Asian countries, which restricts their digital economy growth (Zheng, 2024). Since the 2008 global financial crisis, China has actively intensified its efforts to build its technological dominance, especially in the development and application of AI technology (Chung, 2023).

Although the popularisation of AI technology has surged since the launch of ChatGPT in 2022, China's AI Exports Database (CAIED) indicates that China has strategically been delivering AI export projects globally since decades ago. Existing scholarship covers the analysis of China's DSR partnerships with Southeast Asian countries. However, there is a lack, if not an absence, of original research investigating whether China's global strategy of AI exports has impacted DSR partnerships across Southeast Asia. If not, it is scholarly important to identify the key driver(s) that have impacted DSR partnerships with Southeast Asian countries. This paper will assess whether larger AI importers from China are more active DSR players. If not, it will explore what factor(s) determine how active Southeast Asian countries are as DSR partners. Such an investigation helps enrich the global dialogue and enhance transparency in the dynamics of China's AI exports and DSR cooperation.

Literature review

Despite the 'debt trap' conspiracy criticisms (McBride et al., 2023), many Southeast Asian countries, such as Indonesia and Thailand, have welcomed BRI, including DSR, partnership opportunities (Busbarat et al., 2023; Yu, 2017). From an economic standpoint, Chinese investments have the potential to bolster Southeast Asia's economic growth and regional connectivity. However, there have been concerns across Southeast Asia that countries heavily dependent on Chinese investment may face long-term risks to their own economies due to rising debts and to their societies owing to geopolitical interventions (Busbarat et al., 2023). Additionally, racial tensions and safety issues have compounded the criticisms against Southeast Asian governments that are overly economically dependent on China (Busbarat et al., 2023; Dayant and Stanhope, 2024). Therefore, this paper would like to study today's dynamics of DSR partnerships between China and Southeast Asian countries, in order to present which Southeast Asian countries are more or less willing to form digital trade ties with China.

Existing scholarship suggests that the Philippines is a Southeast Asian country who maintains negative BRI relationships with China, as of writing this paper. During the administration of President Rodrigo Duterte, the Philippines was more willing to form BRI cooperation with China. However, when President Bongbong Marcos took office in 2022, several early-stage infrastructure development projects funded by China were cancelled (Busbarat et al., 2023). Philippine elite and public sentiment have hardened towards the Chinese Government in recent years. Other Southeast Asian countries are more ambiguous, or even divided, in their stance towards the Chinese Government. Southeast Asian elites from countries such as Singapore and Indonesia prefer maintaining robust economic and security ties with major international players to offset China's dominance in the region (Feigenbaum et al., 2024). As this paper focuses on evaluating DSR instead of BRI relationships between China and Southeast Asia, it would be interesting to investigate whether the Philippines has cut DSR ties with China. Also, it would be interesting to understand the attitudes of other leading regional players, such as Singapore and Indonesia, regarding the formation of DSR partnerships with China.

The pandemic boosted digital economies worldwide, facilitating Southeast Asia to offer investment opportunities in e-commerce logistics and digital financial services to circumvent restrictions on personal mobility and in-person meetings between 2020 and early 2023. Here, regionally advanced economies such as Singapore, Malaysia, Thailand, and Indonesia have developed more competitive technological adoption environments (Chung, 2023). In such circumstances, Southeast Asian countries will continue to build and expand their digital economies in the long term. Investigating China-Southeast Asia relations through DSR partnerships is a timely and academically important topic. Understanding how active a Southeast Asian country is as a DSR player indicates its digital capacity, connectivity, and competitiveness. Such digital competence, to some degree, reflects the country's economic strength. This paper will discuss the nuances in digital geopolitics and economics to add transparency to the discourse on the strategic plans of China's technological and AI investment.

Methodology

As highlighted, this paper aims to study whether larger Southeast Asian AI importers from China are more active players in the DSR. If not, this paper aims to explore the major factor(s) that determine how active Southeast Asian countries are as DSR partners. To satisfy these research aims, I need access to databases covering details about China's AI exports and DSR projects. I therefore analyse secondary data from multiple databases: the China's AI Exports Database (CAIED) and the IISS China Connects. I further collect data from the World Bank Open Data.

The CAIED database is run by the RAND Corporation, while the IISS China Connects database is operated by the International Institute for Strategic Studies. The CAIED tracks Chinese government-supported development finance projects that utilised or enabled AI technology in the Global South between 2000 and 2017. Using the latest data mining tools, the CAIED identified a total of 155 AI export projects from China. The CAIED records all AI or AI enabling projects imported across the globe from China, between 2000 and 2017. However, according to the CAIED's tracked data, Chinese government-supported development finance projects that utilised or enabled AI technology in Southeast Asia had been implemented between 2006 and 2017. Here AI projects included all technology-facilitated trades that required AI processing or were AI-powered. AI-enabling projects were, however, much broader. They referred to projects where AI acted as a catalyst to transform different sectors, such as building and delivering technological services (e.g., setting up CCTV network) to create a continuous stream of visual data essential for training AI algorithms—laying the groundwork for future AI integration.

Alternatively, the IISS China Connects database is a virtual interactive tool that visualises independently researched and verified datasets on China's BRI and DSR projects planned, implemented, or completed between 2000 and 2020/2021 (2021 for BRI projects and 2020 for DSR projects). I will use the CAIED to summarise how many AI projects had been imported by each Southeast Asian country from China until 2017. In doing so, I can analyse how active each Southeast Asian country had been as an AI importer from China. Then, I will use the IISS China Connects to summarise how many DSR projects had been planned, implemented, or completed between 2018 and 2020 by each Southeast Asian country. Through this approach, I am able to make data-driven evaluation on whether Southeast Asian countries importing more AI technologies from China until 2017 had formed tighter DSR partnerships with China between 2018 and 2020.

Moreover, since this paper focuses on examining the DSR relationships between China and Southeast Asia, it is scholarly relevant to evaluate the digital capacity of all Southeast Asian countries. The broader digital capacity a Southeast Asian country has, the better digital adoption environment that country can offer and possibly the more DSR projects the country can form. Here, I measure digital capacity based on the World Bank Open Data of (1) mobile cellular subscriptions (per 100 people) and (2) individuals using the Internet (% of the population) using 2018–2020 data. I partly decide to measure digital connectivity by the proxy of mobile cellular subscriptions (per 100 people) because mobile phones instead of landline phones and computers have become more important as daily necessities. Measuring mobile cellular subscriptions in any given country per 100 people is a preferrable methodological design because Southeast Asian countries have drastic differences in population sizes, so measuring and comparing the actual annual numbers of mobile cellular subscriptions between countries is not informative and indicative.

It is equally important to evaluate the economic capacity of all Southeast Asian countries. The broader economic capacity a Southeast Asian country has, the more favourable a digital adoption environment it can offer, and the closer digital trade ties it can form. Here, I measure economic capacity based on Southeast Asia's economic competitiveness, assessed by (3) the real GDP per capita (constant 2015 US$) from the World Bank Open Data and (4) the Index of Economic Freedom scores using 2018–2020 data. I was considering whether I should choose the IMD World Competitiveness Ranking scores, Global Innovation Index scores or Index of Economic Freedom scores as one of the proxies for economic competitiveness. Initially, I believe the Global Innovation Index, which measures countries' innovative capability in knowledge, technology and creative outputs would be ideal to help capture economic capacity. However, the Global Innovation Index has missing data for Laos and Myanmar in the 2018 and 2019 data. Alternatively, while the IMD World Competitiveness Ranking measures how competitive an economy is based on government efficiency, business efficiency, and infrastructure, I find this metric calculates both institutional and economic capacity of any given country which may fail to solely reflect country-level economic competitiveness. Therefore, I decide to use the Index of Economic Freedom, which measures policy environment for business such as trade freedom and fiscal health of any country. Compared to the IMD World Competitiveness Ranking, the Index of Economic Freedom metric is partially but relatively less reliant on institutional aspects to measure economic competitiveness. Therefore, in this research paper, I use both real GDP per capita (constant 2015 US$) and the Index of Economic Freedom scores as proxies to measure Southeast Asian countries' economic competitiveness.

In time-series or panel data, if the variables are non-stationary (i.e., contain trends), regressions can sometimes give false relationships known as spurious regressions. However, since my panel data is short (T = 3; years: 2018, 2019, 2020), I cannot meaningfully run robust panel unit root tests because these methods require longer time spans. However, any potential spurious regression concerns should be minimised given my methodological design. First, I build additional robustness check by re-running regressions using lagged explanatory values and clustered standard errors at the country level (in Table 1) to show that my empirical results are not an artifact of autocorrelation. Autocorrelation tells us that, in panel or time-series data, values today are often correlated with values yesterday. Therefore, in Tables 1, I regress DSR projects in 2019 and 2020 on digital connectivity and economic competitiveness proxies using 2018 and 2019 data, respectively. Such an approach helps avoid running spurious regressions with false significance. Second, and more importantly, I strategically use proxies for digital connectivity and economic competitiveness that are plausibly stationary (or nearly stationary). For example, I use real GDP per capita (constant 2015 US$) which is less trending than aggregate national GDP. Also, I use mobile

TABLE 1 Regression results from fixed-effects and random-effects models (lagged explanatory variables, clustered standard errors).

Variable	Fixed-effects model		Random-effects model	
	Coefficient	Standard error	Coefficient	Standard error
AI_export_i	/	/	−1.40	1.99
$mobile_{i,t-1}$	−0.01	0.06	0.00	0.02
$Internet_{i,t-1}$	−0.56	0.27	−0.07	0.04
$real\_GDP\_per\_capita_{i,t-1}$	−0.01	0.00	−0.00	0.00
$IEF_{i,t-1}$	1.75	0.90	0.28***	0.08
constant	−8.21	43.67	−9.66*	4.20
N	19		19	
F-statistic/ Wald χ^2	6.79 (df: 4,9)		27.76 (df: 5)	
P-value	0.0084		0.0000	
Sargan-Hansen C-statistic	χ^2 (4) = 13.08	p = 0.05		

***, **, * denotes significance at the 0.1, 1, and 5% level, respectively.

cellular subscriptions (per 100 people) instead of the nominal total subscriptions as an independent variable, use individuals using the Internet (% of population), and use index scores from the Index of Economic Freedom. These mean my independent variables are either in percentages and index, which are far less problematic for stationarity.

It is acknowledged that the fixed-effects model, which relies only on within-country variation, inherently cannot estimate the coefficient for the time-invariant AI_export_i variable. While advanced techniques like the between estimator or a two-stage process could potentially recover this estimate, the random-effects model was preferred for both the main analysis (Table 2) and the robustness check (Table 1). This is because the random-effects model allows for the simultaneous estimation of all time-variant and time-invariant variables, directly addressing the core research question of this paper regarding the influence of AI_export_i on DSR activity.

Moreover, as mentioned, the IISS China Connects database shares all BRI and DSR projects planned, implemented, or completed between 2000 and 2020/2021. However, the BRI and DSR were introduced in 2013 and 2015, respectively. Some may question why the IISS China Connects database contains details about BRI and DSR projects from the 2000s while these initiatives were launched in the 2010s. It is noteworthy that the IISS China Connects database consists of officially labelled BRI and DSR projects. These are infrastructure and digital connectivity projects that the Chinese Government, ministerial agencies, or state media have recognised as falling under the broader BRI and DSR enterprises launched in 2013 and 2015, respectively. Yet, the database further includes infrastructure projects that were not officially labelled as part of the BRI or DSR. These include projects initiated in the 2000s or early 2010s that did not receive explicit endorsement from the Chinese Government. These are known as “BRI-like” or “DSR-like” projects and are included in the IISS China Connects database (IISS China Connects, 2025).

Findings

According to the CAIED, 155 China’s AI-export projects were identified in 64 countries, classified as either AI applications or AI infrastructure (i.e., critical infrastructure for AI applications, or as a tool that enabled AI applications to be adapted in the future) (Bouey et al., 2023). Upon directly searching for country reports on the CAIED, as Table 3 summarises, three Southeast Asian countries received Chinese government-supported development finance projects that utilised or enabled AI technology between 2006 and 2017. These countries were Cambodia, Indonesia, and Laos. In Cambodia, in 2014, the Chinese Government granted RMB 20 million (i.e., US$2.76 million) to Cambodia’s Ministry of Public Security for a closed-circuit television (CCTV) Surveillance Project. Also, in 2015, China delivered 200 ultrasound medical equipment units to the Cambodian Government.

In Indonesia, in 2011, the Chinese Government provided a US$5.3 million grant for the Establishment and Operation of the Indonesia Maritime Surveillance Satellite System. In 2014, China signed an agreement to send remote sensing data to Indonesian remote sensing satellite ground stations to help the country update the stations and improve its maritime law enforcement and disaster prevention mitigation. In 2015, in partnership with China’s Huawei, Indonesia revealed the ‘Safe City’ model site in Bandung. The model site includes monitoring points, transmission networks, data platforms, resource management systems, broadband clusters, and emergency command centres.

In Laos, in 2006, the China-Laos preferential loan framework agreement for Phase 1 of the National E-Government Project was signed. In the following year, China Eximbank and the Lao Government signed an RMB 280 million (i.e., US$38.7 million) government concessional loan agreement for Phase 1 of the National E-Government Project. In 2012, Huawei donated a cloud computing laboratory to the National University of Laos in Vientiane. During the same donation ceremony, China also donated an electric car to the university. Then, in 2017, the Chinese Government signed the National Seismic Monitoring Network Project and Earthquake Data Centre Project.

I extract relevant data from the CAIED, IISS China Connects and World Bank Open Data databases and from the Index of Economic Freedom ranking and transport them into a newly created panel dataset on STATA 18.2. The panel dataset contains observations from

TABLE 2 Regression results from fixed-effects and random-effects models (and Hausman test).

Variable	Fixed-effects model		Random-effects model	
	Coefficient	Standard error	Coefficient	Standard error
AI_export_i	/	/	0.62	0.46
$mobile_{i,t}$	0.09	0.04	0.05***	0.01
$Internet_{i,t}$	−0.14	0.09	−0.03*	0.01
$real\_GDP\_per\_capita_{i,t}$	0.00	0.00	−0.00***	0.00
$IEF_{i,t}$	0.75	0.41	0.21***	0.02
constant	−56.51	24.72	−13.59***	1.47
N	29		29	
F-statistic/ Wald χ^2	2.59 (df: 4,9)		265.27 (df: 5)	
P-value	0.1083		0.0000	
Hausman Test	χ^2 (4) = 2.13	p = 0.71		

Heteroscedasticity-Robust Standard Errors were used via vce (robust) in estimation. The Hausman test was performed using the standard command to justify the model choice (p = 0.71). ***, **, * denotes significance at the 0.1, 1, and 5% level, respectively.

TABLE 3 AI import countries in Southeast Asia.

Countries	AI projects/descriptions
Cambodia	Donation of Ultrasound Medical Equipment
	On June 15, 2015, China delivered 200 ultrasound medical equipment to the Cambodian Government.
	CCTV Surveillance Project
	On August 13, 2014, the Chinese Government granted RMB 20 million to Cambodia's Ministry of Public Security for a CCTV Surveillance Project.
Indonesia	Safe City Model Site Project
	Partnered with China's Huawei, Indonesia's first 'Safe City' model site was deployed in the main venue and surrounding areas of the event. The model site includes monitoring points, transmission networks, data platforms, resource management systems, broadband clusters, and emergency command centres. On April 11, 2015, the 'Safe City' model site in Bandung was unveiled.
	Maritime Surveillance Satellite System Project
	In 2011, the Chinese Government provided a US$5.3 million grant for the Establishment and Operation of the Indonesia Maritime Surveillance Satellite System.
	Remote Sensing Data for Maritime Security Project
	On 6 October 2014, China signed an agreement to send remote sensing data to Indonesia remote sensing satellite ground stations to help the country update the stations and improve its maritime law enforcement and disaster prevention mitigation.
Laos	Donation of Cloud Computing Laboratory
	On November 30, 2012, Huawei donated a cloud computing laboratory to the National University of Laos in Vientiane. During the same donation ceremony, China also donated an electric car to the university.
	Phase 1 of National E-Government Project
	On November 20, 2006, the Chinese Government and Lao Government signed a preferential loan framework agreement for Phase 1 of the National E-Government Project. Then, in 2007, China Eximbank and the Lao Government signed an RMB 280 million government concessional loan agreement for Phase 1 of the National E-Government Project. On September 18, 2008, the Chinese Government and Lao Government signed an RMB 546 million preferential loan framework agreement for Phase 2 of the National E-Government Project. However, it is unclear if and when an actual loan agreement for Phase 2 was finalised. This issue merits further investigation.
	National Seismic Monitoring Network Project and Earthquake Data Centre Project
	On Aug 11, 2017, the Chinese Government signed the National Seismic Monitoring Network Project and Earthquake Data Centre Project. After the project is completed, Laos will have the ability to report earthquakes of magnitude 3.0 or above in most parts of the country, effectively improve the seismic monitoring capacity of Laos, improve the level of public service of the Lao Government, and provide a strong guarantee for Laos' economic and social development.

Source: RAND. Had the countries been the beneficiaries of Chinese Government-supported development finance projects that utilized or enabled AI technology between 2006 and 2017?

the same units (i.e., countries) over multiple time periods (i.e., years). Table 4 shows the description of variable definitions and sources. Here I aim to build linear regression models (without and with using lagged explanatory variables) for panel data to examine the average effect of (1) AI export from China, (2) mobile cellular subscriptions (per 100 people) and (3) individuals using the Internet (% of the population), (4) real GDP per capita (constant 2015 US$), (5) the Index of Economic Freedom scores on DSR activities across all involved Southeast Asian countries. Appendix lists out all the relevant variables of the panel dataset. We can see that country and AI export from China are time-invariant variables. Here country refers to the 10 Southeast Asian countries. AI export from China (i.e., the variable AI_export_i) means whether each country had any AI import trade from China between 2006 and 2017 (1 = yes; 0 = no). The variable $DSR_{i,t}$ refers to the number of planned, implemented, or completed DSR projects a Southeast Asian country undertook in any given year, between 2018 and 2020. The variables $mobile_{i,t}$, $Internet_{i,t}$, $real\_GDP\_per\_capita_{i,t}$ and $IEF_{i,t}$ refer to mobile cellular subscriptions (per 100 people), individuals using the Internet (% of the population), real GDP per capita (constant 2015 US$) and the Index of Economic Freedom scores, respectively.

Before building linear regression models for panel data, I would need to examine whether there is any collinearity issue among the independent variables. Table 5 shows the variance inflation factor (VIF) values of all independent variables that are used for building linear regression models for panel data. The VIF values in the panel dataset indicate that there is no significant multicollinearity among the independent variables, as all values are between 1 and 5. The VIF value tells us how much the variance of an estimated regression coefficient is inflated due to its linear relationship with the other independent variables. A VIF value of 1 means there is no correlation between that variable and the others; and a VIF value that is lower than 5 poses no concern.

Once I run the VIF test, there is no meaningful need to conduct the Spearman rank correlations. However, I decide to develop and present Table 6 as an additional source that indicates no concerning multicolliearnity issue is detected. Table 6 shows that correlations between AI export from China and all other independent variables that are used for regression analysis (in Tables 2, 1). We can see that many variables are moderately to strongly correlated to one another at a statistical significance ($p < 0.05$) level. While the correlations between

TABLE 4 Description of variable definitions and sources.

Variable	Description	Source
$Country_i$	Southeast Asian country name (Group Identifier)	By author
$Year_t$	Year of data collection (Time Identifier)	By author
$DSR_{i,t}$	How many DSR projects were planned, implemented, or completed by any given Southeast Asian country in any given year? (Dependent Variable)	IISS China Connects
AI_export_i	How many AI or AI-enabling projects were imported from China by any given Southeast Asian country in any given year? (Time-Invariant Explanatory Variable)	CAIED
$mobile_{i,t}$	What was the number of mobile cellular subscriptions (per 100 people) in any given Southeast Asian country in any given year?	World Bank Open Data
$Internet_{i,t}$	How many individuals were using the Internet (as % of population) in any given Southeast Asian country in any given year?	World Bank Open Data
$real\_GDP\_per\_capita_{i,t}$	What was the real GDP per capita (constant 2015 US$) in any given Southeast Asian country in any given year?	World Bank Open Data
$IEF_{i,t}$	What was the Index of Economic Freedom score in any given Southeast Asian country in any given year?	Index of Economic Freedom

TABLE 5 Variance inflation factor (VIF).

Variable	VIF	1/VIF
AI_export_i	2.11	0.47
$mobile_{i,t}$	1.99	0.50
$Internet_{i,t}$	2.35	0.43
$real\_GDP\_per\_capita_{i,t}$	3.68	0.27
$IEF_{i,t}$	3.62	0.28
Mean VIF	2.75	

$real\_GDP\_per\_capita_{i,t}$ and $IEF_{i,t}$ and between $Internet_{i,t}$ and $real\_GDP\_per\_capita_{i,t}$ are both positively strong, the VIF test results (in Table 5) already assures that no multicollinearity issues need to be addressed.

When building linear regression models for panel data, I use $DSR_{i,t}$ as the dependent variable and AI_export_i, $mobile_{i,t}$, $Internet_{i,t}$,

TABLE 6 Spearman rank correlation table between AI export from China (2006–17) and other variables.

Variable	AI_export_i	$mobile_{i,t}$	$Internet_{i,t}$	$real\_GDP\_per\_capita_{i,t}$	$IEF_{i,t}$
AI_export_i	1.0000				
$mobile_{i,t}$	−0.6177***	1.0000			
$Internet_{i,t}$	−0.4612*	0.2725	1.0000		
$real\_GDP\_per\_capita_{i,t}$	−0.4160*	0.3197	0.7965***	1.0000	
$IEF_{i,t}$	−0.3068	0.3449	0.6293***	0.8684***	1.0000
N (29)					

***, **, *significance at the 0.1, 1, and 5% level, respectively.

$real\_GDP\_per\_capita_{i,t}$ and $IEF_{i,t}$ as the independent variables. Here are the regression equations and assumptions for fixed-effects and random-effects:

Fixed-effects model

The fixed-effects model absorbs all time-invariant, country-specific differences (α_i) into the intercept, effectively estimating only the within-country variation. Since the variable AI_export_i is time-invariant for each country, it is excluded from the fixed-effects estimation.

$$DSR_{it} = \beta_0 + \beta_2\ mobile_{it} + \beta_3\ Internet_{it} + \beta_4 real\_GDP\_per\_capita_{it} + \beta_5\ IEF_{it} + \alpha_i + \epsilon_{it}$$

i α_i: Represents the unobserved time-invariant country-specific effects (group fixed effects).

ii ϵ_{it}: The idiosyncratic error term, assumed to be independent across observations but heteroscedastic (i.e., not identically distributed): $E[\epsilon_{it}|X_{it}, \alpha_i] = 0$ and $Var(\epsilon_{it}) = \sigma_{it}^2$. The heteroscedasticity-robust standard errors are used to provide valid inference despite this non-constant variance.

Random-effects model

The random-effects model assumes the country-specific effects (α_i) are random and uncorrelated with the independent variables, allowing for estimation using both within- and between-country variation.

$$DSR_{it} = \beta_0 + \beta_1\ AI\_export_i + \beta_2\ mobile_{it} + \beta_3\ Internet_{it} + \beta_4\ real\_GDP\_per\_capita_{it} + \beta_5\ IEF_{it} + (\alpha_i + \epsilon_{it})$$

i $u_{it} = \alpha_i + \epsilon_{it}$: The composite error term.

ii α_i: Represents the unobserved time-invariant country-specific effects, modelled as random and assumed to be uncorrelated with X_{it}.

iii ϵ_{it}: *The idiosyncratic error term, assumed to be independent across observations but potentially heteroscedastic. The heteroscedasticity-robust standard errors are used to provide valid inference for this model.*

I then run the Hausman test. The Hausman test is formally conducted to assess the suitability of the random-effects model. The null hypothesis (H_0) of this test states that the unique errors are uncorrelated with the regressors, implying that both the fixed-effects and random-effects estimators are consistent. Since the resulting p-value of 0.71 is substantially greater than the conventional 0.05 threshold, we fail to reject the null hypothesis, confirming the random-effects model as the preferred and most efficient estimator for this primary analysis. Unlike the fixed-effects model, the random-effects model focuses on both within- and between-country variation. The fixed-effects model, however, removes anything that is constant within a group (i.e., within a country). Table 2 shows the empirical outputs of the fixed-effect model, random-effects model and Hausman test. From Table 2, it is conventionally statistically significant (i.e., $p < 0.001$) to argue that for every unit increase in mobile cellular subscriptions (per 100 people), there is 0.05 unit increase in DSR partnerships between Southeast Asian countries and China. Also, it is statistically significant (i.e., $p < 0.05$) to argue that for every unit increase in the use of Internet (as % of population), there is 0.03 unit decrease in DSR partnerships. Moreover, it is statistically significant (i.e., $p < 0.001$) to argue that for every unit increase in the Index of Economic Freedom score, there is 0.21 unit increase in DSR partnerships between Southeast Asian countries and China. It is noteworthy that this research paper addresses associations but not causal relationships.

Conducting this study by solely relying on the empirical results from one single regression model (Table 2) fails to assure the robustness of my research. Therefore, I take autocorrelation into account by building an additional, advanced regression model with lagged explanatory variables and clustered standard errors. I have to build clustered standard errors at the country level in order to give my empirical results (in Table 1) against heteroskedasticity and autocorrelation inside each country's short time series. This helps avoid any spurious significance. To choose between fixed-effects and random-effects estimators, I conduct a Sargan-Hansen test.

Despite efforts to conduct a robust Hausman test using the recommended *rhausman* STATA routine, the procedure could not be completed. The failure was computational, arising from the small, severely unbalanced structure of the panel dataset (19 total observations across 10 groups, with a high proportion of doubletons). Calculating a consistent p-value for the clustered standard errors requires a cluster bootstrap. The repeated resampling of these small groups consistently led to estimation samples with insufficient degrees of freedom and within-group variation, preventing the fixed-effects model from being computed in numerous iterations and generating a "no observations" error.

To overcome this constraint and obtain a statistically sound test of model specification, we adopted the Sargan-Hansen C-statistic, implemented via the community-contributed *xtoverid* routine, as the robust alternative. This approach is superior to the standard Hausman test as it remains consistent when employing clustered standard errors. The test assesses the validity of the random-effects model's central assumption—that the unobserved country-specific effects are uncorrelated with the regressors—by evaluating a set of overidentifying restrictions, thereby providing a reliable basis for model choice.

The application of the Sargan-Hansen C-statistic to the final random-effects estimation yielded a test statistic of 13.079 with four degrees of freedom, resulting in a p-value of 0.0509. Since this value is above the conventional 0.05 significance threshold, we are not statistically confident to reject the null hypothesis—that the random-effects estimator is consistent and efficient. This robust evidence confirms that the random-effects assumption is held, compelling its selection as the preferred and consistent estimator for the final interpretation of the lagged variables in Table 1.

Once we confirm that the random-effects model should be used for data analysis, I develop Table 1 that shows the fixed-effects model and random-effects model with lagged explanatory variables and clustered standard errors at the country level. It is statistically significant (i.e., $p < 0.05$) to argue that for every unit increase in the Index of Economic Freedom score, there is 0.28 unit increase in DSR partnerships between Southeast Asian countries and China (Table 1). Below is the regression equation and assumptions for random-effects with lagged explanatory variables and clustered standard errors:

Random-effects model (with lagged explanatory variables and clustered standard errors)

$$\mathrm{DSR_{it}} = \beta_0 + \beta_1 \ \mathrm{AI\_exporti} + \beta_2 \ \mathrm{mobilei, t-1} + \beta_3 \ \mathrm{Interneti, t-1} + \beta_4 \ \mathrm{real\_GDP\_per\_capitai, t-1} + \beta_5 \ \mathrm{IEFi, t-1} + (\alpha i + \epsilon it)$$

iv *AI_exporti*: The *AI_exporti* variable is time-invariant and does not need to be lagged.*mobilei,t − 1, Interneti,t − 1, real_GDP_per_capitai,t − 1, IEFi,t − 1*: The explanatory variables (digital connectivity and economic competitiveness proxies) are lagged by one period (year $t - 1$).

v αi: The unobserved time-invariant country-specific random effect, as defined in the random-effects model for Table 2.

vi ϵit: The idiosyncratic error term.

vii Error term assumptions (clustered standard errors): The use of clustered standard errors at the country level modifies the core assumption about the error term's variance and covariance structure. It assumes that the errors (*uit*) may be correlated within each country (autocorrelation) and may have different variances across countries (heteroskedasticity), but are independent across countries (clusters). This is a more robust approach that does not require the strong independent and identically distributed assumption for the idiosyncratic errors (ϵit) that is often assumed in standard random-effects models.

Discussion

This paper attempts to explore the relationships between being an active AI importer from China and being an active DSR partner with

China. However, findings suggest that Southeast Asian countries importing AI technologies from China between 2006 and 2017 had not necessarily been more active in DSR partnerships in the next few years (see Tables 2, 1). Instead, the research indicates that digital connectivity (mobile phone instead of Internet access; in Table 2) and economic freedom (in both Tables 2, 1) are minor and significant factors, respectively, in being active DSR partners.

According to the IISS China Connects database, within the region, Indonesia is mediocre in terms of digital connectivity (ranked 6th among all 10 Southeast Asian countries) and economic competitiveness (ranked 5th among all 10 Southeast Asian countries). However, Indonesia was an active AI importer from China and has also been an active DSR player. Despite being an upper-middle-income country currently, Indonesia was a lower-middle-income country between 2006 and 2017. Therefore, during the period when Indonesia imported AI technologies from China, it was significantly underdeveloped digitally and economically. This explains why Indonesia depended on importing AI technologies from China in the 2000s and early 2010s to expand its digital and technological capacity. It is worth noting that the country has had notable economic and geopolitical potential, given its sizable population and willingness as a BRI/DSR partner. As mentioned, Indonesia has been very active in forming BRI/DSR partnerships with China. Despite ongoing geopolitical conflicts, such as the South China Sea disputes, Indonesia has been open to strengthening its DSR ties with China to ensure long-term (digital) infrastructure development. Indonesia's geopolitical attitudes have indicated why it is a leading DSR partner within Southeast Asia.

In addition, the Philippines is a very digitally connected country. It had also been a relatively active DSR player under President Duterte's administration (its DSR activities were only behind Singapore, Indonesia, Thailand and Malaysia between 2018 and 2020). During President Duterte's administration (between 2016 and 2022), the Philippines was a willing BRI and DSR partner with China. The geopolitical attitudes of the Philippines under President Duterte's administration explain why, in parallel with being very digitally connected, the country was willing to form strong DSR ties with China.

Another key finding is that Brunei, being an advanced economy with high GDP per capita, is the second-least active DSR player regionally. This circumstance is due to Brunei's foreign policy attitudes. For example, in 2023, Brunei was the only Southeast Asian country with a negative foreign direct investment (FDI) inflow. Singapore received FDI of nearly US$160 billion, and Indonesia received nearly US$22 billion. Even Myanmar and Laos received nearly US$2 billion each. However, Brunei recorded negative FDI of about US$57 million that year (Statista Research Department, 2025). Therefore, it is not surprising that Brunei had not been an active DSR player between 2018 and 2020 (i.e., only Laos was more DSR-inactive within the region).

Overall, countries lacking digital connectivity were more likely to become AI importers from China (between 2006 and 2017). Also, countries with better digital connectivity might be more likely been active DSR players (between 2018 and 2020). More importantly, we find a positive impact that Southeast Asian countries with more favourable economic and trade environments, measured by their economic freedom, had been more likely to become active DSR partners from 2018 to 2020. The DSR partnerships allow many developing countries to overcome weaknesses in digital infrastructure and tap into vast economic opportunities unlocked by the digital revolution (Ngeow, 2021). Despite the benefits, scepticism has surrounded Southeast Asia, where critics question whether China is exporting its digital authoritarianism to developing countries with weak democratic foundations. China's high-tech surveillance technologies could be used to support authoritarian regimes in monitoring and suppressing political opponents. Critics also express concern that China is building 'internet sovereignty' in the developing world, leading to the long-term development of a more illiberal world order (Ngeow, 2021).

The export of information technology and AI infrastructure appears to be a winning formula for China, allowing the Chinese Government to promote its own standards and open up new markets for Chinese technology companies. Despite advanced technologies traditionally being dominated by American, European, and South Korean companies, Chinese technological products—where the prices and quality are generally considered lower—are acceptable in new, emerging markets (Chung, 2023). To further consolidate its technological dominance in the developing world, partnerships play a crucial economic and geopolitical role in disseminating China's global influence.

From Southeast Asia's standpoint, stronger digital connectivity and competitiveness help open possibilities for regional economic development, narrow the digital divide in accessibility, and provide good-value-for-money products and services for local citizens. Reliable data collection, transmission, and sharing among DSR partner countries regionally and globally may also provide supplementary information to monitor and evaluate the progress on technology-facilitated sustainable development (Sen and Li, 2019). Therefore, despite national security concerns, DSR partnerships, if properly regulated, are conducive to developing countries' long-term development. This explains why most Southeast Asian countries have been active DSR players in recent years.

Conclusion

Southeast Asia has been a key player in China's BRI and DSR cooperation. A major driver of forming DSR partnerships with China is to facilitate Southeast Asia's economic, financial, and sustainable growth, in addition to strengthening the region's digital connectivity. Geopolitical tensions between China and Southeast Asia may not necessarily hinder DSR partnerships. For example, countries such as Indonesia and Thailand had been open to tightening their DSR ties with China, according to 2018–2020 data. Singapore, Indonesia, Thailand, Malaysia, the Philippines and Vietnam are the six largest economies (by national GDP) in Southeast Asia. These six Southeast Asian countries had also been the most active DSR partners in recent years within the region. In this study, the main takeaway is that, among all measured time-variant independent variables, Southeast Asian countries' levels of economic freedom had been the strongest determining factor of whether they would form close DSR ties with China. Forming strong DSR ties with the largest economies in Southeast Asia allows China to exert significant geopolitical, economic, and technological influence regionally. This further reinforces China's global position as a leader in shaping the order of the developing world.

Findings suggest that importing AI technologies from China might have been need-based between 2006 and 2017. The findings show that Southeast Asian countries with the least digital and economic capacities were more likely to have been AI importers from China. However, in the 2020s, the AI revolution has drastically transformed the global landscape in the digital economy and digital geopolitics. As the United States, China, and the European Union have been actively and fiercely competing in technological and AI fields, China's DSR partnerships may gain more traction in the developing world. This is not only because China may become more active in expanding its DSR ties with new and emerging markets, but also because more developing economies have recognised the importance of staying digitally relevant and competitive for long-term developmental growth. It will be interesting to see whether Indonesia will surpass Singapore to become the most active DSR player within Southeast Asia. It will also be valuable to see whether Southeast Asian countries, despite the persistent geopolitical tensions with China, have strengthened their DSR ties with China in the 2020s as technological advancement continues to shape the regional and global order.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JH: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing.

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The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declared that Generative AI was not used in the creation of this manuscript.

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Appendix

See Table A1

TABLE A1 List of relevant variables from the CAIED and IISS China connects database.

$Country_i$	$Year_t$	$DSR_{i,t}$	AI_export_i	$mobile_{i,t}$	$Internet_{i,t}$	$real\_GDP\_per\_capita_{i,t}$	$IEF_{i,t}$
Brunei	2018	0	0	129.27	95.0	29200.20	64.2
Brunei	2019	1	0	129.85	95.0	29996.20	65.1
Brunei	2020	1	0	119.93	96.3	30016.00	66.6
Cambodia	2018	2	1	119.31	.	1884.28	58.7
Cambodia	2019	6	1	129.96	52.3	2008.32	57.8
Cambodia	2020	0	1	126.08	53.7	1908.63	57.3
Indonesia	2018	0	1	118.33	39.9	3701.32	64.2
Indonesia	2019	8	1	125.24	47.7	3850.90	65.8
Indonesia	2020	5	1	129.40	53.7	3739.45	67.2
Laos	2018	0	1	51.38	36.3	2459.98	53.6
Laos	2019	0	1	64.07	47.0	2554.96	57.4
Laos	2020	0	1	63.11	54.0	2529.75	55.5
Malaysia	2018	6	0	128.87	81.2	10610.20	74.5
Malaysia	2019	9	0	133.37	84.2	10903.00	74.0
Malaysia	2020	0	0	129.02	89.6	10171.50	74.7
Myanmar	2018	3	0	116.97	29.4	1361.57	53.9
Myanmar	2019	5	0	155.67	36.5	1440.99	53.6
Myanmar	2020	1	0	148.16	45.4	1301.31	54.0
Philippines	2018	5	0	122.96	44.1	3410.94	65.0
Philippines	2019	4	0	151.01	43.0	3575.88	63.8
Philippines	2020	1	0	133.46	53.8	3198.67	64.5
Singapore	2018	2	0	152.07	88.2	61250.40	88.8
Singapore	2019	9	0	159.35	88.9	61345.50	89.4
Singapore	2020	6	0	150.26	92.0	59189.70	89.4
Thailand	2018	5	0	175.27	56.8	6314.20	67.1
Thailand	2019	8	0	181.22	66.7	6434.54	68.3
Thailand	2020	5	0	162.33	77.8	6035.19	69.4
Vietnam	2018	2	0	146.14	69.8	3048.28	53.1
Vietnam	2019	2	0	140.19	68.7	3241.08	55.3
Vietnam	2020	4	0	141.66	70.3	3303.17	58.8