Journal of Agricultural and Applied Economics, 45,4(November 2013):617–637

Causality among Foreign Direct Investment and Economic Growth: A Directed Acyclic Graph Approach

Yarui Li, Joshua D. Woodard, and David J. Leatham

With the aim of examining the causal structure between foreign direct investment (FDI) and economic growth, this study derives inductive causal inference using the directed acyclic graph approach, which makes no a priori causal assumptions. There are three major findings of this study. First, economic growth causes FDI inflows for developing countries, whereas FDI induces economic growth for developed countries. Second, trade is an important intermediary to facilitate the interaction between FDI and other factors. Third, the stock market is found to be an intermediary that amplifies the influence on FDI from many causal variables of FDI for developed countries.

Key Words: causality, economic growth, DAG, FDI

JEL Classification: F21

Foreign direct investment (FDI) is believed to be an important factor contributing to economic growth. However, previous studies find conflicting results regarding the relationship between FDI and economic growth. Some studies find a positive relationship between FDI and economic growth (see, e.g., Neuhaus, 2006) and argue that FDI boosts growth through capital accumulation and through technology transfer spillover effects, whereas other studies conclude that FDI can distort resource allocation, that the effect is highly conditional on country-specific trade policies and other institutional factors, and that in some cases, FDI can actually inhibit economic growth (see, e.g., Boyd and Smith, 1992; Brecher, 1983; Brecher and Diaz-Alejandro, 1977).

Conflicting findings in earlier studies have aroused interest in identifying the causal patterns between FDI and economic growth to better understand their interaction. FDI-led growth is a long-held causal assumption backed by both endogenous growth theory and many empirical studies (De Mello, 1999). Endogenous growth theory proposes that long-run economic growth is determined by forces that are internal to the economic system and that create technological knowledge. These forces may result from research and development undertaken by profit-seeking firms; from economic policies with respect to trade, competition, education, and taxes; and from accumulation of intellectual property. Because FDI is expected to encourage the use of new inputs/technologies and investment in human capital, one might expect that FDI should lead to economic growth in the recipient country, yet both endogenous growth theory and the FDI-led growth assumption

Yarui Li is a graduate student, Department of Agricultural Economics, Texas A&M University, College Station, Texas. Joshua D. Woodard is an assistant professor, Dyson School of Applied Economics and Management, Cornell University, Ithaca, New York. David J. Leatham is a professor, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

have been challenged in recent years (Barro and Sala-i-Martin, 1992; Evans, 1996; Mankiw, Romer, and Weil, 1992), and a growth-driven FDI hypothesis has been developed as an alternative, which argues that economic growth attracts FDI by opportunistic investors.

We argue that neither the endogenous growth nor growth-driven FDI explanations may serve as absolute rules and instead opt for a more institutional explanation. When making investment decisions, investors may take into account many more factors than those that classical theories suggest (Laudicina, Gott, and Phol, 2010; Laudicina and Pau, 2008). For example, concerns regarding political, social, and environmental risks likely play a large role in both attracting FDI and its effectiveness in stimulating economic growth. Large developed economies such as United States and Germany attract FDI from investors seeking safety, whereas emerging economies such as China, India, and Brazil likely draw investors seeking access to new markets. Safe markets are those characterized as having stable macroeconomic environments (e.g., low currency volatility, interest rate risk, and energy prices) and governments/institutions but usually are quite competitive and developed. On the other hand, emerging markets usually have a large untapped consumer base, low labor costs, abundant natural resources, and the potential for faster economic growth but often lack the institutional structures and investment necessary to realize their potential.

This institutional view is supported by recent industry approaches to evaluating FDI opportunities. For example, surveys of business executives collected by Laudicina, Gott, and Phol (2010) and Laudicina and Pau (2008)—which serve as the basis for the *A.T. Kearney Foreign Direct Investment Confidence Index*®[1]—support that FDI is mediated by economic, political, and social factors in determining impacts on economic growth. Accordingly, the impact of FDI may therefore be offset or strengthened by the influence from these other factors. Moreover, FDI is expected to interact with these mediating factors differently in developing economies versus developed economies. This is consistent with the view that the motivation for FDI varies based on an investor's preferences (safety versus opportunity-seeking) and that the nature of FDI may differ dramatically among developed and developing countries.

The purpose of this study is to examine the causal structure between FDI and economic growth in conjunction with other institutional, economic, political, and social factors considered. In doing so, this study attempts to shed light on both the direct and indirect causation between FDI and economic growth and also distinguishes between different causal patterns in developing and developed countries and with respect to other mediating institutional and social factors.

Three main questions are addressed in this study. First, is a change in FDI the cause or the effect of a change in economic growth? Second, how does FDI interact with economic, social, and political factors to affect economic growth either directly or indirectly? Third, how does FDI work differently in developing countries and developed countries?

The contributions of this study are threefold. First, no a priori assumptions are made about the relationship among FDI, gross domestic product (GDP), and other variables; instead, an inductive directed acyclic graph (DAG) approach is applied to identify causal structure among these variables. Second, a comprehensive data set is compiled, which contains a variety of institutional, political, and social factors in addition to economic variables. Third, we explicitly investigate whether the nature of FDI differs in developed and developing countries.

The rest of the study is organized as follows. Section two provides a literature review. Section three introduces and illustrates causal modeling under the DAG approach. Section four discusses the data. Section five presents results. Section six concludes and discusses the limitations of this study.

[1] The *A.T. Kearney Foreign Direct Investment Confidence Index*® results from a regular survey of global executives conducted by A.T. Kearney, a management consulting firm. The aim of the index is to provide intelligence for international investment flows. A.T. Kearney reports that companies participating in the survey account for more than $2 trillion in annual global revenue (www.atkearney.com/gbpc/foreign-direct-investment-confidence-index).

Literature Review

Previous studies use a variety of methods to identify causal patterns between FDI and economic growth. For example, Li and Liu (2005) investigate causality between FDI and growth from an endogeneity perspective in a simultaneous equation framework. They use a bilateral causality test and find that the degree of endogeneity between FDI and economic growth varies based on the sample period in their data. Carkovic and Levine (2002) control for simultaneity and country-specific effects by using a dynamic panel model to examine the interaction between FDI and economic growth. They do not find a robust causal link between FDI and economic growth. Chowdhury and Mavrotas (2006) adopt a methodological approach, namely the Toda-Yamamoto test for causality, to explore causality between FDI and growth in Chile, Malaysia, and Thailand. They find strong evidence of a bidirectional causality between GDP and FDI. Hansen and Rand (2006) use a Granger causation framework and a standard neoclassical growth model and find a strong causal link from FDI to GDP.

The methods used by these studies have two points in common. First, the relationship between FDI and economic growth (GDP) is estimated with econometric models and then causality tests are conducted to verify the a priori causal assumptions. As such, these methods follow the notion that causation is defined from an underlying set of maintained hypotheses (e.g., restrictive optimizing behavior) but is not to be formulated by looking at data. Some would argue that the use of such a priori assumptions assumes most of the problem away. Although such a priori causal assumption approaches were considered hugely successful in the first half of the 20th century (see, e.g., work by Samuelson and Hicks, which was worthy of Nobel prizes in the 1970s), they have perhaps been considered less successful because of their failures in explaining observed empirical data (Bessler, 2010). As Bessler points out, although such a priori causal assumption models may serve as a reasonable starting point for analyzing aggregate observational data, they by no means govern the way that observational data must interact in reality. This is all just to say, simply, that one should be cognizant of the fact that the conclusions that flow from such models are not independent of the a priori assumptions inherent in their construction. Insofar that this is the case, the results from this framework can be misleading if this fact is forgotten. Thus, we use the DAG approach in this study to overcome such problems inherent in the a priori causation assumption approach to estimate the causal relationship between FDI and economic growth.

The second point in common is that only a small number of economic variables are considered in most previous studies. Because FDI interacts with a large number of institutional, economic, political, and social factors, it is difficult to fully measure the indirect impact of FDI on economic growth based on only a small group of variables.[2] There are many studies, however, that give useful information regarding the factors that FDI generally affects. For example, Zhang (2001) finds that the role of FDI in host economies seems country-specific and sensitive to the host's economic conditions, trade policy, and export propensities. Fallon, Cook and Billimoria (2001) suggest that government assistance and education levels are significant positive determinants of FDI, whereas the size of the regional population has a negative effect on FDI inflows. In addition, unemployment and average regional wage earnings are also found to be important. Pfaffermayr (1996) discovers significant causality of FDI and exports in both directions. In De Backer and Sleuwaegen (2003), evidence is found that suggests that import competition and FDI crowd out domestic entrepreneurship in both the product and labor markets. Borensztein, De Gregorio, and Lee (1998) emphasize the interactions between human capital and the efficiency of FDI and find that FDI has positive effects on economic growth only if the level of education exceeds a given threshold. The relationship between

[2] We would add, as a qualification, that the choice of which variables to include in an analysis is also a sort of a priori assumption that necessarily conditions the conclusions, albeit this choice is often forced by data availability (unavailability).

FDI and the stock market activity is studied in Claessens, Klingebiel, and Schumkler (2002), who conclude that FDI is a complement, rather than a substitute, for domestic stock market development. Froot and Stein (1991) examine the connection between exchange rates and FDI; their empirical results confirm the popular claim that a depreciated currency can boost FDI. Finally, Michie (2001) suggests that human capital is more likely to be developed by domestic government investment as a way of attracting inward investment as opposed to inward investment flows leading to the development of human capital.

As a complement to academic studies, methodology of the *A.T. Kearney Foreign Direct Investment Confidence Index*® (Laudicina, Gott, and Phol, 2010; Laudicina and Pau, 2008) provides additional direction regarding the potential interaction between FDI and other factors. The *Index* is prepared using proprietary survey data from senior executives of large corporations. Participating companies represent 44 countries and span 17 industry sectors across all six inhabited continents. Together, the companies comprise more than $2 trillion in annual global sales and are responsible for more than 75% of global FDI flows (Laudicina, Gott, and Phol, 2010). These reports suggest a close connection between FDI and the many political and social factors we consider in this study. For example, the 2008 report (Laudicina and Pau, 2008) cited uncertainty surrounding 2008 elections as a significant factor that influenced foreign investments in the United States. The unpredictability in the political, legal, and institutional environments was also cited as a major determinant of FDI in China. Sustainability issues are also found to be important determinants of investor behavior as it regards FDI and include issues such as climate change, natural resource exploitation, overpopulation, and the wealth/income gap.

To sum up, most previous studies that investigate the impact of FDI use models implied by a priori causal systems approaches and may embody inherent biases. Arguably, when the aim is to identify causal patterns, the DAG approach may be more appropriate because it makes no a priori causal assumptions, but rather lets the data speak for themselves. Moreover, because FDI interacts with a large number of other factors, the use of a small group of variables in such models is not adequate to capture the richness of the various direct and indirect interactions among FDI and economic growth and may exaggerate their direct interaction. We use a comprehensive data set consisting of not only economic, but also institutional, political, and social variables to more fully account for the direct and indirect interactions between FDI and economic growth. Also, in view of the fact that investors make an FDI decision with different financial objectives, causal patterns in developing economies are examined comparatively to those in developed economies.

Causal Modeling—Directed Acyclic Graph

Empirical studies in economics have primarily relied on economic theory or researchers' intuitions to identify the structure and parameters of economic models (Kwon and Bessler, 2011). However, theory is oftentimes too heterogeneous to provide a conclusive causal structure or does not provide sufficient information to identify the underlying causal structure. Moreover, such a priori models fail to define the way observational data must interact and may provide incorrect causal inference. Distinguished from "deductive causation," which arises from either innate ideas or from mathematics on assumed behavior, "inductive causation" relies on observational data and infers a causal graph from conditional independencies among variables. As a basis for inductive causal inference in econometrics, the DAG method has been applied to many research topics, e.g., environmental and economic sustainability (Bessler, 2005), market integration and price discovery (Bizimana, Angerer, and Bessler, 2012), and price dynamics in agricultural markets (Bessler and Akleman, 1998; Bessler, Yang, and Wongcharupan, 2003), among others.

A directed graph uses arrows and vertices to illustrate the causal relationships among variables, whose values are measured in nontime sequence. Vertices connected by an edge are said to be adjacent. A directed edge is an edge that has an arrow indicating its causal direction, whereas undirected edge does not have a causal direction. If we have a set of vertices (A, B, C, D), the undirected graph contains only undirected edges, for example A−B. A directed graph contains only directed edges, for example C → D. An acyclic graph is one for which there is no path from any given variable, which leads back to that variable. For example, the path A → B → C → D → A is labeled as "cyclic" because we move from A to B but then return to A by way of C. A DAG is a directed graph that contains no directed cyclic paths. Because cyclic graphs are not identifiable, only acyclic graphs are discussed in this article. The terms from genealogy are used when referring to variables in causal model. For example, in the path

A → B → C, the variables A and B are ancestors of variable C. Variable C is the descendent of variables A and B. Variable A is the grandparent of variable C and parent of variable B.

There are several algorithms discussed in the machine learning literature that can be used to identify DAGs. This study uses the PC algorithm (Bessler, 2003). Three conditions should be satisfied to apply the PC algorithm. First, the causal Markov condition, which states that given its parents, a variable should be conditionally independent of its nondescendants. The second condition requires that no variable is omitted, which causes two or more other variables selected for analysis. The last condition requires that a zero correlation between variables should not be the results of cancellations of deeper parameters connecting these variables.

The PC algorithm determines the causal pattern among a set of variables in three steps. First, starting with a completely undirected graph, each variable in the set is connected to every other variable through an undirected edge, i.e., the graph shown in Figure 1. Next, edges between variables are removed if the null hypothesis cannot be rejected that the correlation between any two variables is not significantly different from zero. Edges that remain are said to survive "zero order conditioning" and these edges are subjected to a series of

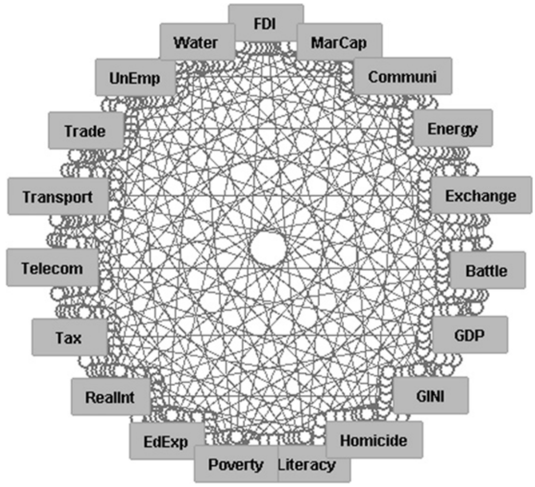
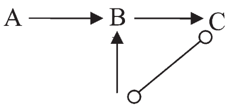


Figure 1. Complete Undirected Graph on 19 FDI Related Variables

first-order conditioning tests with the null hypothesis that the conditional correlation between any two variables on a third variable is not significantly different from zero. Edges are removed if the null hypothesis cannot be rejected. The test of second- and higher-order conditioning then continues following the same rule. Last, an arrow (direction) is assigned to each of the surviving edges according to the directional separation (d-separation) definition, which is given in Pearl (2000):

> Definition: X, Y, and Z are three disjoint sets of variables. A path p is said to be d-separated by a set of nodes Z if and only if 1) p contains a chain $i \to m \to j$ or a fork $i \leftarrow m \to j$ such that the middle node m is in Z; or 2) p contains an inverted fork (or collider) $i \to m \leftarrow j$ such that the middle node m is not in Z and such that no descendant of m is in Z. A set Z is said to d-separate X from Y if and only if Z blocks every path from a node in X to a node in Y.

The reasoning of sorting out causal patterns by d-separation can be illustrated by a simplified example. There are four variables (A, B, C, D) and corr (A, D) = 0 and corr (A, C) ≠ 0. Assume we find that corr (A, D| B) ≠ 0 and corr(A, C| B) = 0, which means variables A and D are d-connected, whereas variables A and C are d-separated. According to the d-separation definition, there exists three possible DAGs for variables A and C, which are A → B → C, A ← B ← C, and A ← B → C. Using only this information we cannot determine which graph presents the true causal pattern between variables A and C; however, when coupled with the unique directed graph for variable A and D (A → B ← *D*), a complete directed graph can be drawn for these four variables as follows:

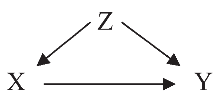


When analyzing real-world problems, a large number of variables is tested and the causal patterns are much more complicated. TETRAD IV, a software program developed at Carnegie Mellon University, is used for the estimation in this study.

After causal structure is identified, parameters are estimated. Generally, for two indirectly connected variables, X and Y (no impact from a third variable), ordinary least squares (OLS) regression may give unbiased and consistent estimate for $\partial Y/\partial X$. However, when a back door problem occurs, which means a third variable is causing both X and Y, the OLS estimate of Y on X is biased and inconsistent. In this case, parameters can be estimated in one of the following three ways—the back door method, the front door method, or the instrumental variable method (Bessler, 2010).

Back Door Method

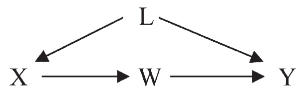
A set of variables Z satisfies the back door criterion relative to X and Y if 1) no variables in Z are descendants of X; and 2) Z blocks every path between X and Y that contains an arrow into X. For example,



In the graph, X, Y, and Z are three variables, and Z blocks flow from X to Y through the back door. Given Z can be observed, OLS works to block the back door, and a regression of Y on X and Z gives an unbiased and consistent estimate of $\partial Y/\partial X$.

Front Door Method

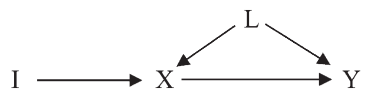
A set of variables, W, meets the front door criterion relative to X and Y if 1) W intercepts all paths directed from X to Y; 2) there is no unblocked back door path from X to W; and 3) all back door paths from W to Y are blocked by X. For example,



In the graph, X, Y, and W are three variables and L is a latent variable. There are three steps to calculate $\partial Y/\partial X$. The first step is regressing Y on W and X to get an unbiased and consistent OLS estimate of $\partial Y/\partial W$. Next, regress W on X to get the OLS estimate of $\partial W/\partial X$. Last, $\partial Y/\partial X$ is then calculated as $\frac{\partial Y}{\partial W}\cdot\frac{\partial W}{\partial X}$.

Instrumental Variable Method

If one does not have observable variables Z or W that satisfy the back door or front door criteria, one may have to look for an instrumental variable I such that it causes X and causes Y only through X. For example,



In the graph, X and Y are two variables, I is an instrumental variable for X, and L is a latent variable. To calculate $\partial Y/\partial X$, first regress X on I and find the predictor of X based on I (call the predictor X^*). Then, regress Y on X^* to find the unbiased and consistent estimate of $\partial Y/\partial X$.

In addition to the methods discussed, the Appendix also summarizes the other calculations of $\partial Y/\partial X$ for basic causal patterns.

Although DAG has gradually demonstrated its usefulness to address such identification issues (Kwon and Bessler, 2011), there are some limitations of the method and the PC algorithm as well. First, DAG may give misleading results when one attempts to infer causal relations among variables where one or more of the variables has an infinite variance (Bessler, 2005). Second, variables used in a DAG model need to follow a multivariate normal distribution for the model to be fully efficient. Third, the PC algorithm result depends on the significance level chosen by the researcher in determining edges. Namely, for the algorithm to converge to all correct decisions with a probability of 1, the significance level used in making the decisions should decrease as the sample size increases. Thus, the use of higher significance levels may improve performance in small sample sizes (Sprites, Glymour, and Scheines, 2000).

Data

As motivated by previous research, the 19 variables are used in the analysis for calendar year 2008, for which the most recent data are available, and are reported in Table 1. FDI per capita is defined as FDI net inflows based on current US dollars divided by total population. GDP per capita is defined as GDP based on current US dollars divided by total population. GDP per capita is used as the proxy for economic development. Unemployment rate is defined as the percentage of total labor force that is unemployed and is looking for a paid job and is suggested by Fallon, Cook and Billimoria (2001) to be an important factor in FDI decisions. Tax rate is defined as tax as a percentage of net profit by the World Development Report 2007/2008. The tax rate is reported as a major concern for FDI investors in Laudicina and Pau (2008). Trade is defined as the share of imports plus exports in GDP. The inclusion of trade is based on the findings of Laudicina and Pau (2008) and Pfaffermayr (1996).

Literacy rate is defined as the percentage of those aged 15 years and older who are literate, and public educational expenditure is defined as a percentage of GDP. These two measures are used as proxies for education level, as suggested by Fallon, Cook, and Billimoria (2001). Official exchange rate is defined as the annual average of the local currency per US dollar. Froot and Stein (1991) show a significant connection between exchange rate and FDI.

Real interest rate is calculated as $\frac{1 + r_{nominal}}{1 + r_{inflation}} - 1$. Data for both inflation rates and nominal interest rates are from the World Development Report. Market capitalization per capita is defined as the total market value of all listed companies' outstanding shares divided by total population. Claessens, Klingebiel, and Schumkler (2002) report a complementary relationship between stock market activity and FDI. GINI index is defined as the ratio of the area below the Lorenz Curve to the area below the diagonal, as suggested by Laudicina and Pau (2008). Poverty gap at \$2 a day is defined as the percentage of each country's population living on \$2 or less per day.

Four sectors are examined for project investment: energy, telecommunication, transportation, and water. As a result of data unavailability for developed countries, these four variables are only used in the model for developing countries. These variables are defined as the total investment in each sector based on current US dollars divided by total population, as suggested by Laudicina and Pau (2008).

Homicide rate is defined as homicides per 100,000 population, and battle-related death is defined as the best estimate of annual battle fatalities. These two variables are used as the proxy for social stability. Communist social system is a dummy variable that indicates whether a country is implementing or has ever implemented communism. There are no developed communist countries, so this variable is only used in a developing country model.

Table 1 summarizes the descriptive statistics of the 19 variables and lists their acronyms. The countries considered are listed in Table 2 (61 developing and 27 developed countries). Data availability is the major criteria for including a country in our list. Many developing countries in Africa and the Middle East are omitted because data are not available. Thus, when we try to explain the causal patterns between FDI and economic growth from the perspective of

Table 1. Descriptive Statistics of Variables

Variable	Acronyms	Mean for Developing Countries	Mean for Developed Countries	Minimum	Country	Maximum	Country
FDI per capita	FDI	$291.52	$8,971.12	–$3,691.76	Ireland	$201,565.20	Luxembourg
GDP per capita	GDP	$5,181.71	$47,828.60	$7.98	Zimbabwe	$117,954.68	Luxembourg
Unemployment rate	UnEmp	13.60%	5.32%	2.60%	Norway	80%	Zimbabwe
Tax rate	Tax	43.86%	42.85%	10.40%	Namibia	108%	Argentina
Trade	Trade	89.87%	117.80%	27.20%	United States	423.11%	Singapore
Literacy rate	Literacy	87.49%	98.26%	48.70%	Cote d'Ivoire	99%	Most countries
Public educational expenditure	EdExp	4.36%	5.17%	0.90%	Nigeria	8.25%	Moldova
Official exchange rate	Exchange	See data section					
Real interest rate	RealInt	0.83%	2.72%	11.52%	Kazakhstan	37.11%	Brazil
Market capitalization per capita	MarCap	$1,493.94	$34,482.64	$17.77	Kyrgyz Republic	$190,440.55	Hong Kong
GINI index	GINI	43.48	32.03	24.7	Denmark	74.3	Namibia
Investment in energy sector	Energy	$126.07	N/A	$0	Some countries	$604.72	Bulgaria
Investment in telecom. sector	Telecom	$266.43	N/A	$0	Some countries	$1,177.04	Croatia
Investment in transportation sector	Transport	$82.85	N/A	$0	Some countries	$612.71	Malaysia
Investment in water sector	Water	$23.12	N/A	$0	Some countries	$375.50	Malaysia
Poverty gap at $2 a day	Poverty	27.95%	10.99%	0.01%	Singapore	86.00%	Zambia
Homicide rate	Homicide	13.2361	1.4179	0.405	Morocco	68.0391	South Africa
Battle-related death	Battle	217.55	24.7407	0	Most countries	6665	Pakistan
Communism social system	Communi	See data section					

FDI, foreign direct investment; GDP, gross domestic product; N/A, not available because the variable is a dummy variable.

Table 2. Countries Studied

Developing		Developed
Argentina	Malaysia	Australia
Armenia	Mauritius	Austria
Bangladesh	Mexico	Belgium
Bolivia	Moldova	Canada
Botswana	Mongolia	Denmark
Brazil	Morocco	Finland
Bulgaria	Namibia	France
Chile	Nepal	Germany
China	Nigeria	Greece
Colombia	Pakistan	Hong Kong SAR, China
Costa Rica	Panama	Iceland
Cote d'Ivoire	Papua New Guinea	Ireland
Croatia	Paraguay	Israel
Ecuador	Peru	Italy
Egypt, Arab Rep.	Philippines	Japan
El Salvador	Poland	Korea, Rep.
Georgia	Romania	Luxembourg
Ghana	Russian Federation	Netherlands
Guyana	Serbia	New Zealand
India	South Africa	Norway
Indonesia	Swaziland	Portugal
Iran, Islamic Rep.	Thailand	Singapore
Jamaica	Tunisia	Spain
Jordan	Turkey	Sweden
Kazakhstan	Ukraine	Switzerland
Kenya	Uruguay	United Kingdom
Kyrgyz Republic	Venezuela, RB	United States
Latvia	Vietnam	
Lebanon	Zambia	
Lithuania	Zimbabwe	
Macedonia, FYR		

the whole developing economies and developed economies, we would qualify that our results may embody selection effects toward applicability to these countries.

Cross-section data for 2008 are used, which are the most recent available data as of the writing of this study. Data come from a variety of sources including the "World Development Indicator" data set of the World Bank Table, the "World Factbook" of the CIA, the World Trade Organization, and the Battle Deaths Dataset from the Center for the Study of Civil War.

Empirical Results

Results for Developing Countries

First, preliminary results are presented by examining the correlation matrix reported in Table 3. At 5% significance level, FDI is found to be significantly correlated with GDP and eight other variables. GDP is estimated to have a significant correlation with many other variables as well. Except for official exchange rate, all the other variables are significantly correlated with at least one other variable. Thus, we can reasonably expect significant direct and indirect causal flows between FDI and GDP and among other variables.

Next, we discuss the results of the DAG analysis. The resulting pattern is presented in Figure 2. Arrows indicate directions of causation and signs indicate whether a causal variable and its effect variable are positively (+) or negatively (–) correlated. A chi-square test is performed by the PC algorithm on the null hypothesis that "the population covariance matrix over all of the measured variables is equal to the estimated covariance matrix over all of the measured variables written as a function of the free model parameters" (TETRAD IV User's Manual). The DAG method assumes variables follow multivariate normal distributions, for which correlation is the canonical measure (Embrechts, McNeil, and Straumann, 1999). Under this assumption, all the information about the dependence structure among variables is expected to be conveyed by their covariance matrix. If the population covariance matrix is equal to the estimated covariance matrix, then the causal structure derived from the estimated covariance matrix is expected to be valid. After applying the PC algorithm, a p value of 0.6382 for chi-square test is reported. Thus, we fail to reject the null hypothesis and conclude that the causal structure obtained from the PC algorithm is valid.

Examining Figure 2 tier by tier, the first tier contains the variable of interest—FDI, and the second tier consists of those variables with

Table 3. The Correlation Matrix for Developing Countries

	GDP	UnEmp	Tax	Trade	Literacy	EdExp	Exchange	RealInt	MarCap	GINI	Poverty	Energy	Telecom	Transport	Water	Homicide	Battle	Communi
FDI	0.631*	–0.257*	–0.115	0.203	0.463*	–0.132	–0.169	0.086	0.395*	–0.241	–0.353*	0.449*	0.560*	0.424*	0.235	–0.259*	–0.142	–0.157
	(0.000)	(0.047)	(0.383)	(0.119)	(0.000)	(0.315)	(0.197)	(0.516)	(0.002)	(0.064)	(0.006)	(0.000)	(0.000)	(0.001)	(0.071)	(0.046)	(0.278)	(0.231)
GDP		–0.349*	0.032	–0.046	0.518*	–0.051	–0.198	0.158	0.421*	–0.037	–0.415*	0.310*	0.731*	0.382*	0.218	–0.133	–0.156	–0.055
		(0.006)	(0.808)	(0.729)	(0.000)	(0.700)	(0.130)	(0.227)	(0.001)	(0.779)	(0.001)	(0.016)	(0.000)	(0.003)	(0.094)	(0.310)	(0.234)	(0.675)
UnEmp			–0.110	–0.169	–0.282*	0.100	–0.048	–0.600*	–0.141	0.262*	0.565*	–0.254	–0.249	–0.191	–0.140	0.324*	–0.031	–0.049
			(0.401)	(0.197)	(0.029)	(0.447)	(0.717)	(0.000)	(0.282)	(0.043)	(0.000)	(0.050)	(0.055)	(0.145)	(0.286)	(0.012)	(0.816)	(0.710)
Tax				–0.311*	0.148	0.088	–0.081	–0.118	–0.118	0.065	–0.083	0.059	–0.135	–0.100	–0.080	0.010	0.019	0.299*
				(0.016)	(0.260)	(0.506)	(0.537)	(0.370)	(0.369)	(0.624)	(0.530)	(0.655)	(0.304)	(0.447)	(0.544)	(0.940)	(0.887)	(0.020)
Trade					0.264*	0.409*	0.110	0.054	0.092	–0.159	–0.239	0.231	0.139	0.210	0.186	–0.181	–0.268*	–0.117
					(0.041)	(0.001)	(0.402)	(0.681)	(0.483)	(0.226)	(0.066)	(0.076)	(0.291)	(0.107)	(0.154)	(0.166)	(0.039)	(0.374)
Literacy						0.070	0.011	0.002	0.183	–0.019	–0.239	0.252	0.367*	0.265*	0.181	–0.156	–0.318*	0.089
						(0.597)	(0.931)	(0.985)	(0.163)	(0.883)	(0.066)	(0.052)	(0.004)	(0.041)	(0.166)	(0.234)	(0.013)	(0.501)
EdExp							–0.023	–0.056	–0.006	0.073	–0.026	–0.011	–0.009	–0.113	–0.119	0.049	–0.174	0.113
							(0.864)	(0.671)	(0.965)	(0.579)	(0.843)	(0.932)	(0.943)	(0.390)	(0.363)	(0.712)	(0.183)	(0.388)
Exchange								–0.053	–0.151	–0.079	–0.075	–0.173	–0.247	–0.149	–0.078	–0.086	–0.038	0.129
								(0.690)	(0.248)	(0.550)	(0.571)	(0.187)	(0.057)	(0.257)	(0.552)	(0.512)	(0.775)	(0.326)
RealInt									0.110	0.067	–0.189	0.180	0.158	0.147	0.084	–0.155	0.013	0.095
									(0.402)	(0.613)	(0.148)	(0.169)	(0.228)	(0.263)	(0.521)	(0.236)	(0.922)	(0.471)
MarCap										0.165	–0.227	0.374*	0.388*	0.650*	0.517*	0.183	–0.098	0.042
										(0.207)	(0.082)	(0.003)	(0.002)	(0.000)	(0.000)	(0.162)	(0.454)	(0.751)
GINI											0.388*	0.109	–0.188	0.152	0.171	0.464*	–0.135	0.106
											(0.002)	(0.407)	(0.151)	(0.248)	(0.192)	(0.000)	(0.303)	(0.421)
Poverty												–0.235	–0.315*	–0.247	–0.148	0.411*	–0.007	0.066
												(0.070)	(0.014)	(0.057)	(0.258)	(0.001)	(0.956)	(0.617)
Energy													0.359*	0.575*	0.584*	–0.120	–0.046	–0.021
													(0.005)	(0.000)	(0.000)	(0.361)	(0.727)	(0.873)
Telecom														0.363*	0.031	–0.029	–0.134	–0.111
														(0.004)	(0.816)	(0.824)	(0.308)	(0.398)
Transport															0.745*	–0.079	–0.083	–0.114
															(0.000)	(0.549)	(0.529)	(0.386)
Water																–0.102	–0.036	–0.005
																(0.438)	(0.785)	(0.971)
Homicide																	–0.046	0.111
																	(0.727)	(0.399)
Battle																		–0.106
																		(0.420)

GDP, gross domestic product; FDI, foreign direct investment.

* Indicates that a correlation coefficient is significantly different from zero at 5% significance level.

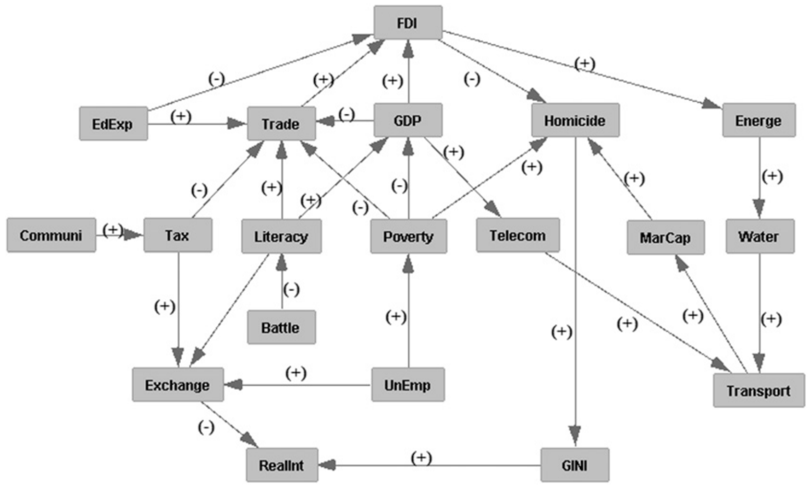


Figure 2. Causal Pattern of 19 FDI Related Variables, Estimated with TETRAD IV for 61 Developing Countries

which FDI is directly correlated. GDP, trade, and educational expenditure are the three direct causal variables to FDI. GDP and trade have a positive impact on FDI, whereas educational expenditure affects FDI negatively. GDP is a typical indicator used to measure a country's economic health and thus higher GDP signals opportunity and attracts FDI. Next, a larger volume of trade implies a higher level of globalization of the host economy, which represents a more favorable environment for FDI investment. Last, the negative impact of educational expenditure on FDI conforms to the finding in Michie (2001) and is consistent with a lagged effect of education enhancement on a host country's economic attractiveness. In addition to their direct impacts on FDI, GDP and educational expenditure are also found to have an indirect impact on FDI through an intermediary variable: trade. Their indirect impacts have an opposite sign to their direct impacts, respectively, which makes their overall effect on FDI ambiguous. Coefficient estimation is discussed next to clarify this ambiguity.

To estimate the impact of GDP and educational expenditure on FDI accounting for their indirect effects through an intermediary variable—trade, an unbiased estimate of the coefficient between trade and FDI is required. This estimate can be obtained by applying OLS to the following equation:

$$FDI = \alpha_0 + \alpha_1 Trade + \alpha_2 GDP + \alpha_3 EdExp + \varepsilon_1. \tag{1}$$

With GDP and educational expenditure as explanatory variables, $\hat{\alpha}_1$ captures the direct interaction between trade and FDI, whereas the indirect correlation between these two variables is blocked out by conditioning on GDP and educational expenditure (Table 4-1). There are three other variables that also affect FDI through their impact on trade: tax rate, literacy rate, and poverty level. However, these variables are not incorporated in equation (1), because there exists no back door problem among these variables and FDI. According to Figure 2, trade is the parent of tax rate, literacy rate, and poverty level and FDI is the grandparent. Based on the Markov condition stated in section two, these three variables are conditionally independent of FDI given trade. Thus, there is no need to include them to obtain an unbiased estimate of $\hat{\alpha}_1$.

After obtaining $\hat{\alpha}_1$, the rest of the estimation is straightforward. We take GDP as an example. By estimating the following two equations:

$$FDI = \beta_0 + \beta_1 GDP + \varepsilon_2 \tag{2}$$

$$Trade = \gamma_0 + \gamma_1 GDP + \varepsilon_3 \tag{3}$$

we obtain unbiased estimates of β_1 and γ_1. So, the direct impact of GDP on FDI is captured by

Table 4. Regressions of Foreign Direct Investment Per Capita on Alternative Causal (independent) Variables for Developing Countries

No.	Causal pattern	Regressions	Coefficient	Estimation	Elasticity at mean
1	EdExp → Trade; EdExp → FDI; Trade → FDI; Trade → GDP; GDP → FDI	According to back-door criteria, $FDI = \alpha_0 + \alpha_1 Trade + \alpha_2 GDP + \alpha_3 EdExp + \varepsilon_1$	$\hat{\alpha}_1 = 2.7078$* (0.0026)	$\frac{\partial FDI}{\partial Trade} = \hat{\alpha}_1 = 2.7078$	0.8348
2	EdExp → Trade $\xrightarrow{\hat{\alpha}_1}$ FDI; EdExp → FDI	According to Appendix eq.3, $FDI = \varphi_0 + \varphi_1 EdExp + \varepsilon_4$; $Trade = \phi_0 + \phi_1 EdExp + \varepsilon_5$	$\hat{\varphi}_1 = -25.4848$ (0.3152); $\hat{\phi}_1 = 9.5790$* (0.0012)	$\frac{\partial FDI}{\partial EdExp} = \hat{\varphi}_1 + \hat{\alpha}_1\hat{\phi}_1 = 0.4532$	0.0068
3	GDP → Trade $\xrightarrow{\hat{\alpha}_1}$ FDI; GDP → FDI	According to Appendix eq.3, $FDI = \beta_0 + \beta_1 GDP + \varepsilon_2$; $Trade = \gamma_0 + \gamma_1 GDP + \varepsilon_3$	$\hat{\beta}_1 = 0.0498$* (0.0000); $\hat{\gamma}_1 = -0.0004$ (0.7290)	$\frac{\partial FDI}{\partial GDP} = \hat{\beta}_1 + \hat{\alpha}_1\hat{\gamma}_1 = 0.0487$	0.8656
4	Literacy → Trade $\xrightarrow{\hat{\alpha}_1}$ FDI	According to Appendix eq.2, $Trade = \delta_0 + \delta_1 Literacy + \varepsilon_6$	$\hat{\delta}_1 = 0.7411$* (0.0412)	$\frac{\partial FDI}{\partial Literacy} = \hat{\alpha}_1 \frac{\partial Trade}{\partial Literacy} + \frac{\partial GDP}{\partial Literacy}\frac{\partial FDI}{\partial GDP}$ $= \hat{\alpha}_1\hat{\delta}_1 + \hat{\lambda}_1(\hat{\beta}_1 + \hat{\alpha}_1\hat{\gamma}_1)$ $= 9.4055$	2.8228
	Literacy → GDP → FDI; GDP → Trade $\xrightarrow{\hat{\alpha}_1}$ FDI	According to Appendix eq.3, $GDP = \lambda_0 + \lambda_1 Literacy + \varepsilon_7$	$\hat{\lambda}_1 = 151.9243$* (0.0000)		
5	Poverty → Trade $\xrightarrow{\hat{\alpha}_1}$ FDI	According to Appendix eq.2, $Trade = \upsilon_0 + \upsilon_1 Poverty + \varepsilon$	$\hat{\upsilon}_1 = -0.5116$ (0.0665)	$\frac{\partial FDI}{\partial Poverty} = \hat{\alpha}_1 \frac{\partial Trade}{\partial Poverty} + \frac{\partial GDP}{\partial Poverty}\frac{\partial FDI}{\partial GDP}$ $= \hat{\alpha}_1\hat{\upsilon}_1 + \hat{\omega}_1(\hat{\beta}_1 + \hat{\alpha}_1\hat{\gamma}_1)$ $= -5.9158$	-0.5671
	Poverty → GDP → FDI; GDP → Trade $\xrightarrow{\hat{\alpha}_1}$ FDI	According to Appendix eq.3, $GDP = \omega_0 + \omega_1 Poverty + \varepsilon$	$\hat{\omega}_1 = -93.0295$* (0.0010)		
6	Tax → Trade $\xrightarrow{\hat{\alpha}}$ FDI	According to Appendix eq.2, $Trade = \eta_0 + \eta_1 Tax + \varepsilon_8$	$\hat{\eta}_1 = -0.6974$* (0.0157)	$\frac{\partial FDI}{\partial Tax} = \hat{\alpha}_1\hat{\eta}_1 = -1.8884$	-0.2841
7	Communi → Tax → Trade $\xrightarrow{\hat{\alpha}}$ FDI	According to Appendix eq.2, $Tax = \mu_0 + \mu_1 Communi + \varepsilon_9$	$\hat{\mu}_1 = 13.6020$* (0.0203)	$\frac{\partial FDI}{\partial Communi} = \hat{\mu}_1 \frac{\partial FDI}{\partial Tax} = \hat{\alpha}_1\hat{\eta}_1\hat{\mu}_1$ $= -25.6863$	-0.0147
8	Battle → Literacy → GDP → FDI; Literacy → TRD; GDP → TRD; TRD $\xrightarrow{\hat{\alpha}_1}$ FDI	According to Appendix eq.2, $Literacy = \rho_0 + \rho_1 Battle + \varepsilon_{10}$	$\hat{\rho}_1 = -0.0047$* (0.0132)	$\frac{\partial FDI}{\partial Battle} = \hat{\rho}_1 \frac{\partial FDI}{\partial Literacy} = \hat{\rho}_1[\hat{\alpha}_1\hat{\delta}_1 + \hat{\lambda}_1(\hat{\beta}_1 + \hat{\alpha}_1\hat{\gamma}_1)]$ $= -0.0442$	-0.0330
9	UnEmp → Poverty → GDP → F/P; Poverty → TRD; GDP → TRD; TRD $\xrightarrow{\hat{\alpha}_1}$ F/P	According to Appendix eq.2, $Poverty = \tau_0 + \tau_1 UnEmp + \varepsilon_{11}$	$\hat{\tau}_1 = 0.6341$* (0.0000)	$\frac{\partial FDI}{\partial UnEmp} = \hat{\tau}_1 \frac{\partial FDI}{\partial Poverty} = \hat{\tau}_1[\hat{\alpha}_1\hat{\upsilon}_1 + \hat{\omega}_1(\hat{\beta}_1 + \hat{\alpha}_1\hat{\gamma}_1)]$ $= -3.7512$	-0.1750

Note: the numbers in the parentheses are p values and * indicates that the coefficient is statistically significant at the 5% significance level.

$\hat{\beta}_1$ and the indirect counterpart is calculated as $\hat{\alpha}_1\hat{\gamma}_1$, which makes the total impact equal to $\hat{\beta}_1 + \hat{\alpha}_1\hat{\gamma}_1$ (Table 4-3).

The OLS estimate of α_1 is 2.7078, which is significant at the 5% significance level. Thus, an increase in trade by one percentage point of GDP results in an increase in FDI per capita of $2.7078. The elasticity of FDI with respect to trade is 0.8348, suggesting a 1% increase in trade volume results in a 0.83% increase in FDI per capita. Thus, FDI is inelastic with respect to trade volume. The direct positive impact (β_1) on FDI from GDP is significantly different from zero at the 5% significance level, whereas the indirect negative component is insignificant and smaller than the direct positive part. The sum of these opposite effects is equal to 0.0487, indicating that FDI per capita will increase by approximately \$0.05 when GDP per capita increases by \$1. The elasticity of FDI with respect to GDP is 0.86 at the mean.

We estimate the impact of educational expenditure on FDI in a similar way (Table 4-2). The direct negative impact of educational expenditure is not significantly different from zero at the 5% significance level, whereas the indirect positive impact is significant and larger than the direct negative impact. The resulting estimate of the total impact is 0.4532. So we expect that an increase in educational expenditure by one percentage point of GDP will cause an increase of approximately \$0.45 in FDI per capita net. The elasticity of FDI with respect to educational expenditure is 0.0068, which indicates a very small increase in FDI per capita when the educational spending as share of GDP increases by 1% (at the mean). This likely reflects that fact that educational spending is such a long time horizon investment.

The other two variables in the second tier are homicide rate and investment in energy projects, both of which are effect variables of FDI. FDI has a negative impact on homicide rate; presumably, this is the result of the fact that FDI inflows are expected to stimulate the local economy, leading to increased living standards and educational levels, which in turn reduces crime and homicide incidences. Regarding investment in energy projects, the spillover effect of FDI during the course of technology transfer should advance the techniques required by infrastructure projects and boost investment in the energy industry.

By examining the graph around these two variables further, we find positive causal patterns exist for the following four pairs of variables: investment in energy projects and water projects, investment in water projects and transportation projects, investment in transportation projects and market capitalization, and market capitalization and homicide rate. These positive effects suggest that FDI leads to improved water infrastructure construction through its effect on the energy industry. The investment in water projects passes on the positive impact from FDI to the transportation industry and then to financial markets (market capitalization) and social stability (homicide rate). Therefore, it is reasonable to expect an increase in FDI to indirectly advance water and transportation industries, which in turn lays the groundwork for improved financial market functioning and social stability.

The third tier is comprised of variables that are connected with FDI through variables in the second tier. The results suggest that a higher tax rate will depress FDI inflows through its negative effect on trade. Both higher literacy rates and lower poverty levels can increase trade activities, enhance GDP growth, and ultimately attract more FDI investment. An increase in FDI causes a reduction in the GINI index through its impact on social stability and equitable wealth distribution. That is, increased FDI enhances social stability and mitigates income divergence.

Because literacy rate has its impact on FDI through both trade and GDP, the estimate of its impact has two components. Running the following regressions:

$$(4) \qquad Trade = \delta_0 + \delta_1 Litera + \varepsilon_6$$

$$(5) \qquad GDP = \lambda_0 + \lambda_1 Litera + \varepsilon_7$$

we obtain unbiased estimates of δ_1 and λ_1. Based on the impact of trade ($\hat{\alpha}_1$) and GDP ($\hat{\beta}_1 + \hat{\alpha}_1\hat{\gamma}_1$) on FDI, the impact of literacy rate on FDI is calculated as $\hat{\alpha}_1\hat{\delta}_1 + \hat{\lambda}_1(\hat{\beta}_1 + \hat{\alpha}_1 \times \hat{\gamma}_1)$ (Table 4-4), which equals 9.4055. Both of the two components are significantly different from zero at the 5% significance level. This indicates that if literacy rate rises by one percentage point, FDI per capita will increase by \$9.41. The elasticity of FDI with respect to literacy rate is 2.8228, which means a 1% increase in literacy rate will result in a 2.82% increase in FDI per capita, and thus FDI is elastic with respect to literacy rate.

Following the same steps, we estimate the impact of poverty level on FDI (Table 4-5). The indirect impact passed onto FDI through trade is not significantly different from zero at the 5% significance level, whereas the one passed onto FDI through GDP is significant. The total effect is equal to –5.9158. Thus, if people under the poverty line as a share of total population declines by one percentage point, FDI per capita will increase by \$5.91. The elasticity of FDI with respect to poverty level is –0.5671, which implies a 0.57% increase in FDI per capita when poverty rate decreases by 1%.

Because there is no back door problem in this case, the estimation for the impact of tax rate on FDI is straightforward. After obtaining an OLS estimate of η_1 from regression (6),

$$(6) \qquad Trade = \eta_0 + \eta_1 Tax + \varepsilon_8$$

we calculate the estimate for tax rate as $\hat{\alpha}_1 \times \hat{\eta}_1$, which equals–1.8884 (Table 4-6). This estimate is significantly different from zero at the 5% significance level and indicates that a one percentage point increase in the tax rate reduces FDI per capita by \$1.89. The elasticity of FDI with respect to the tax rate is –0.2841, indicating a 0.28% decrease in FDI per capita when the tax rate increases by 1%.

There are six variables in the fourth tier: communist social system, exchange rate, unemployment rate, real interest rate, investment in transportation project, and battle-related death. Communist countries usually have a higher tax rate, which indirectly discourages trade and inward investment. Higher battle-related deaths reduce FDI investment and exert their impact through other variables such as literacy rate and trade. Unemployment contributes to poverty and has negative effects on both GDP and FDI. The other fourth-tier variables are not significantly connected with FDI.

Without the back door problem, the calculation for impact of communist social system, battle-related death, and unemployment rate is straightforward. First applying OLS to the following equations:

$$(7) \qquad Tax = \mu_0 + \mu_1 Commu + \varepsilon_9$$

$$(8) \qquad Litera = \rho_0 + \rho_1 Battle + \varepsilon_{10}$$

$$(9) \qquad Poverty = \tau_0 + \tau_1 UnEmp + \varepsilon_{11}$$

and then obtaining unbiased estimates of μ_1, ρ_1 and τ_1. Based on the estimates from equations (1) to (9), we can compute the estimate for communist social system as $\hat{\alpha}_1\hat{\eta}_1\hat{\mu}_1 =$ –25.6863 (Table 4-7), for battle-related death as $\hat{\rho}_1[\hat{\alpha}_1\hat{\delta}_1 + \hat{\lambda}_1(\hat{\beta}_1 + \hat{\alpha}_1 \times \hat{\gamma}_1)] = -0.0442$ (Table 4-8), and for unemployment rate as $\hat{\tau}_1[\hat{\alpha}_1\hat{\upsilon}_1 + \hat{\omega}_1(\hat{\beta}_1 + \hat{\alpha}_1 \times \hat{\gamma}_1)] = -3.7512$ (Table 4-9). All estimates are significantly different from zero at the 5% significance level. According to these results, the FDI per capita for communist countries is expected to be less than that for noncommunist countries by \$25.69. One more battle-related death (per 100,000) is expected to reduce FDI per capita by \$0.05, whereas a one percentage point decrease in unemployment rate is expected to be accompanied by a \$3.75 increase in FDI per capita. The elasticity of FDI with respect to communist social system, battle-related death, and unemployment rate is –0.0147, –0.0330, and –0.1750, respectively, and thus FDI is inelastic with respect to all of these variables.

To summarize, for developing countries, FDI per capita is expected to positively affect public educational expenditure, GDP per capita, trade, and literacy rate, whereas it is negatively impacted by tax rate, poverty level, battle-related deaths, communist social system, and unemployment rate. Homicide rate declines as more FDI flows into the host country, and infrastructure construction in energy, water, and transportation industries is enhanced by inward investments, which then leads to improved financial market and social stability. The rest of the examined variables do not have significant relationships with FDI. From the perspective of elasticity, FDI is only elastic with respect to literacy rate and inelastic with respect to all other causal variables.

Results for Developed Countries

The correlation matrix of variables examined for developed countries is reported in Table 5. FDI is significantly correlated with GDP and three other variables at the 5% significance level. GDP has significant correlations with many other variables as well, and all the other variables are significantly correlated with at least one other variable.

After removing edges based on the zero conditional correlation criterion, the resulting

Table 5. The Correlation Matrix for Developed Countries

	GDP	UnEmp	Tax	Trade	Literacy	EdExp	Exchange	RealInt	MarCap	GINI	Poverty	Homicide
FDI	0.446*	–0.001	–0.196	0.459*	–0.155	0.251	–0.440	–0.446*	0.516*	0.292	–0.225	–0.008
	(0.048)	(0.996)	(0.407)	(0.042)	(0.513)	(0.286)	(0.052)	(0.049)	(0.020)	(0.212)	(0.340)	(0.974)
GDP		0.008	0.278	–0.061	0.498*	0.270	–0.465*	–0.527*	0.448*	–0.299	–0.133	–0.352
		(0.972	(0.236)	(0.798)	(0.026)	(0.249)	(0.039)	(0.017)	(0.048)	(0.201)	(0.575)	(0.128)
UnEmp			0.631*	–0.385	0.144	0.281	–0.501*	–0.042	–0.348	–0.074	0.479*	0.111
			(0.003)	(0.094)	(0.544)	(0.230)	(0.024)	(0.860)	(0.133)	(0.756)	(0.033)	(0.641)
Tax				–0.553*	0.551*	0.271	–0.261	–0.091	–0.471*	–0.515*	0.398	–0.180
				(0.012)	(0.012)	(0.248)	(0.266)	(0.703)	(0.036)	(0.020)	(0.083)	(0.446)
Trade					–0.619*	–0.369	0.068	–0.167	0.343	0.292	–0.631*	–0.194
					(0.004)	(0.109)	(0.776)	(0.481)	(0.139)	(0.211)	(0.003)	(0.413)
Literacy						0.634*	–0.054	–0.324	–0.192	–0.612*	0.494*	–0.089
						(0.003)	(0.822)	(0.163)	(0.417)	(0.004)	(0.027)	(0.711)
EdExp							–0.240	–0.344	–0.201	–0.253	0.575*	0.269
							(0.308)	(0.137)	(0.397)	(0.281)	(0.008)	(0.251)
Exchange								0.059	0.063	–0.302	–0.008	0.054
								(0.806)	(0.792)	(0.195)	(0.974)	(0.822)
RealInt									–0.316	0.279	–0.087	–0.020
									(0.175)	(0.234)	(0.715)	(0.932)
MarCap										0.233	–0.311	–0.160
										(0..323)	(0.183)	(0.500)
GINI											–0.264	0.487*
											(0.260)	(0.029)
Poverty												0.166
												(0.484)

GDP, gross domestic product; FDI, foreign direct investment;
* Indicates that a correlation coefficient is significantly different from zero at 5% significance level.

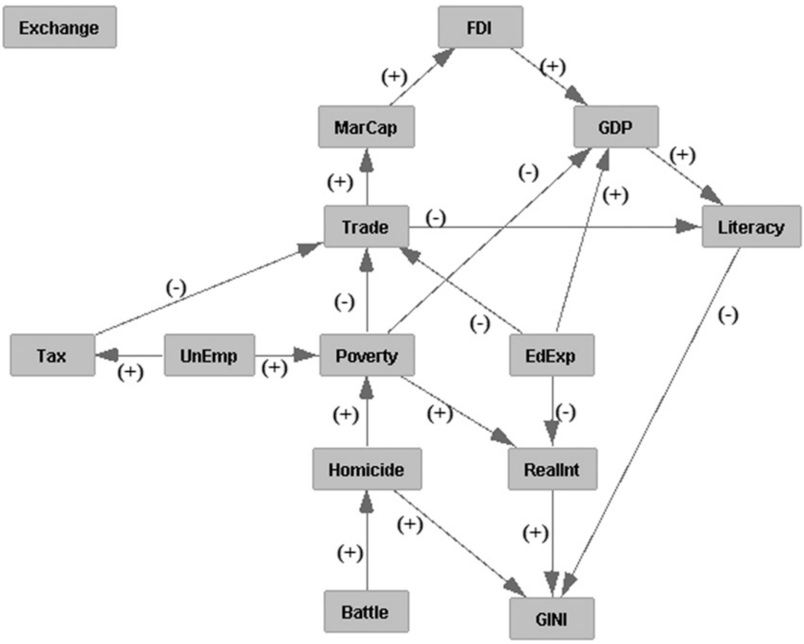


Figure 3. Causal Pattern of 14 FDI Related Variables, Estimated with TETRAD IV for 27 Developed Countries

pattern for developed countries is shown in Figure 3. A p value of 0.5937 is obtained and, thus, we fail to reject that the causal structure obtained from the PC algorithm is valid. There are only two variables connected directly with FDI, market capitalization as the causal variable and GDP as the effect variable. Because developed countries play roles as investment safe harbors, especially during an economic turmoil year like 2008, investors seeking safety increase flows of FDI to these countries. The capitalization of the stock market can be used as a rough indicator of the economic condition of the region, and thus it is reasonable to expect a positive causal impact of market capitalization on FDI. The finding that GDP is a variable affected by FDI conforms to the endogenous growth theory and the findings of many previous studies (Anwar and Nguyen, 2010; De Mello, 1999; Oliveira, 2001).

Market capitalization is not only a direct causal variable for FDI; it also works as an intermediary to pass onto FDI the impact of many other variables, i.e., trade, educational expenditure, tax rate, poverty level, unemployment rate, homicide rate, and battle-related death. Trade is, again, an important intermediary working together with market capitalization to pass the impact of other variables onto FDI. Moreover, trade is the only variable that has an indirect but positive causal relationship with FDI.

In these interactions between FDI and other factors, there are no two variables d-separated by a third one, i.e., no pattern exists similar to the one between FDI and trade for developing countries (in that pattern, FDI and trade are d-separated by GDP and educational expenditure). Thus, neither back door criteria nor front door criteria need to be considered in the parameter estimation, and simple OLS regression is sufficient to obtain unbiased and consistent estimates. All the calculations follow those shown in the Appendix Table A1. Table 6 reports the results for regressions of FDI on alternative causal variables, and all the reported numbers are statistically significant at the 5% significance level. As reported, a \$1 increase in market capitalization is accompanied with an increase of \$0.45 in FDI per capita. Trade as a share of GDP increasing by one percentage point will cause a \$121.75 increase in FDI per capita; and a one percentage point decrease in the percent of the population below the poverty

Table 6. Regressions of Foreign Direct Investment Per Capita on Alternative Causal (independent) Variables for Developed Countries

Causal Sub-Graph	Independent Variables	Coefficient estimate	$\frac{\partial FDI}{\partial X}$ (X is the indep.var.)	Elasticity of FDI with respect to X (at mean)
MarCap → FDI	MarCap	0.4517* (0.0077)	0.4517	1.7362
Trade → MarCap	Trade	269.5301* (0.0002)	121.7467	1.5987
Poverty → Trade	Poverty	-7.1479* (0.0157)	-870.2332	-1.0657
Tax → Trade	Tax	-4.0130* (0.0046)	-488.5695	-1.5557
UnEmp → Tax	UnEmp	3.6646* (0.0026)	-3446.6396	-2.0445
UnEmp → Poverty		1.9032* (0.0012)		
Homicide → Poverty	Homicide	2.5569* (0.0114)	-2225.0993	-0.3517
Battle → Homicide	Battle	0.0097* (0.0000)	-21.5835	-0.0595

Note: the numbers in the parentheses are p values and * indicates that the coefficient is statistically significant at the 5% significance level.

line (tax rate) leads to an increase in FDI per capita of $870.23 ($488.58).

Unemployment rate affects FDI through both tax rate and poverty level, and its combined impact causes a $3446.67 increase in FDI per capita when there is one percentage point decrease in unemployment rate. As homicide rate (battle-related death) declines by one person per 100,000, FDI per capita is expected to increase by $2225.09 ($21.58). Elasticities of FDI with respect to all the causal variables are also reported in Table 6. FDI is elastic with respect to market capitalization (1.7362), trade (1.5087), poverty level (–1.0657), tax rate (–1.5557), and unemployment rate (–2.0445). FDI is inelastic with respect to homicide rate (–0.3517) and battle-related death (–0.0595).

Comparison between Developing and Developed Countries

There are two common points in the causal measures between developing and developed countries. First, FDI is closely connected with trade, poverty level, and tax rate in both models. Second, trade serves as an intermediary between FDI and many of its causal variables. Poverty level, tax rate, unemployment rate, and battle-related death all exert their impacts on FDI through trade in both models. Despite these common points, the causal measures for the two groups of countries are different to a large extent, and these differences can be summarized as follows.

First, GDP is an effect variable for FDI in developed countries, whereas it is a causal variable for FDI in developing markets. The difference is well explained by Michie (2001) who argues that the governments of developing countries implement policies to attract inward investment, whereas developed countries treat FDI as a component that contributes to economic activity. Second, market capitalization affects FDI positively and directly for developed economies, whereas it is indirectly impacted by FDI for developing countries. This represents the difference between developed and developing worlds from the perspective of financial markets. In developed countries, the financial system is sophisticated and matured. It has various attractive financial instruments drawing a large amount of inward investment including FDI, and this investment contributes to the economic prosperity to a large extent. However, in developing countries, financial markets are typically not well organized and operated, and their development relies partially on the capital accumulation effects of FDI, rendering it an effect factor of FDI as opposed to a causal factor. Third, public educational expenditure only has an indirect relationship with FDI through other variables for developed countries, and its impact on FDI is negative. However, for developing economies, public educational expenditure interacts with FDI both directly and indirectly through the intermediary variable—trade; thus, this variable has a positive impact on FDI if its indirect positive influence exceeds the direct negative counterpart. Fourth, the exchange rate does not have a significant relationship with any other variables for developed markets but is the causal variable of real interest rate and the effect variable of tax rate, literacy rate, and unemployment rate for developing economies. This difference may be the result of strong relative currencies of developed countries.

Next, we compare the estimated coefficients for developed countries with those obtained for developing countries. A unit increase in trade as a share of GDP for developed countries has a much larger impact on FDI per capita (127.75) than that for developing countries (2.7078). Examining more carefully, for both developed and developing countries, trade works as an important intermediary between FDI and other factors such as tax rate, poverty level, and unemployment rate. However, the influence of trade is passed onto FDI through market capitalization in developed countries, whereas it is exerted directly on FDI in developing countries. The existence of market capitalization working between trade and FDI is believed to be the major explanation for the much larger impact of trade on FDI in developed countries.

In addition to the effect of trade, the impact of all the other causal variables on FDI is exaggerated significantly through the stock market variable (market capitalization). This amplifying effect increases the success of developed countries in attracting FDI.

Among the other seven causal variables of FDI for developed countries, FDI is elastic with respect to five of them, i.e., market capitalization, trade, poverty level, tax rate, and unemployment rate. This suggests that FDI is more elastic with respect to its causal variables for developed countries than for developing economies where FDI is elastic only with respect to literacy rate. Trade, poverty level, tax rate, unemployment rate, and battle-related deaths are common causal variables of FDI for both developing and developed countries. The elasticity of FDI with respect to unemployment rate for developed countries (–2.0445) is more than ten times that for developing countries (–0.1750). The FDI elasticity with respect to the tax rate for developed countries (–1.5557) is more than five times that of developing economies (–0.2841). Finally, the elasticities of FDI with respect to trade and poverty level for developed countries are almost twice those for developing countries. These comparisons between the two models further support the conclusion that higher stock market capitalization can amplify the impacts of causal variables on FDI.

Conclusion

We use the DAG approach to investigate causal patterns among FDI, economic growth, and several other institutional, economic, political, and social factors. Cross-section analyses of FDI from 61 developing countries and 27 developed countries are examined by a series of conditional independence tests. Measurements of causal patterns for developing countries and developed countries are conducted separately. There are two common points in the causal measures of the two groups of countries. First, FDI is closely connected with trade, poverty level, and tax rate in both developing and developed models. Second, trade serves as an intermediary between FDI and many of the causal variables for FDI. Poverty level, tax rate, unemployment rate, and battle-related death all exert their impacts on FDI through trade in both models.

The differences in causal measures between developing and developed countries are more stark. First, we find that GDP (economic growth) is an effect variable for developed countries, whereas it is a causal variable for developing economies. Second, market capitalization affects FDI positively and directly for developed economics, whereas it is an indirect effect variable of FDI for developing countries. Third, public educational expenditure does not have an indirect relationship with FDI for developed countries, whereas it interacts with FDI through an intermediary variable—trade—for developing markets. Last, market capitalization (stock market or financial market size) has a significantly amplifying effect for developed countries. Through this effect, a subtle improvement in fundamental economic variables such as trade, tax rate, unemployment rate, and poverty level can amplify changes in FDI.

Our findings are consistent to some extent with endogenous growth theory and other literatures, which assert that FDI promotes economic growth directly or indirectly (Carkovic and Levine, 2002; Li and Lin, 2004) in that this study finds a direct connection between FDI and economic growth. Moreover, our results indicate that FDI promotes economic growth in developed countries, whereas economic growth attracts FDI in developing economies. This finding for developed and developing countries suggests that the role of FDI in host economies is perhaps country-specific or regional-specific, as reported in Asiedu (2001), Chowdhury and Mavrotas (2006), and Zhang (2001) and its effect depends to a large extent on exogenous institutional, social, and political factors.

In addition, some consistency is found between the results of our article and those of previous studies regarding causal patterns between FDI and other variables such as unemployment rate (Fallon, Cook, and Billimoria, 2001), market capitalization (Alfaro et al., 2004; Claessens, Klingebiel, and Schumkler, 2002; Hermes and Lensink, 2003), education level (Borensztein, De Gregorio, and Lee, 1998), and trade (Balasubramanyam, Salisu, and Sapsford, 1996).

Our findings suggest that developing countries attempting to attract more FDI should fund education or training programs so as to increase the number of skillful workers, which in turn stimulate trade and FDI inflows. We note however that this investment process is a long-horizon endeavor. Also, developing countries may potentially improve the environment to attract FDI by expanding investments in infrastructure such as energy, telecommunication, transportation, and water projects. This expansion may not only further stabilize the macroeconomy, but may also facilitate the establishment of more sound and efficient financial markets, whose presence can amplify the benefits of FDI and other growth policies.

One major qualification is in order. This study is based on a cross-section for one year. Thus, the results should be cast in a context of understanding relationships among FDI, growth, and other variables, across countries, and not necessarily causal relationships among variables or their responses within a country over time. Thus, future work along this line could investigate panel data and dynamic DAG approaches.

[Received June 2012; Accepted May 2013.]

References

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek. "FDI and Economic Growth: The Role of Local Financial Markets." *Journal of International Economics* 64(October 2004): 89–112.

Anwar, S., and L.P. Nguyen. "Foreign Direct Investment and Economic Growth in Vietnam." *Asia Pacific Business Review* 16(2010):183–202.

Asiedu, E. "On the Determinants of Foreign Direct Investment to Developing Countries: Is Africa Different?" Working paper, Dept. of Econ., University of Kansas, Lawrence, KS, 2001.

Balasubramanyam, V.N., M. Salisu, and D. Sapsford. "Foreign Direct Investment and Growth in EP and IS Countries." *The Economic Journal* 106(1996):92–105.

Barro, R., and X. Sala-i-Martin. "Convergence." *Journal of Political Economy* 100(1992):223–51.

Bessler, D.A. *On World Poverty: Its Causes and Effects*. Rome, Italy: Food and Agricultural Organization of the United Nations, Research Bulletin, 2003.

———. "On Modeling Environmental and Agricultural Interfaces with Directed Acyclic

Graphs." Comments for OECD Conference, Paris France, June 30–July 2005.

———. "On Correlation and Causation." Unpublished manuscript, Texas A&M University, March 2010.

Bessler, D.A., and D.G. Akleman. "Farm Prices, Retail Prices, and Directed Graphs: Results for Pork and Beef." *American Journal of Agricultural Economics* 80(1998):1144–49.

Bessler, D.A., J. Yang, and M. Wongcharupan. "Price Dynamics in the International Wheat Market: Modeling with Error Correction and Directed Acyclic Graphs." *Journal of Regional Science* 43(2003):1–33.

Bizimana, J., J.P. Angerer, and D.A. Bessler. "Cattle Markets Integration and Price Discovery in Three Developing Countries of Mali, Kenya, and Tanzania," Paper presented at AAEA annual meeting, Seattle, WA, August 12–14, 2012.

Borensztein, E., J. De Gregorio, and J. Lee. "How Does Foreign Direct Investment Affect Economic Growth?" *Journal of International Economics* 45(1998):115–35.

Boyd, J.H., and B.D. Smith. "Intermediation and the Equilibrium Allocation of Investment Capital: Implications for Economic Development." *Journal of Monetary Economics* 30(1992):409–32.

Brecher, R. "Second-Best Policy for International Trade and Investment." *Journal of International Economics* 14(1983):313–20.

Brecher, R.A., and C.F. Diaz Alejandro. "Tariffs, Foreign Capital and Immiserizing Growth." *Journal of International Economics* 7(1977): 317–22.

Carkovic, M., and R. Levine. "Does Foreign Direct Investment Accelerate Economic Growth?" Working Paper, Dept. of Finance, University of Minnesota, Minneapolis, MN, 2002.

Chowdhury, A., and G. Mavrotas. "FDI and Growth: What Causes What?" *World Economy* 29(2006):9–19.

Claessens, S., D. Klingebiel, and S. Schmukler. "Explaining the Migration of Stocks from Exchanges in Merging Economies to International Centres." CEPR Discussion Paper No. 3301, Washington, DC: Development Research Group, World Bank, 2002.

De Backer, K., and L. Sleuwaegen. "Does Foreign Direct Investment Crowd Out Domestic Entrepreneurship?" *Review of Industrial Organization* 22(2003):67–84.

De Mello, J.L. "Foreign Direct Investment-Led Growth: Evidence from Time Series and Panel Data." *Oxford Economic Papers* 51(1999):133–51.

Embrechts, P., A. McNeil, and D. Straumann. "Correlation and Dependence in Risk Management: Properties and Pitfalls." RISK Magazine (May 1999):69–71.

Evans, P. "Using Cross-Country Variances to Evaluate Growth Theories." *Journal of Economic Dynamics & Control* 20(1996):1027–49.

Fallon, G., M. Cook, and A. Billimoria. "What Factors Attract Foreign Direct Investment?" Magazine article in *Teaching Business & Economics* (Autumn 2001).

Froot, K.A., and J.C. Stein. "Exchange Rates and Foreign Direct Investment: An Imperfect Capital Markets Approach." *The Quarterly Journal of Economics* 106(1991):1191–217.

Hansen, H., and J. Rand. "On the Causal Links between FDI and Growth in Developing Countries." *World Economy* 29(2006):21–41.

Hermes, N., and R. Lensink. "Foreign Direct Investment, Financial Development and Economic Growth." *The Journal of Development Studies* 40(2003):142–63.

Kwon, D., and D. Bessler. "Graphical Methods, Inductive Causal Inference, and Econometrics: A Literature Review." *Computational Economics* 38(2011):85–106.

Laudicina, P.A., J. Gott, and S. Phol. *Investing in a Rebound—The 2010 A.T. Kearney FDI Confidence Index*. Chicago, IL: A.T. Kearney, Inc., 2010.

Laudicina, P.A., and J. Pau. *New Concerns in an Uncertain World—The 2008 A.T. Kearney FDI Confidence Index*. Chicago, IL: A.T. Kearney, Inc., 2008.

Li, L., and Z. Lin. "Foreign Direct Investment Decisions under Environmental Uncertainty: Some Implications for the Chinese Market." Paper presented at the Inaugural Conference of International Association for Chinese Management Research (IACMR), Beijing, China, June 17–20, 2004.

Li, X., and X. Liu. "Foreign Direct Investment and Economic Growth: An Increasingly Endogeneous Relationship." *World Development* 33(2005):393–407.

Mankiw, N.G., D. Romer, and D.N. Weil. "A Contribution to the Empirics of Economic Growth." *The Quarterly Journal of Economics* 107(1992):407–37.

Michie, J. "The Impact of Foreign Direct Investment on Human Capital Enhancement in Developing Countries." Report for the Organization for Economic Co-operation and Development (OECD), November 2001.

Neuhaus, M. *The Impact of FDI on Economic Growth: An Analysis for the Transition Counties of Central and Eastern Europe*. New York, NY: Physica-Verlag Heidelberg, 2006.

Oliveira, L.H. "Foreign Direct Investment and Export-Led Growth: A Challenge to Brazil." Working paper, XIV Minerva Program, School of Business and Public Management, The George Washington University, Washington, DC, 2001.

Pearl, J. *Causality*. Cambridge, UK: Cambridge University Press, March 2000.

Pfaffermayr, M. "Foreign Outward Direct Investment and Exports in Austrian Manufacturing: Substitutes or Complements?" *Review of World Economics* 132(1996):501–22.

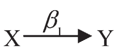
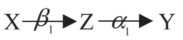
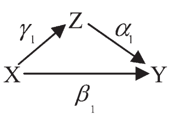
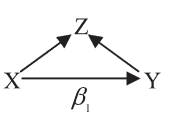
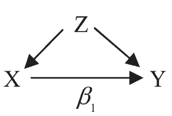
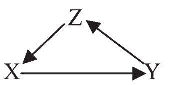
Sprites, P., C. Glymour, and R. Scheines. *Causation, Prediction, and Search*. 2nd ed. Boston, MA: MIT Press, 2000.

Zhang, K.H. "Does Foreign Direct Investment Promote Economic Growth? Evidence from East Asia and Latin America." *Contemporary Economic Policy* 19(2001):175–85.

Appendix

When estimating the parameters in a DAG, we divide the graph into several units, in which each unit consists of two or three variables. This appendix illustrates parameters estimation for various causal patterns. Assume X, Y, and Z are three variables of interest.

Table A1. Parameter Estimation for Different Causal Patterns

No.	Causal pattern	Estimation steps and regression equations	$\partial Y / \partial X$
1		$Y = \beta_0 + \beta_1 X + \varepsilon$	$\hat{\beta}_1$
2		$Y = \alpha_0 + \alpha_1 Z + \varepsilon$ $Z = \beta_0 + \beta_1 X + \varepsilon$	$\hat{\alpha}_1 \hat{\beta}_1$
3		$Y = \alpha_0 + \alpha_1 Z + \alpha_2 X + \varepsilon$ $Z = \gamma_0 + \gamma_1 X + \varepsilon$ $Y = \beta_0 + \beta_1 X + \varepsilon$	$\hat{\beta}_1 + \hat{\alpha}_1 \hat{\gamma}_1$
4		$Y = \beta_0 + \beta_1 X + \varepsilon$	$\hat{\beta}_1$
5		$Y = \beta_0 + \beta_1 X + \beta_2 Z + \varepsilon$	$\hat{\beta}_1$
6		This is not a directed acyclic graph	