Economics Bulletin

Volume 43, Issue 1

How do economic complexity and productive capacities foster foreign direct investment flows? Evidence from the Asian economies

Nathapornpan Uttama
Economics Program, School of Management, Mae Fah Luang University

Popkarn Arwatchanakarn
Mae Fah Luang University

Abstract

This study focuses on a critical question for Asian economies whether economic complexity and productive capacities influence foreign direct investment (FDI) flows. The analysis is carried out for FDI flows in 17 Asian countries from 1995 to 2020. A penalized Poisson pseudo-maximum likelihood regression with an adaptive lasso for consistent variable selection is utilized in the estimation. The major findings reveal that economic complexity has a negative influence on FDI flows, while productive capacity has a positive impact on FDI flows, particularly inward FDI. Most Asian economies are more likely to encourage foreign direct investment (investing countries) and to market themselves as foreign direct investment hubs (recipient countries) . Consequently, policymakers should encourage the transformation of economic complexity, the strengthening of productive capacity, and sustainable investment.

The author thanks anonymous reviewers and the editor for their valuable comments and suggestions. This work was supported by Mae Fah Luang University, Thailand.

Citation: Nathapornpan Uttama and Popkarn Arwatchanakarn, (2023) "How do economic complexity and productive capacities foster foreign direct investment flows? Evidence from the Asian economies", *Economics Bulletin*, Volume 43, Issue 1, pages 629-643

Contact: Nathapornpan Uttama - nathapornpan@mfu.ac.th, Popkarn Arwatchanakarn - popkarn.arw@mfu.ac.th.

Submitted: January 03, 2022. **Published:** March 30, 2023.

1. Introduction

As a result of globalization, inward and outward foreign direct investments (FDI) have become a crucial engine driving the global economy's growth and development. The favorable investment climate in host countries has attracted home countries to invest abroad, whether for market-seeking FDI, resource-seeking FDI, efficiency-seeking, or strategic asset-seeking FDI purposes (Dunning and Lundan, 2008). These inward FDIs have a significant impact on knowledge and technology spillovers in host countries, leading to specialization on a national and international scale. This international specialization is also one of the primary motivation for nations to invest abroad.

Recent studies[1] have demonstrated that the characteristics of the home country, the host country, and bilateral relations have a profound influence on inward and outward FDI in Asian countries. In terms of inward FDI (sometimes called FDI inflow), the characteristics of the host country, including economic, political and infrastructural factors[2], play a significant role in attracting FDI inflow (Mishra and Jena, 2019; Nguyen and Su, 2021; Nguyen et al., 2020). Furthermore, the characteristics of the home country, such as market size, per capita income, technological advancement, rising labor costs, and intensifying international competition, serve as a driving force for outward FDI. Additionally, bilateral relations, such as geography, location and trade agreements, are important drivers of foreign direct investment (Nguyen et al., 2020). Therefore, countries with high investment potential[3] can be both foreign investors and recipients of foreign investment. As a result, total foreign direct investment (FDI) flows relative to GDP are indication of a nation's FDI performance depending on FDI recipients and source of investment. Furthermore, nations have sought to encourage FDI flows in order to maintain economic and investment stability.

Since the 1990s, FDI flows to GDP in developing countries have substantially increased. In recent years, Asian countries have emerged as key participants as foreign investors and foreign investment recipients, fueling rapid economic growth and recovery, particularly in the aftermath of the COVID-19 pandemic. Figure 1 depicts significant variation in the growth of FDI as a proportion of GDP in 2020 (with the COVID-19 pandemic), ranging from -41.85% in developing countries to -68.20% in developed countries. The share of FDI in Asia's GDP can reflect potential investment performance, with South-East Asia having the highest FDI performance.

[1] They include Adhikary (2017), Hoshi and Kiyota (2019), Iqbal et al. (2019), Kubo (2019), Liu et al. (2017), Mishra and Jena (2019), Nguyen et al. (2020), and Ramasamy and Yeung (2022).

[2] In terms of economic factors, this include market size, income per capita, inflation rate, interest rate and exchange rate, labor costs, trade costs and other macroeconomic performance etc. In addition, political and infrastructural factors are economics and commercial laws, market access, the degree of trade openness, natural resources, factor endowment, technology, regulatory policies, good governance, and the institutional and infrastructure quality etc.

[3] Investment potential may include the following: a competitive and favourable investment climate; macroeconomic stability; productive resources; productive specialization; technological capacity; entrepreneurial capability; effective investment agreements; and so on.

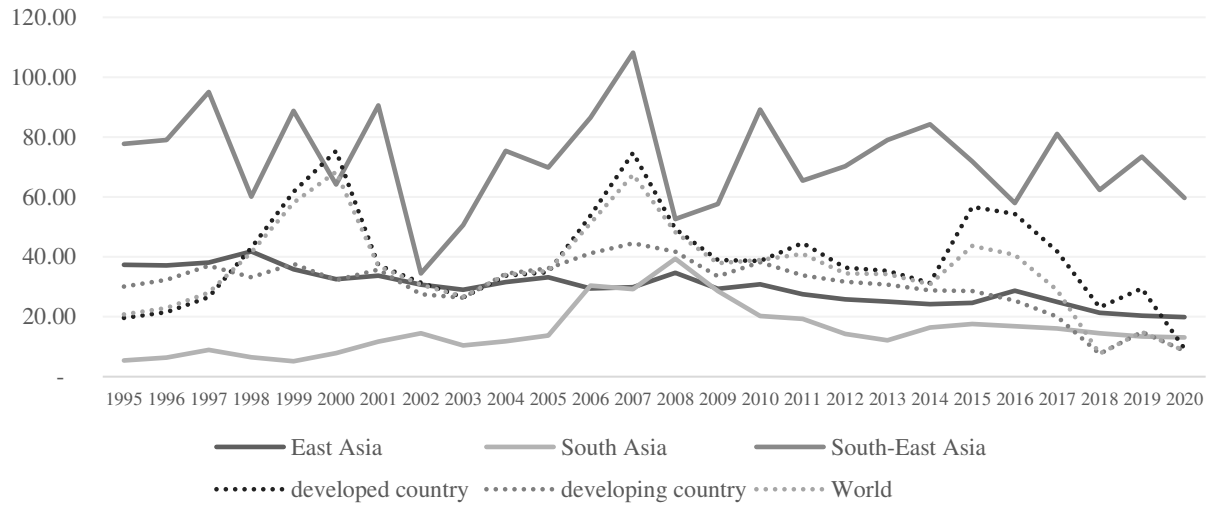

Figure 1. FDI inflow and outflow to GDP, 1995-2020 (UNCTAD, 2021a, b)

Many scholars have studied the composition of FDI to attract foreign investment that will eventually lead to sustainable investment development. It found that the FDI flows have been found to be sensitive to both macroeconomic stability[4], such as economic growth, openness, globalization, and economic freedom and macroeconomic instability[5], such as uncertainty, shock, and disease outbreak.

Currently, the role of economic complexity is frequently addressed and used to reflect the degree of a country's productive economic structure and capability (Balland et al., 2022; Hausmann et al., 2013). The Economic Complexity Index (henceforth ECI), created by Harvard University's Growth Lab, is widely utilized to assess a country's production capability on a sophisticated and knowledge-based basis (Hausmann et al., 2013). The ECI was measured by the diversification of export goods produced in various countries. A number of studies[6] reveal that a country with a high level of economic complexity has a better capacity for productivity. Also, it suggests that economic complexity contributed to a growth in production and the global value chain, as well as an increase in FDI flows (Khan et al., 2020; Koch, 2021; Sadeghi et al., 2020). This implies that a shift in economic complexity may have a substantial effect on the global economy, subsequently, on FDI flows. In other words, a nation with a high degree of economic complexity is more prone to attracting FDI activities, resulting in a surge in FDI flows.

---

[4] The role of macroeconomic stability on FDI has been previously investigated by authors such as Alon et al. (2012), Antonakakis and Tondl (2015), Cieślik and Ghodsi (2021), Dang and Nguyen (2021), Dimitrova (2020), Economou (2019), Fan et al. (2018), Greaney and Kiyota (2020), Hou et al. (2021), Islam et al. (2021), Kurtović et al. (2020),Saini and Singhania (2018), Tolentino (2010), and Uttama and Promnart (2022).

[5] The role of macroeconomic instability on FDI has been examined by authors such as Asamoah et al. (2016), Azam et al. (2012), Chenaf-Nicet and Rougier (2016), Fang et al. (2021) and Nguyen and Lee (2021).

[6] The economic determinants of economic complexity have been studied by several authors such as Antonietti and Franco (2021), Avom et al. (2021), Balland et al. (2022), Kamguia et al. (2021), and Nguyen and Su (2021). In addition, the effects of economic complexity on the economy have been investigated by authors such as Doğan et al. (2020), Lapatinas (2016), Marco et al. (2022), Nguyen (2021), Qi (2022), Tabash et al. (2022), and You et al. (2021). Despite their interconnectedness, there are few studies investigating the effect of economic complexity on foreign trade and investment.

Recently, the United Nations Conference on Trade and Development (UNCTAD) introduced the productive capacities index (henceforth PCI) as an indicator of a country's capacities based on the utilization of its fundamentals and a comparative index of productive capacities among countries (UNCTAD, 2021c). UNCTAD defines productive capacities as "*the productive resources, entrepreneurial capabilities, and production linkages that together determine a country's ability to produce goods and services that will help it grow and develop.*" The PCI is measured using eight components: human capital, natural capital, energy, transport, information and communication technology (ICT), institutions, private sector, and structural change. A country with high degrees of productive resources, entrepreneurial capabilities, and production linkages has greater productive capacities. In considerations of FDI, high productive capacities may promote FDI flows. For example, the home-country productive capacities of Brazil, Russia, India, China, and South Africa (BRICS) sustained and increased their foreign direct investments, particularly their outbound FDI (Elish, 2022). Moreover, the PCI was employed to investigate the effect on economic complexity, and it found a positive linkage between PCI and ECI. As a result, the importance of production capability and productive capacity for FDI cannot be overlooked, given that they encourage more confidence among foreign investors. Despite their interconnectedness, there is a lack of studies investigating the relationship among production capability, productive capacity, and FDI flows in Asia. The relationship between economic complexity, productive capacities, and FDI performance, which may contribute to sustained economic development, requires further study.

As its importance is highlighted above, this raises the crucial question of how economic complexity and productive capacity influence foreign direct investment in Asian countries. Moreover, the question remains as to what factors tend to promote or hinder FDI in Asia and how policymakers should approach this matter. The main objective of this paper is to develop a comprehensive investigation of the effects of economic complexity and productive capacity on FDI flows. This study contributes to the literature on the driver of FDI in three ways. First, this study examines the influence of economic complexity and productive capacity as two augmented drivers of foreign direct investment (FDI), thereby giving a better depiction of a country's FDI performance. Second, this study fills a gap in the existing literature in Asian FDI by analyzing the effects of economic complexity and productive capacity on FDI flows at regional level with 17 Asian economies. There are a small number of studies on the linkage between economic complexity, productive capacity, and FDI flows, especially the Asia region. Third, this study utilizes a data-driven approach based on machine learning algorithms to analyze Asian FDI in order to ensure data quality and high prediction accuracy (Athey and Imbens, 2019; Fu et al., 2021; Mullainathan and Spiess, 2017; Portugal et al., 2018). Yet, the research on FDI regression estimation with machine learning techniques has barely appeared. Hence, a penalized Poisson pseudo-maximum likelihood regression with an adaptive lasso for consistent variable selection is employed to improve the reliability and validity of these estimation results.

The remainder of the paper is structured as follows. The methodology and data used are described in the next section. Section 3 presents and discusses the empirical results. The last section is the conclusion, with implications

2. Methodology and data

2.1 Model and methodology

The model for this analysis is developed from the FDI framework and the Eclectic theory[7] (Dunning, 1980, 1988, 2000) with regard to economic complexity, productive capacity and macroeconomic determinants, described in the previous section. The estimation model is as follows:

$$FDI_{it} = \propto + \beta_1 ECI_{it} + \beta_2 PCI_{it} + \beta_3 MACRO_{it} + \epsilon_{ijt} \qquad (1)$$

where FDI_{it} is the share of FDI inflow and outflow in the gross domestic product (GDP) of i-th country in year t. ECI_{it} is a measure of economic complexity index that reflects the production capabilities at national level. PCI_{it} is a measure of productive capacities at industry (or firm) level based on productive resources, entrepreneurial capabilities, and production linkages. $MACRO_{it}$ is macroeconomic factors of i-th country in year t consisting of gross domestic product (GDP), GDP growth, labor force participation, level of globalization (one-year lag), level of economic freedom, and global shock. ϵ_{ijt} is an error term for $i = 1, \dots, 17$ countries, $t = 1995, \dots, 2020$, and β_s are the parameters to be estimated.

This study employs a data-driven machine learning approach, known as "Poisson pseudo-maximum likelihood with the adaptive least absolute shrinkage and selection operator method (PPML Post-Lasso)," to examine the causal inference. Employing the PPML Post-Lasso can eliminate data quality issues such as multicollinearity, cross-sectional dependence, autocorrelation, and heteroskedasticity. The model is first estimated using a Poisson pseudo-maximum likelihood (PPML) estimator with fixed effects proposed by Silva and Tenreyro (2011, 2006) as a traditional econometric analysis. The PPML is an estimator that generates consistent and unbiased estimates (Silva and Tenreyro, 2011). Silva and Tenreyro (2006) demonstrated the advantages of the PPML estimator in mitigating the Jensen's inequality ($E[\ln Y] \neq \ln E(Y)$) where E is the conditional mean, the trouble of zeros in the observed data $\left(\sum_{i=1}^{n}\left[Y_i - exp\left(X_i\tilde{\beta}\right)\right]X_i = 0\right)$ where $exp(X_i\beta)$ is the conditional expectation of Y_i given X, and the heteroskedasticity problem by allowing the assumption of conditional mean: $E[Y_i|X] = exp(X_i\beta) \propto V[Y_i|X]$ where $V[Y_i|X]$ is the conditional variance of Y_i given X. The specification model for PPML is shown below:

$$FDI_{it} = exp[\mu_{it} + \alpha_t + \beta_1 ECI_{it} + \beta_2 PCI_{it} + \beta_3 MACRO_{it}] * \epsilon_{ijt} \qquad (2)$$

where μ_{it} and α_t are country fixed effects and time fixed effects.

Furthermore, variable selection must be considered to avoid overfitting, which results in inconsistent parameter estimates. In the next step, a machine-learning regularization technique is applied for consistent variable selection to avoid overfitting bias and out-of-sample error in a model. The regularization algorithms can reduce overfitting and generalization errors in the

[7] The Eclectic theory is a combination of three different theories of foreign direct investments (see Dunning, 1980, 1988). Additionally, the Eclectic theory reveals that the advantages of ownership (O), location (L), and internationalisation (I) are the major determinants of foreign direct investment.

regression model (Tibshirani, 1996). This study utilizes the adaptive lasso penalized (or regularization) approach, developed by Zou (2006), to select the most influential variables affecting the goodness-of-fit model and then reduce the irrelevant variables to precisely zero. The adaptive lasso estimates, $\hat{\beta}^{(n)}(adaptive\ lasso)$, are given by

$$\hat{\beta}^{(n)}(adaptive\ lasso) = \underset{\beta}{\operatorname{argmin}} \|Y - X\beta\|^2 + \underbrace{\lambda_n \sum_{j=1}^{P} \widehat{\omega}_j |\beta_j|}_{Lasso\ penalty} \quad (3)$$

where λ_n is a non-negative regularization parameter varying with n and $\widehat{\omega}_j$ is a weight vector that is equal to $1/|\hat{\beta}^{(n)}|^{\gamma}$ when $\gamma > 0$. The final step is to estimate the "Post-Lasso" PPML regression model using a cross-fit, partialing-out lasso Poisson regression developed by Chernozhukov et al. (2018) that yields unbiased estimation and inference.

Additionally, this study employs alternative potential estimators for robustness checks, including the feasible generalized least squares model, Driscoll and Kraay (1998) standard errors for the coefficients, Newey-West standard errors for the coefficients, the panel-corrected standard error approach, and a fixed effect model as robustness checks.

2.2 Data

This study uses panel data for 17 Asian countries[8] over the 1995-2020 period. The selection of countries and periods depends on the data availability. The dependent variable is FDI flow[9]. Data for FDI inflow (henceforth inward FDI), FDI outflow (henceforth outward FDI) and GDP are drawn from the UNCTAD (2021a, 2021b). Following Dorakh (2020), the negative FDI value is transformed to 1 to avoid inconsistency in the estimation. The main explanatory variables are the economic complexity index and productive capacities index, which capture the country's production capabilities and productive capacities at industry (or firm-specific) level, respectively. The data for the economic complexity index is sourced from the Center for International Development at Harvard University (The Growth Lab at Harvard University, 2019) and the productive capacities index from the UNCTAD (2021c). In terms of macroeconomic variables, data for gross domestic products and growth of GDP (at constant 2010 prices), and labor force participation are gathered from the World Bank (2021). Data for the globalization index is collected from the KOF Swiss Economic Institute (Gygli et al., 2019; KOF, 2021), whereas the economic freedom index is obtained from The Heritage Foundation (2021). Lastly, global shock is a dummy variable with the value of 1 when it takes place. The subprime crisis of 2007-2010 and the COVID-19 pandemic of 2019-2020 are assume to be the global shock. The descriptive statistics of all variables are shown in Table 1.

[8] The 17 Asian countries used in this study include Bangladesh, Cambodia, China, India, Indonesia, Islamic Republic of Iran, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Pakistan, Philippines, Republic of Korea, Singapore, Thailand, Viet Nam, and Sri Lanka

[9] More specifically, this study estimates the specified model using three dependent variables as follows: (1) FDI flow to GDP; (2) Inward FDI to GDP; and (3) Outward FDI to GDP. In addition, the first dependent variable, FDI flow to GDP, is measured as the ratio of inward FDI plus outward FDI to GDP at a constant price of the US dollar in 2010.

Table 1: Descriptive statistics

Variables	Unit	Mean	Std. Dev.	Min.	Max.	Jarque-Bera	Obs.
Dependent variables:							
FDI flow to GDP	Index	5.286	7.778	0.0006	46.142	2785*	442
Inward FDI to GDP	Index	4.061	5.612	0.0001	43.912	2789*	442
Outward FDI to GDP	Index	1.225	3.012	0.0000	22.594	8996*	442
Independent variables:							
Economic complexity	Score	-0.005	0.930	-1.465	2.168	34.59*	442
Productive capacity	Index (0-100)	28.945	6.500	17.183	45.209	32.44*	323
Gross domestic product	Billion US$ (logarithm)	4.546	2.260	-2.017	9.845	9.261*	442
Growth of GDP	Percent	0.084	0.112	-0.557	0.469	254.2*	442
Labor force participation	Million People (logarithm)	3.209	1.666	-0.176	6.668	3.048	442
Globalization	Index (0-100)	56.109	13.750	22.737	84.360	5.993**	442
Economic freedom	Index (0-1)	0.575	0.114	0.335	0.894	60.9*	442
Global shock		0.230	0.421	0	1	122.8*	442

Note: The Jarque and Bera (1987) test is the normality test whether the observed data has a normal distribution (Null hypothesis). * and ** indicates significance at the 1% and 5% levels, respectively.

In addition, the Jarque-Bera normality test is performed, and the results confirm the non-normal distributions in all observed variables (except labor force participation) in the specified model. Consequently, the Lasso-penalized regression approach is appropriate in model estimation (Casella et al., 2010). Moreover, the diagnostic tests, e.g., unit root test and cross-section dependence test, are conducted before empirical analysis. The cross-section dependence (CD) test proposed by Pesaran (2021) (henceforth Pesaran-CD) is carried out under the null hypothesis of no cross-section dependence. Furthermore, the first-generation Levin-Lin-Chu unit root test (LLC), proposed by Levin et al. (2002), and the second-generation cross-section augmented Dickey-Fuller panel unit root test (CADF), proposed by Pesaran (2007), are employed in the unit root test. These tests are used to check whether the panel-data variables are stationary, with the null hypothesis of the presence of the panel unit root test.

Table 2 displays the results of cross-section dependence and the first- and second-generation panel unit root tests for all variables used in the baseline model. First, the results of the first-generation LLC panel unit root test indicate that most variables (with the exception of productive capacity, gross domestic products, and economic freedom) are stationary at the level, and almost all variables, with the exception of labor force participation, are stationary at the first difference. Second, the Pesaran-CD statistics show that all variables have cross-sectional dependence except for inward FDI to GDP. In conclusion, the results of the second-generation CADF panel unit root test indicate that the majority of panel data series are stationary at the level and that all series are stationary at the first difference level.

Table 2: Results of the cross-section dependence test and the first- and second-generation panel unit root tests

Testing	LLC		Pesaran-CD	CADF	
	Level	First Diff.		Level	First Diff.
FDI flow to GDP	-9.782*	-18.789*	6.325*	-3.352*	-5.233*
Inward FDI to GDP	-7.776*	-18.875*	1.237	-3.112*	-5.169*
Outward FDI to GDP	-7.075*	-19.662*	11.949*	-3.008*	-5.230*
Economic complexity	-5.169*	-18.258*	21.136*	-2.220**	-5.137*
Productive capacity	-2.156	-11.023*	47.831*	-1.572	-3.637*
Gross domestic product	-2.069	-10.697*	58.644*	-2.393*	-4.113*
Growth of GDP	-11.821*	-24.274*	31.121*	-4.269*	-6.035*
Labor force participation	-5.647*	-4.670	56.333*	-1.495	-3.495*
Globalization	-10.527*	-11.335*	54.054*	-2.058***	-4.160*
Economic freedom	-5.434	-16.123*	10.008*	-2.396*	-4.777*

Note: *, **, and *** are the level of significance at 1%, 5%, and 10%, respectively.

3. Empirical results

3.1 Baseline results

The results to analyze whether a country's economic complexity and productive capacities are complementary or substitutable in influencing foreign direct investment flows are discussed here. Table 3 presents the estimation results[10]. The results of traditional Poisson Pseudo-Maximum Likelihood (henceforth PPML), the adaptive lasso penalized regression results (henceforth Lasso), and "Post-Lasso" PPML (henceforth PPML Post-Lasso) are displayed sequentially.

Initially, the Model 1 is incorporated with economic complexity and productive capacity simultaneously and then is estimated by the PPML (see column [1]). It found that the coefficient on economic complexity is negative and statistically significant. As expected, the coefficient on productive capacities is positive with high statistical significance. The labor force participation is the sole of macroeconomic variables that is positive and statistically significant, as well as global shock is negative and statistically significant. Subsequently, the Lasso results (see column [2]) exhibit that there are five variables selected by the adaptive lasso penalized regression approach. Then, these five selected variables are re-estimated using PPML approach. The results obtained from PPML Post-Lasso (see column [3]) indicate that the estimated coefficients on economic complexity and productive capacities are similar to the PPML estimated coefficients.

As illustrated in the Model 1, the coefficients on economic complexity (in both columns [1] and [3]) bear a negative sign and are statistically significant. This result suggests a negative relationship between economic complexity and FDI flows. An interpretation of this is that the higher the economic complexity, the lower the FDI flows in Asia, indicating that the country's economic complexity capabilities tend to substitute for FDI flows or FDI performance in Asian countries. This reflects that developing countries with highly productive capabilities could be self-reliant in producing sophisticated and knowledgeable products, resulting in a decline in inward FDI. Additionally, developing countries with highly productive capabilities could enter into an outward

[10] For all the models, the dependent variable is the FDI flows to GDP.

foreign investment market, but the transition must be gradual. The results are in line with Antonietti and Franco (2021).

Meanwhile, the coefficients on productive capacity (in both columns [1] and [3]) bear a positive sign and statistically significant. This result reveals that the greater the productive capacity leads to an increasing FDI flows in Asia. It implies that the country's productive capacity is complementary to attract FDI flow in Asian countries. In other words, productive capacity, consisting of productive resources, productive specialisation, production linkages, technical innovation, entrepreneurial potential, trade cost reduction, investment treaties, and other related production and trade enhancements, is prone to attracting foreign direct investment flows. The findings are similar to those of existing studies, e.g., Adhikary (2017), Hoshi and Kiyota (2019), Liu et al. (2017), Mishra and Jena (2019), and Nguyen et al. (2020).

Table 3: Estimation results of FDI flow to GDP in the 17 Asian Countries

	Model 1			Model 2		Model 3	
	PPML	Lasso	PPML Post-Lasso	PPML	PPML Post-Lasso	PPML	PPML Post-Lasso
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Economic complexity	-0.441*	-0.366	-0.515*	-0.681*	-0.565*		
	(-2.46)		(-3.89)	(-4.26)	(-4.39)		
Productive capacity	0.159*	0.092	0.082*			0.147**	0.048**
	(2.38)		(4.62)			(2.17)	(2.17)
Gross domestic product	0.186			-0.147***		0.328**	
	(1.14)			(-1.63)		(2.11)	
Growth of GDP	1.260	1.452	1.538*	0.953	0.847***	1.218	1.443**
	(1.34)		(2.62)	(1.27)	(1.66)	(1.29)	(2.00)
Labor force participation	1.770*	-0.179	-0.133*	0.836**	-0.021	2.115*	-0.100**
	(2.47)		(-4.37)	(2.27)	(-0.29)	(2.73)	(-2.04)
Globalization	0.018	0.014	0.023*	0.038*	0.037*	0.015	0.029*
	(1.19)		(3.33)	(3.78)	(6.44)	(0.96)	(3.14)
Economic freedom	1.601			0.709		1.830	
	(1.40)			(0.78)		(1.59)	
Global shock	-0.925**			0.261		-1.209*	
	(-1.96)			(1.06)		(-2.48)	
Constant	-5.649*	-1.671	-2.044*	-1.042	-0.549	-5.332*	-1.921*
	(-2.55)		(-3.86)	(-1.20)	(-1.44)	(-2.42)	(-3.41)
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	323		323	442	442	323	323
R-square	0.84		0.82	0.82	0.80	0.84	0.80
VIF	6.38			4.08		5.06	

Note: The "PPML Post-Lasso" column displays the PPML coefficients for variables selected by adaptive lasso method. *t*-statistics are in parentheses; * significant with $p < 0.01$; ** significant with $p < 0.05$; *** significant with $p < 0.1$.

Regarding the macroeconomic variables, the coefficients on the growth of GDP and globalization are positive and statistically significant, in accordance with Antonakakis and Tondl (2015),

Kurtović et al. (2020), and Saini and Singhania (2018). These results suggest that the greater the degree of globalization and economic growth, the greater the FDI flows. Simultaneously, the coefficient of labor force participation bears a negative sign and is statistically significant. Surprisingly, the higher the labor force participation, the lower the FDI flows. This could be owing to a lack of workforce, particularly skilled labors, to facilitate foreign direct investment. Additionally, foreign direct investment may arise in manufacturing sectors with a high capital intensity. It is also primarily dependent on technological innovations. Therefore, it is unnecessary to hire unskilled labors. As a consequence of this, although labor force participation in the host country increases, the flows of foreign direct investment declines.

Secondly, the Model 2 is included only the economic complexity and then is estimated by PPML and PPML Post-Lasso (see columns [4] and [5] respectively). According to the results obtained by PPML and PPML show that the coefficient on economic complexity is negative and statistically significant. Similarly, the coefficients on growth of GDP and globalization are consistent with Model 1. Lastly, the Model 3, which solely incorporate contain the productive capacity (see columns [6] and [7]), shows that the overall findings correspond with those of the Model 1. The coefficient on productive capacity bear a positive sign and is statistically significant. This finding is in line with Khan et al. (2020) and Sadeghi et al. (2020). Additionally, due to the consistency of the findings of the three models, the estimation results of Model 1 have been supported by those of Models 2 and Model 3.

In summary, it is worth noting that the economic complexity and productive capacity have a substantial impact on FDI flows in Asian countries. The economic complexity tends to substitute for Asia's FDI flows, especially inward FDI. However, the productive capacity complements Asia's FDI flows. Moreover, macroeconomic factors, especially GDP growth, globalization, and labor force participation, have a significant impact on FDI flows. Thus, specific policy implementations concerning economic complexity, production capacities, and macroeconomic aspects are essential.

3.2 Robustness check

As a robustness check, this study accounts for the possibility of endogeneity problems in our model by comparing estimators and dependent variables.

First, as to verify the robustness and validity of the model, we apply the different estimators to Model 1. The robustness estimates are presented in Table 4 (see column [1] – [5]). These coefficients are estimated using five panel-data estimators: the feasible generalized least squares method (GLS), Driscoll and Kraay's (1998) standard errors for the coefficients (SCC), Newey-West's standard errors for the coefficients (NEWEY), the panel-corrected standard error approach (PCSE), and a fixed effect model (FE), respectively. Overall, the results show that economic complexity and productive capacity have identical signs and statistically significant coefficients to those of the baseline results. Except for GLS estimator, the majority of estimators show a negative and statistically significant coefficient on economic complexity. Moreover, with the exception of the FE estimator, the majority of estimators indicate that the coefficient on productive capacity is positive and statistically significant. These findings support the notion that economic complexity and productive capability have an influence on FDI in Asian countries. Furthermore, it finds some evidence that macroeconomic variables, such as GDP growth and labor force participation, affect

FDI flow in Asian countries. As a result, the estimation results using the various estimators for the key variables are comparable to the baseline results, confirming the robustness of the the baseline results.

Second, we modify the dependent variable to (i) inward FDI to GDP and (ii) outward FDI to GDP. The estimates are illustrated in Table 5. For the results of inward FDI (see column [2]), the coefficient on economic complexity carries a negative sign and is statistically significant, while the coefficient on productive capacity is positive with a high level of statistical significance. In addition, not only the economic complexity and productive capacity but also the coefficients on growth of GDP and globalization are aligned with the baseline model. Also, the results of outward FDI (see column [4]) show that economic complexity has a positive and statistically significant coefficient. This means that a greater degree of economic complexity will lead to a greater outward FDI. Yet, these results appear inconsistent with the baseline results. Despite these differences, estimation results, employing inward FDI as the dependent variable, are comparable to those of the baseline model. This supports that the baseline results are valid and robust.

Table 4: Robust estimation results of total FDI to GDP in the 17 Asian countries

	GLS	SCC	NEWEY	PCSE	FE
	[1]	[2]	[3]	[4]	[5]
Economic complexity	-0.463	-2.437***	-2.437**	-2.718***	-4.777***
	(-0.82)	(-1.77)	(-1.98)	(-1.60)	(-1.80)
Productive capacity	0.308*	0.474*	0.474*	0.554**	0.682
	(2.71)	(4.21)	(3.05)	(2.05)	(1.53)
Gross domestic product	-1.067*	-0.245	-0.245	-0.993	-1.233**
	(-3.36)	(-0.79)	(-0.55)	(-1.15)	(-2.59)
Growth of GDP	2.300*	13.760**	13.760*	5.880**	9.345
	(2.35)	(2.31)	(2.50)	(1.93)	(1.28)
Labor force participation	0.179	-0.786**	-0.786***	-0.532	7.568
	(0.52)	(-2.56)	(-1.79)	(-0.61)	(1.46)
Globalization	0.124*	-0.044	-0.044	0.184	0.196**
	(2.62)	(-0.60)	(-0.56)	(1.45)	(2.13)
Economic freedom	0.654	41.956*	41.956*	15.885	-3.995
	(0.19)	(5.16)	(5.79)	(1.41)	(-0.51)
Global shock	0.635**	0.843	0.843	0.894	0.515
	(2.34)	(1.40)	(1.00)	(1.10)	(1.22)
Constant	-8.531**	-27.663*	-27.663*	-27.793*	-43.015*
	(-2.28)	(-4.17)	(4.20)	(-2.49)	(-2.94)
Observations	323	323	323	323	323
R-square		0.49			0.26
F test	48.24*		14.31*	22.14*	
Hausman test					17.01*

Note: *t*-statistics are in parentheses; * significant with $p < 0.01$; ** significant with $p < 0.05$; *** significant with $p < 0.1$.

Table 5: Robust estimation results of inward FDI and outward FDI in the 17 Asian countries

	Inward FDI to GDP		Outward FDI to GDP	
	PPML	PPML Post-Lasso	PPML	PPML Post-Lasso
	[1]	[2]	[3]	[4]
Economic complexity	-0.413** (-2.01)	-0.474* (-3.14)	-0.087 (-0.34)	0.391* (3.87)
Productive capacity	0.150** (2.21)	0.068* (3.17)	-0.049 (-0.57)	
GDP	0.428* (2.38)		-0.044 (-0.21)	
Growth of GDP	1.209 (1.24)	1.698** (2.20)	1.387 (1.58)	
Labor force participation	3.262* (4.23)		-3.428* (-3.71)	
Globalization	0.016 (0.97)	0.022* (2.77)	0.015 (0.76)	0.079* (11.44)
Economic freedom	1.936 (1.56)	2.448** (2.26)	-0.719 (-0.33)	
Global shock	-1.428* (-3.16)		-0.151 (-0.36)	
Constant	-11.758* (-5.21)	-8.772* (-11.52)	19.752** (2.20)	-10.107* (-24.48)
Country fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	323	323	304	442
R-square	0.79	0.77	0.92	0.86
VIF	4.08		5.06	

Note: The "PPML Post-Lasso" column displays the PPML coefficients for variables selected by adaptive lasso method. t-statistics are in parentheses; * significant with $p < 0.01$; ** significant with $p < 0.05$.

4. Conclusion and Policy Implications

This paper investigates the effects of economic complexity and productive capacity on FDI flows in 17 selected Asian countries from 1995 to 2020. A penalized Poisson pseudo- maximum likelihood regression with an adaptive lasso for consistent variable selection is employed to obtain the reliability and validity of the estimation results. The key findings indicate that the economic complexity has a negative influence on FDI flows to Asian countries, while productive capacity has a favorable impact on FDI flows to Asian countries. In other words, as economic complexity increases, Asian nations may face the FDI substitution effect, resulting in a decline in FDI flows, particularly inward FDI. Furthermore, strengthening productive capacity could have a synergistic (or complementary) effect to attract FDI flows in Asian countries, hence boosting FDI activity, especially inward FDI. Moreover, inward and outward FDI inducements have emerged key challenges and strategies for promoting economic growth and recovery, particularly in Asian nations.

The findings from this study offer three policy implications that countries should pursue to mitigate the loss of sustainable foreign direct investment. First, transforming the economic complexity pattern by integrating international trade and investment activities would improve production capability and attract more substantial FDI flows. Second, strengthening productive capacity through increased productive resources, entrepreneurial capabilities, and production linkages would increase the attractiveness and confidence of investment. Lastly, implementing investment strategies, policies, regulations, and treaties based on UNCTAD's Investment Policy Framework for Sustainable Development (UNCTAD, 2015) would enable Asian nations in securing more sustainable foreign investment.

References

Adhikary, B.K. (2017) "Factors influencing foreign direct investment in South Asian economies: A comparative analysis" *South Asian Journal of Business Studies* 6(1), 8-37.

Alon, I., T. Molodtsova and J. Zhang (2012) "Macroeconomic prospects for China's outward FDI" *Transnational Corporations Review* **4(2)**, 16-40.

Antonakakis, N and G. Tondl (2015) "Robust determinants of OECD FDI in developing countries: Insights from Bayesian model averaging" *Cogent Economics & Finance* **3(1)**, 1095851.

Antonietti, R. and C. Franco (2021) "From FDI to economic complexity: A panel Granger causality analysis" *Structural Change and Economic Dynamics* **56**, 225-239.

Asamoah, M.E., C.K.D. Adjasi and A.L. Alhassan (2016). Macroeconomic uncertainty, foreign direct investment and institutional quality: Evidence from Sub-Saharan Africa. Economic Systems, **40(4)**: 612-621.

Athey, S. and G.W. Imbens (2019) "Machine learning methods that economists should know about" *Annual Review of Economics* **11**, 685-725.

Avom, D., B. Kamaguia and J.P. Ngameni (2021) "Does volatility hinder economic complexity?" *Economics Bulletin* **41(3)**, 1187-1202.

Azam, M., M.A. Khan and N. Iqbal (2012) "Impact of Political Risk and Uncertainty on FDI in South Asia" *Transition Studies Review* **19**, 59-77.

Balland, P-A., T. Broekel, D. Diodato, E. Giuliani, R. Hausmann, N. O'Clery and D. Rigby (2022) "The new paradigm of economic complexity" *Research Policy* **51(3)**, 104450.

Casella, G., M. Ghosh, J. Gill and M. Kyung (2010) "Penalized regression, standard errors, and Bayesian lassos" *Bayesian Analysis* **5(2)**, 369-411.

Chenaf-Nicet, D. and E. Rougier (2016) "The effect of macroeconomic instability on FDI flows: A gravity estimation of the impact of regional integration in the case of Euro-Mediterranean agreements" *International Economics* **145**, 66-91.

Chernozhukov, V., D. Chetverikov, M. Demirer, E. Duflo, C. Hansen, W. Newey and J. Robins (2018) "Double/debiased machine learning for treatment and structural parameters" *The Econometrics Journal* **21**, C1-C68.

Cieślik, A. and M. Ghodsi (2021) "Economic sentiment indicators and foreign direct investment: Empirical evidence from European Union countries" *International Economics* **168**, 56-75.

Dang, V.C. and Q.K. Nguyen (2021) "Determinants of FDI attractiveness: Evidence from ASEAN-7 countries" *Cogent Social Sciences* **7(1)**, 2004676.

Dimitrova, A., T. Rogmans and D. Triki (2020) "Country-specific determinants of FDI inflows to the MENA region: A systematic review and future research directions" *Multinational Business Review* **28(1)**, 1-38.

Doğan, B., D. Balsalobre-Lorente and M.A. Nasir (2020) "European commitment to COP21 and the role of energy consumption, FDI, trade and economic complexity in sustaining economic growth" *Journal of Environmental Management* **273**, 111146.

Dorakh, A. (2020) "A gravity model analysis of FDI across EU member states" *Journal of Economic Integration* **35(3)**, 426-456.

Dunning, J. H. (1980) "Toward an Eclectic Theory of International Production: Some Empirical Tests" *Journal of International Business Studies* **11,** 9-31.

Dunning, J. H. (1988) "The Eclectic Paradigm of International Production: A restatement and some possible extensions" *Journal of International Business Studies* **19(1),** 1-31.

Dunning, J. H. (2000) "The eclectic paradigm as an envelope for economic and business theories of MNE activity" *International Business Review* **9(2),** 163-190.

Dunning, J.H. and S.M. Lundan (2008) *Multinational Enterprises and the Global Economy, Second Edition*. Edward Elgar Publishing Limited: Cheltenham, UK and Northampton, MA, USA.

Economou, F. (2019) "Economic freedom and asymmetric crisis effects on FDI inflows: The case of four South European economies" *Research in International Business and Finance* **49**, 114-126.

Elish, E. (2022) "Political and productive capacity characteristics as outward foreign direct investment push factors from BRICS countries" *Humanities and Social Sciences Communications* **9**, 432.

Fan, H., F. Lin and L. Tang (2018) "Minimum wage and outward FDI from China" *Journal of Development Economics* **135**, 1-19.

Fang, J., A. Collins and S. Yao (2021) "On the global COVID-19 pandemic and China's FDI" *Journal of Asian Economics* **74**, 101300.

Fu, C., C. Xu, M. Xue, W. Liu and S. Yang (2021) "Data-driven decision making based on evidential reasoning approach and machine learning algorithms" *Applied Soft Computing* **110**, 107622.

Gnangnon, S.K. (2021) "Effect of productive capacities on economic complexity: Do aid for trade flows matter?" *Journal of Economic Integration* **36(4)**, 626-688.

Greaney, T.M. and K. Kiyota (2020) "Japan's outward FDI potential" *Journal of the Japanese and International Economies* **57**, 101073.

Gygli, S., F. Haelg, N. Potrafke and J-E. Sturm (2019) "The KOF globalisation index-revisited" *Review of International Organizations* **14(3)**, 543-574.

Hausmann, R., C. Hidalgo, S. Bustos, M. Coscia, S. Chung, J. Jimenez, A. Simoes and M. Yildirim (2013). *The Atlas of Economic Complexity*. Cambridge, MA: MIT Press.

Hausmann, R., C.A. Hidalgo, S. Bustos, M. Coscia, A. Simoes and M.A. Yildirim (2013) *The atlas of economic complexity: Mapping paths to prosperity 2nd ed.*, MIT Press: Cambridge.

Hoshi, T. and K. Kiyota (2019) "Potential for inward foreign direct investment in Japan" *Journal of the Japanese and International Economies* **52**, 32-52.

Hou, L., Q. Li, Y. Wang and X. Yang, X. (2021) "Wages, labor quality, and FDI inflows: A new non-linear approach" *Economic Modelling* **102**: 105557.

Iqbal, B.A., S. Sami and A. Turay (2019) "Determinants of China's outward foreign direct investment in Asia: a panel data analysis" *Economic and Political Studies* **7(1)**, 66-86.

Islam, M.A., H. Liu, M.A. Khan, M.T. Islam and M.R. Sultanuzzaman (2021) "Does foreign direct investment deepen the financial system in Southeast Asian economies?" *Journal of Multinational Financial Management* **61**, 100682.

Kamguia, B., S. Tadadjeu, C. Miamo and H. Njangang (2021) "Does foreign aid impede economic complexity in developing countries?" *International Economics* **169**, 71-88.

Khan, H., U. Khan and M.A. Khan (2020) "Causal nexus between economic complexity and FDI: Empirical evidence from time series analysis" *The Chinese Economy* **53(5)**, 374-394.

Koch, P. (2021) "Economic complexity and growth: Can value-added exports better explain the link?" *Economics Letters* **198**, 109682.

KOF Swiss Economic Institute (KOF) (2021) "KOF globalisation index". Available at https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html (Accessed: 30 October 2021).

Kubo, A. (2019) "A note on determinants of Japanese foreign direct investment in Southeast Asia, 2008–2015" *Economic Analysis and Policy* **62**, 192-196.
Kurtović, S., N. Maxhuni, B. Halili and S. Talović (2020) "The determinants of FDI location choice in the Western Balkan countries" *Post-Communist Economies* **32(8)**, 1089-1110.
Lapatinas, A. (2016) "Economic complexity and human development: A note" *Economics Bulletin* **36(3)**, 1441-1452.
Levin, A., C.-F. Lin and C.-S. J. Chu (2002) "Unit root tests in panel data: Asymptotic and finite-sample properties" *Journal of Econometrics* **108**, 1-24.
Liu, H.Y., Y.K. Tang, X.L. Chen and J. Poznanska (2017) "The Determinants of Chinese Outward FDI in Countries Along "One Belt One Road" *Emerging Markets Finance and Trade* **53(6)**, 1374-1387.
Marco, R., C. Llano and S. Pérez-Balsalobre (2022) "Economic complexity, environmental quality and income equality: A new trilemma for regions?" *Applied Geography* **139**, 102646.
Mishra, B.R. and P.K. Jena (2019) "Bilateral FDI flows in four major Asian economies: a gravity model analysis" *Journal of Economic Studies* **46(1)**, 71-89.
Mullainathan, S. and J. Spiess (2017) "Machine learning: An applied econometric approach" *Journal of Economic Perspectives* **31(2)**, 87-106.
Nguyen, A.T.N., A.A. Haug, P.D. Owen and M. Genç (2020) "What drives bilateral foreign direct investment among Asian economies?" *Economic Modelling* **93**, 125-141.
Nguyen, C.P. (2021) "Does economic complexity matter for the shadow economy?" *Economic Analysis and Policy* **73**, 210-227.
Nguyen, C.P. and G.S. Lee (2021) "Uncertainty, financial development, and FDI inflows: Global evidence" *Economic Modelling* **99**, 105473.
Nguyen, C.P. and T.D. Su (2021) "Economic integration and economic complexity: The role of basic resources in absorptive capability in 40 selected developing countries" *Economic Analysis and Policy* **71**, 609-625.
Pesaran, M. H. (2007) "A simple panel unit root test in the presence of cross-section dependence" *Journal of Applied Economics* **22(2)**, 265-312.
Pesaran, M. H. (2021) "General diagnostic tests for cross-sectional dependence in panels" *Empirical Economics* **60**, 13-50.
Portugal, I., P. Alencar and D. Cowan (2018) "The use of machine learning algorithms in recommender systems: A systematic review" *Expert Systems with Applications* **97**, 205-227.
Qi, X. (2022) "Building a bridge between economic complexity and the blue economy" *Ocean & Coastal Management* **216**, 105987.
Ramasamy, B. and M. Yeung (2022) "China's outward foreign direct investment (OFDI) to developing countries: the case of Central and Eastern Europe (CEE)" *Journal of the Asia Pacific Economy* **27(1)**, 124-146.
Sadeghi, P., H. Shahrestani, K.H. Kiani and T. Torabi (2020) "Economic complexity, human capital, and FDI attraction: A cross country analysis" *International Economics* **164**, 168-182.
Saini, N. and M. Singhania (2018) "Determinants of FDI in developed and developing countries: A quantitative analysis using GMM" *Journal of Economic Studies* **45(2)**, 348-382.
Silva, S.J.M.C. and S. Tenreyro (2006) "The log of gravity" *The Review of Economics and Statistics* **88(4)**, 641-658.
Silva, S.J.M.C. and S. Tenreyro (2011) "Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator" *Economics Letters* **112(2)**, 220-222.

Tabash, M.I., E.P. Mesagan and U. Farooq (2022) "Dynamic linkage between natural resources, economic complexity, and economic growth: Empirical evidence from Africa" *Resources Policy* **78**, 102865.

The Growth Lab at Harvard University (2019) "Growth Projections and Complexity Rankings, V2" [Data set]. https://doi.org/10.7910/dvn/xtaqmc (Accessed: 30 October 2021).

The Heritage Foundation (2021) "2021 index of economic freedom". Available at https://www.heritage.org/index/ (Accessed: 30 October 2021).

The World Bank (2021) "World development indicators", World Bank Group. Available at https: / / databank. worldbank. org/ reports. aspx?source= world- development- indicators (Accessed: 30 October 2021).

Tibshirani, R. (1996) "Regression shrinkage and selection via the lasso" *Journal of the Royal Statistical Society. Series B (Methodological)* **58(1)**, 267-288.

Tolentino, P.E. (2010) "Home country macroeconomic factors and outward FDI of China and India" *Journal of International Management* **16(2)**, 102-120.

United Nations Conference on Trade and Development (UNCTAD). (2015) Investment policy framework for sustainable development, United Nations.

United Nations Conference on Trade and Development (UNCTAD). (2021a) "World investment report". Available at https: / / unctad. org/ topic/ investment/ world- investment- report (Accessed: 30 October 2021).

United Nations Conference on Trade and Development (UNCTAD). (2021b) "UNCTADStat" Data Center. Available at https: / / unctadstat. unctad. org/ EN/ Index. html (Accessed: 30 October 2021).

United Nations Conference on Trade and Development (UNCTAD). (2021c). UNCTAD productive capacities index methodological approach and results, United Nations Publication: Geneva.

Uttama, N.P. and R. Promnart (2022) "Shadow economy and the efficiency of FDI inflow: The case of ASEAN economies" International Journal of Economics and Business Research **23(2)**, 136-155.

You, W., Y. Zhang and C-C. Lee (2021) "The dynamic impact of economic growth and economic complexity on CO2 emissions: An advanced panel data estimation" *Economic Analysis and Policy* **73**, 112-128.

Zou, H. (2006) "The Adaptive Lasso and Its Oracle Properties" *Journal of the American Statistical Association* **101(476)**, 1418-1429.