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**The Causality of Foreign Direct Investment and Its Effects on Economic Growth:
Re-estimated by a Directed Graph Approach**

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The Causality of Foreign Direct Investment and Its Effects on Economic Growth: Re-estimated by a Directed Graph Approach

1. Introduction

Foreign direct investment (FDI) is believed to be an important factor contributing to the economic growth of the host country. However, previous studies have come to conflicting conclusions regarding the relationship between FDI and economic growth and their causal patterns. Some studies support a positive correlation between FDI and economic growth (Neuhaus, 2005) based on the rationale that FDI boosts economic growth through capital accumulation and via technology transfer spillover effects. In contrast, other studies have found that FDI—depending on country specific trade policies, and other institutional factors—can distort resource allocation and slow growth (Brecher and Diaz-Alejandro, 1977; Brecher, 1983; Boyd and Smith, 1999).

Ambiguity in the correlation between FDI and economic growth has provoked much interest in obtaining a better understanding of the causal patterns between them. The long held assumption of FDI-led growth becomes a hypothesis, and is tested together with the other growth-driven FDI hypothesis. Various causality tests have been implemented by previous literatures and their results differ to a large extent.

The purpose of this study is to examine the causal patterns between FDI and GDP based on variables from all economic, political and social perspectives. This study differs from previous work in two respects. First, no a priori presumption is made with respect to the relationship between FDI, GDP, and other factors, and instead, an inductive ‘directed acyclic graph’ (DAG) model is employed to estimate the structure of such relationships. Under the DAG approach, a set of measured variables are selected without subjective causal assumptions, and allows for the possibility that each variable is a cause of, an

effect of, or irrelevant to any other variables in the set. Secondly, a comprehensive dataset is employed which includes measures of political and social factors in addition to economic fundamental variables.

Three main questions are addressed. First, is FDI a causal or an effect variable for economic growth? Second, does FDI interact with economic, social and political factors directly and indirectly in affecting economic growth? Third, how do the causes and effects of FDI in developing economies differ from those in developed economies?

The rest of the study is organized as follows. Section 2 provides literature review. Causal modeling under the DAG approach is introduced and illustrated in section 3. Section 4 defines and explains the data employed. Empirical results are presented and discussed in section 5. Section 6 contains concluding remarks.

2. Literature Review

Previous studies employ various methods to sort out the causal patterns between FDI and economic growth, and different results are obtained. Zhang (2001) investigates the long-run causality between FDI and GDP in East Asia and Latin America with the Error Correction Model, and 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. He also notes that FDI is more likely to promote economic growth in host countries with liberalized trade regime, higher education level, and stable macroeconomic condition. Li and Liu (2004) investigate causality between FDI and growth from an endogeneity perspective in a simultaneous equation framework. They use a bilateral causality test and find that endogeneity between FDI and economic growth does not exist

for the whole sample period they use. However, for a sub period FDI and economic growth do become significantly complementary to each other and form an increasingly endogenous relationship. Carkovic and Levine (2002) control for simultaneous bias, country-specific effects, and the routine use of lagged dependent variables in growth regression, and adopt 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 that GDP causes FDI in Chile and not vice versa, while in Malaysia and Thailand, they find strong evidence of a bi-directional causality between GDP and FDI. Hansen and Rand (2006) employ a Granger causation framework and a standard neoclassical growth model, and find a strong causal link from FDI to GDP.

When making investment decisions, investors may take into account many more factors than classical theories suggest. For example, concerns regarding political, social, and environmental risks also likely play a large role in FDI. Yet, the interactions among FDI, economic growth, country specific macro factors, and other risks are still not well understood and deserve further attention. As a complement of academic studies, A. T. Kearney report of FDI confidence index is an informative source for understanding the present and future prospects for FDI flows. The report is prepared using a proprietary survey administered to senior executives of the world's leading corporations.

Participating companies represent 44 countries and span 17 industries 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 percent of global FDI flows.

The A. T. Kearney reports reveal connections between FDI and many political and social factors. For example, the 2008 report cited uncertainty surrounding 2008 elections as a significant factor that influencing foreign investments in the United States.

Unpredictability in the political, legal, and institutional environments was also cited a major determinant of foreign investment in China. Sustainability issues are also mentioned to be important determinants in investment decision. These issues include global competition for scarce energy reserve and other natural resource, climate change, increased pollution from developing countries, and wealth and income gap between developed and developing worlds.

A clear picture is shown that when seeking causal pattern between FDI and economic growth, only using GDP and a few other fundamental variables such as labor and capital investment is not enough. More economic, political and social variables should be incorporated into model to unveil the indirect interaction between FDI and economic growth.

Regarding the factors that FDI generally interacts with, several studies give useful information. Grahame (2001) finds that government regional assistance and levels of education are significant positive determinants of FDI, while the size of the regional population has a negative effect on FDI inflows. In addition, unemployment and average regional wage earnings are important too. Pfaffermayr (1994) discovers significant causality of FDI and exports in both directions. In De Backer and Sleuwaegen (2003), evidence is found suggesting that import competition and FDI crowd out domestic

entrepreneurship on both product and labor market. Borensztein, De Gregorio and Lee (1995) emphasizes the interactions between human capital and the efficiency of FDI, and shows empirically that FDI has positive effects on economic growth, but this only happens when the level of education is higher than a given threshold. The relationship between FDI and the stock market activity is studied in Claessens, Klingebiel, and Schumkler (2001), and they conclude that FDI is a complement, rather than a substitute of domestic stock market development. In other words, FDI is positively correlated with stock market capitalization and value traded. Froot and Stein (1991) examine the connection between exchange rates and FDI, and their empirical results confirm the popular claims that a depreciated currency can boost FDI. Michie (2001) takes human resource as an example and suggests that human resource have more often been developed not so much by the inward investment but rather by the domestic governments themselves as a way of attracting that inward investment.

As mentioned before, the FDI confidence index reported by A.T. Kearney is also very informative in terms of suggesting relationships between FDI and other factors. The most notice-worthy point in 2008 and 2010 reports is that large developed economies, such as the United States and Germany, attract FDI as investors seek safety, while emerging economies, such as China, India and Brazil, draw investors who look for access to new markets. Safety markets are characterized by stable macroeconomic environment with less volatility in currency, interest rate and energy prices, as well as more stable government. On the other hand, emerging markets usually have large consumer base, low labor costs, abundant natural resources, and faster economic growth. Thus, factors are deemed related to FDI.

2. Causal Modeling – Directed Acyclic Graph

One reason for studying a causal model, represented as $X \rightarrow Y$, is to predict the consequences of changing the effect variable (Y) by changing the cause variable (X). The possibility of manipulating Y by way of manipulating X is at the heart of causation (Bessler, 2003). A directed graph uses arrows and vertices to illustrate the causal relationships among variables, whose values are measured in non-time sequence. Adopting the notation of Bessler and Alkeman (1998), a graph is an ordered triple $\langle V, M, E \rangle$, where V is a nonempty set of vertices (variables), M is a nonempty set of symbols attached to the end of undirected edges, and E is a set of ordered pairs. Vertices connected by an edge are said to be adjacent. Directed edge is an edge which has an arrow indicating its causal direction, while 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 $C \rightarrow D$. A directed acyclic graph is a directed graph that contains no directed cyclic paths. An acyclic graph has no path that is from a variable and return to that same variable. For example, the path $A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$ is labeled as “cyclic” because we move from A to B, but then return to A by way of C. Because cyclic graphs are not identified, only acyclic graphs are discussed in this paper.

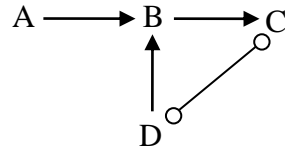
The terms from genealogy are generally used when referring to variables in causal model. For example, in the figure above, the variables A and C are ancestors of variable E. Variable E is the descendent of variables A and C. Variable A is the grandparent of variable E and parent of variable C.

The DAG approach 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 by an undirected edge. Next, correlation and partial correlation are calculated for each pair of variables. If they are not significantly different from zero according to some critical statistic, then no significant relationship is defined for this pair of variables, and the edge between them is removed. Last, the remaining edges are believed to have directions, and an arrow (direction) is assigned to each of the 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 $i \rightarrow m \rightarrow j$ or a fork $i \leftarrow m \rightarrow j$ such that the middle node m is in Z , or (2) p contains an inverted fork (or collider) $i \rightarrow m \leftarrow j$ 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 definition can be illustrated by a simplified example. There are four variables $\{A, B, C, D\}$, and $\text{corr}(A, D) = 0$ and $\text{corr}(A, C) \neq 0$. Assume we find that $\text{corr}(A, D | B) \neq 0$ and $\text{corr}(A, C | B) = 0$, which means variables A and D are d-connected while variables A and C are d-separated. According to the d-separation definition, there exist three possible directed acyclic graphs for variables A and C , which are $A \rightarrow B \rightarrow C$, $A \leftarrow B \leftarrow C$, and $A \leftarrow B \rightarrow C$. 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 ($A \rightarrow B \leftarrow D$), a complete directed graph can be drawn for these four variables as follows:



When analyzing real world problems, a large number of variables are tested and the causal patterns are much more complicated. TETRAD II, software developed at Carnegie Mellon University, determines such causal patterns using a correlation based approach. TETRAD II begins with the complete undirected graph such as in Figure 1. In that figure, each variable is connected to every other variable in the set without direction. Lines are removed if the null hypothesis cannot be rejected that the correlation between any two variables is not significantly different from zero. TETRAD II considers all possible correlations between these nineteen variables. Edges that remain are said to survive zero order conditioning, and these edges are subjected to a series of 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. Lines are removed if the null hypothesis cannot be rejected. The test of second order conditioning will continue following the same rule. TETRAD II cannot remove remaining edges at higher order conditioning.

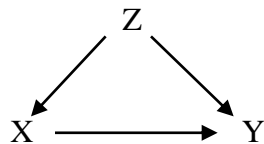
Three conditions should be satisfied for TETRAD II. The first is the causal Markov condition which states that, given its parents, any variable is conditionally independent of its nondescendants. The second condition requires that no variable is omitted which cause two or more variable selected for analysis. The last condition requires that a zero

correlation between variables should not be the result of cancellations of deeper parameters connecting these variables (Bessler, 2003).

Having discussed causal identification, next we focus on parameter estimation. Generally, for two directly connected variable X and Y(no impact from a third variable), OLS regression may give unbiased and consistent estimate for $\partial Y / \partial X$. However, when a back door problem occurs, which is a third variable causing both of X and Y, OLS estimate of Y on X is biased and inconsistent. In this situation, parameters are usually estimated in one of these three ways—back-door method, front-door method and instrumental variable method.

Back-door method

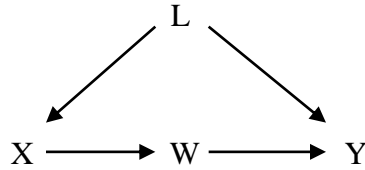
A set of variables Z satisfies the back-door criterion relative to X and Y if (1) no variables in Z are descendants of X, and (2) Z blocks every path between X and Y that contains an arrow into X. For example,



In the graph, X, Y and Z are three variables, and Z blocks flow from X to Y via the back door. Given Z can be observed, OLS works to block the back door and 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,

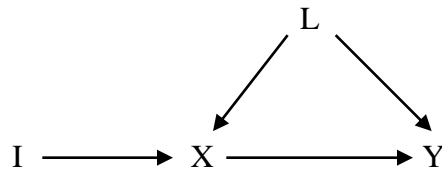


In the graph, X , Y and W are three variables, and L is a latent variable. There are two steps to calculate $\partial Y / \partial X$. First step is using OLS of Y on W and X to get an unbiased and consistent estimate of $\partial Y / \partial W$. Next is using OLS of W on X to get an estimate of

$\partial W / \partial X$. $\partial Y / \partial X$ is 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 just I (call the predictor X^*). Then, regress Y on X^* to find an unbiased and consistent estimate of $\partial Y / \partial X$.

Besides the methods discussed above, Appendix 1 also summarizes other calculations of $\partial Y / \partial X$ for basic causal patterns.

3. Data

The following variables are included for analysis:

FDI per capita. It is defined as FDI net inflows based on current US dollars divided by total population. The average value of this measure for developing countries is \$291.5187 and for developed countries is \$8971.1216. The minimum value of FDI per capita is observed for Ireland (-\$3691.7609) and the highest value is for Luxembourg (\$201565.1950).

GDP per capita. It is defined as GDP based on current US dollars divided by total population. GDP per capita is used as the proxy for economic development. The average GDP per capita for developing countries is \$5181.7050 and for developed countries is \$47828.5966. The lowest value of this measure is for Zimbabwe (\$7.9757) and the highest value is again for Luxembourg (\$117954.6797).

Unemployment. It is defined as the percentage of total labor force who are unemployed and are looking for a paid job. Grahame (2001) suggests unemployment is an important factor in FDI decision. The average value of this measure for developing countries is 13.5964% and for developed countries is 5.3222%. The country having the highest unemployment rate is Zimbabwe (80%), and the country with the lowest unemployment rate is Norway (2.6%).

Tax rate. It is total tax rate and defined as percentage of profit by World Development Report 2007/2008. Tax rate/ tax exempt is reported as a major concern for FDI investor

in 2008 A. T. Kearney report of FDI confidence index. The average value of this measure is 43.8550% for developing countries and 42.8518% in developed countries. The highest tax rate is 108% of profit for Argentina, and the lowest value is 10.4% for Namibia.

Trade. It is defined as share of imports plus exports in GDP. The inclusion of trade is based on Pfaffermayr (1994) and 2008 A.T.Kearney report page 4. The average value of trade for developing countries is 89.8704% and for developed countries is 117.8041%. The highest value is for Singapore (423.1149%) and the lowest value is for United States (27.3%).

Literacy rate. It is defined as the percentage of those aged 15 years and above who are literate. This measure and public spending on education are used as the proxy for education level. Grahame (2001) reports the significant relationship between educational level and FDI. The average value for this measure is 87.4921% for developing countries and 98.2556% for developed countries. Most of developed countries have a literacy rate as high as 99%, and the lowest value is 48.7% for Cote d'Ivoire.

Public spending on education. It is defined as the percentage of GDP. This measure is used as a proxy for education level. The average value for developing countries is 4.3642% and for developed countries is 5.1681%. The country with the highest value is Moldova (8.2480%) and the country with the lowest value is Nigeria (0.9000%).

Official exchange rate. It is defined as the annual average of local currency per US dollar. Froot and Stein (1991) show a significant connection between exchange rate and FDI. The average value of developing countries is LCU 857.8131 per US dollar and the value for this measure has a wide range from 0.4808 in Latvia to 16302.25 in Vietnam. For developed countries, the average value is LCU 49.5560 per US dollar, and the value

range is much smaller, from £0.5440 per US dollar in United Kingdom to 1102.0467 Won per US dollar in South Korea. Most developed countries have values lower than LCU 10 per US dollar except for Iceland (87.9479), Japan (103.3595) and South Korea (1102.0467).

Real interest rate. It is calculated as $\frac{1 + r_{nominal}}{1 + r_{inflation}} - 1$. Data for both inflation rate and

nominal interest rate are from World Development Report. The inclusion of real interest rate is based on the 2008 A.T.Kearney report page 4. The average value for developing countries is 0.8304% and for developed countries is 2.7238%. The small average number of developing countries is due to high inflations which result in negative real interest rates in many countries. The largest value is 37.1136% for Brazil and the lowest value is -11.5238% for Kazakhstan.

Market capitalization per capita. It is defined as the total market value of all listed companies' outstanding shares divided by total population. Claessens, Klingebiel and Schumkler (2001) report the complementary relationship between stock market activity and FDI. The average value for developing countries is \$1493.943 and for developed countries is \$34482.64. The area having the largest market capitalization is Hong Kong (\$190440.5539) and the one having the lowest value is Kyrgyz Republic (\$17.7708).

GINI index. It is defined as ratio of area below the Lorenz Curve, which plots share of population against income share received, to the area below the diagonal. It is a measure of income inequality. The inclusion of GINI index is based on the 2008 A.T.Kearney report page 11. The average value of this measure for developing countries is 43.48 and for developed countries is 32.03. The highest value is 74.30 for Namibia and the lowest value is 24.70 for Denmark.

Total investment in project by sector. There are totally four sector examined—energy, telecommunication, transportation and water. Due to data unavailability for developed countries, these four variables are only employed in the model for developing countries. The inclusion of this variable is based on the 2008 A.T.Kearney report page 3 and 4. For energy sector, the average and highest values are \$126.0666 and \$604.7175 for Bulgaria respectively. For telecommunication sector, the average and highest values are \$266.4286 and \$1177.0410 for Croatia respectively. For transportation sector, the average value is \$82.8455 and the highest value is for Malaysia (612.7117). For water sector, the average and highest values are \$23.1164 and \$375.5043 for Malaysia respectively. Many countries have zero investment in one or more of these sectors.

Poverty gap at \$2 a day. It is defined as the percentage of each country's population living on two dollars or less per day. The inclusion of this variable is based on the 2008 A.T. Kearney report page 11. The average value of this measure for developing countries is 27.9468% and for developed countries is 10.9859%. The highest value is 86.0000% for Zambia and the lowest value is 0.0100% for Singapore.

Homicide rate. It is defined as homicides per 100,000 population. This measure and battle related deaths are used as the proxy for social stability. The inclusion of these two variables is based on the 2008 A. T. Kearney report page 3. The average value for developing countries is 13.2361 and for developed countries is 1.4179. The highest value is 68.0391 for South Africa and the lowest value is 0.4050 for Morocco.

Battle related death. It is defined as the best estimate of annual battle fatalities. Battle is a leading risk to the health of the host economy. As reported in 2008 A. T. Kearney FDI confidence index, investors rank the cost of Iraq war as the number one risk jeopardizing

U.S. economy. The average value for developing countries is 217.55 and for developed countries is 24.7407. The highest value for developing countries is 6665 for Pakistan.

Communism social system. It is a dummy variable, and 1 indicates a country is implementing or ever implemented communism and 0 indicates other social system (Capitalism). There is no developed country adopting communism, so this variable is not used in modeling developed countries.

Table 1 lists all the above nineteen variables and their acronyms. The countries considered are listed in Table 2 (sixty-one developing and twenty-seven developed economies). Data availability is the major criteria for including a country in our list. Many developing countries in Africa and Middle East are omitted because data are not available. Thus, when we try to explain the causal patterns between FDI and economic growth in the perspective of the whole developing economies and developed economies, there is a selection bias.

We use cross section data in 2008, which are the most recent available ones. Using cross-section data, the identified causal pattern reflects what went on for that year and does not necessarily imply that the future will be the same. However, because the sub-prime mortgage crisis started in 2008 and world's largest companies remain wary of investing during current climate and few expect a full turn around before 2011(2010 A. T. Kearney report), we expect causation to be robust across time. Data come from the 'World Development Indicator' data set of World Bank table (WBT), "World Factbook" of CIA (Central Intelligence Agency), World Trade Organization database and 'Battle Deaths Dataset 1946-2008' of center for the Study of Civil War (CSCW) .

4. Empirical Results

We present results for two different models, one for developing and one for developed countries.

Results for Developing countries

The correlation matrix for the nineteen variables listed in Table 3. A strong positive relationship is found between FDI per capita and GDP per capita (0.63). The relationship of FDI per capita with literacy rate (0.46) is modestly strong and positive. Trade (0.2) and most of those variables having negative correlations with FDI per capita, such as unemployment rate (-0.26), poverty level (-0.35), Gini index (-0.24) and homicide rate (-0.26), have correlation coefficients with reasonable magnitudes. So we might well expect significant causal patterns between and among these variables.

Next, we focus on the results of the DAG analysis. The resulting pattern is presented in Figure 2. Arrows indicate directions of causation and a sign indicates whether the causal variable and effect variable are positively (+) or negatively correlated (-).

Turning attention to Figure 2, tier by tier, the first tier contains the variable of interest—FDI per capita, and the second tier consists of those variables that have direct connections with it. We can see that public spending on education (% GDP), trade (% of GDP), and GDP per capita are direct causal variables to FDI per capita. Public spending on education (%GDP) has direct negative influence on FDI while the other two causal variables have direct positive impacts.

Discussing in detail, first, a larger volume of trade implies a higher level of globalization of the host economy, which represents a more favorable environment for

FDI investment. Next, GDP is a typical indicator used to measure a country's economic health. A higher GDP can be interpreted as a healthier economy. Last, public spending on education (%GDP) itself has negative influence on FDI. This conforms to the finding in Michie (2001) and the expected lagged effect of education enhancement on host country's economic attractiveness. Despite its negative direct influence on FDI, public spending on education also affects FDI positively through an intermediary variable—trade. Thus, the two opposite effects render the sign of its true impact on FDI ambiguous. The same ambiguity also exists for variable of GDP per capita. Coefficient estimation is needed to determine the sign of these influences, and we will discuss it later.

The other two variables in the second tier are homicide rate and investment in energy projects of the host country, which are both the effect variables of FDI. FDI inflows are expected to stimulate the local economy, increase people's living standard and education level, which in turn reduce homicide incidences. From the standpoint of energy infrastructure construction, the spillover effect of FDI in the course of technology transfer can advance the techniques needed in infrastructure projects and boost investment in the energy industry.

Examining the arrows going in and out of these two variables further, positive causal patterns also exist for the following four pairs of variables-- investment in energy project and water project, investment in water project and transportation project, investment in transportation project and market capitalization, as well as market capitalization and homicide rate. These positive correlations suggest that FDI helps improve water infrastructure construction through its effect on energy industry. The investment in water projects passes on the positive influence of FDI to the transportation industry, and then to

financial market (market capitalization) and social stability (homicide rate). Therefore, it's reasonable to expect an increase in FDI can indirectly advance water and transportation industries, which in turn improve financial market functioning and social stability.

The third tier is comprised of variables that may be connected with FDI through variables contained 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 rate and a lower poverty level can increase trade activities, enhances GDP growth, and ultimately can attract more FDI inflows. An increase in FDI causes a reduction in the GINI index (GI) through its impact on homicide rate. Thus, we can see that increased FDI enhances social stability and mitigates income divergence.

There are six variables in the fourth tier-- communism social system (CO), exchange rate (EX), unemployment rate (UE), real interest rate (RI), investment in transportation project (TR) and battle related death (BA). Communism countries usually have higher tax rate, which indirectly discourage trade and inward investment. More battle related death reduces FDI investment, and exerts its impact through other variables, such as literacy rate and trade in this case. Unemployment contributes to poverty and has negative effects on both GDP and FDI. The other fourth-tier variables are not significantly connected with FDI.

Among all the causal variables for FDI per capita, trade is one of the most important variables. Trade has not only direct effect on FDI but also secondary effects because it is the intermediary for other causal variables that interact with FDI. There are five variables affecting FDI through their influence on trade: public spending on education (% GDP),

GDP per capita, tax rate, literacy rate and poverty level. In order to correctly evaluate the influence of trade on FDI, an unbiased estimate of the coefficient between trade and FDI per capita is needed. This estimate can be obtained by applying OLS to Equation (1):

$$F / P = \alpha_0 + \alpha_1 TRD + \alpha_2 PS + \alpha_3 G / P + \varepsilon_1. \quad (1)$$

There are only two of the five variables included in Equation (1). The reason that tax rate, literacy rate and poverty level are excluded from the above equation is because these three variables do not have direct influence on FDI per capita and trade is the only intermediary passing their influence onto FDI per capita (no back door problem). According to Figure 2, trade is the parent of tax rate, literacy rate and poverty level, and FDI per capita is the grandparent of them. Based on the Markov condition stated in the section 2, tax rate, literacy rate and poverty level are conditionally independent of FDI per capita given trade. Thus, there is no need to include these three variables in the equation.

The unbiasedness of $\hat{\alpha}_1$ can be reasoned by the back-door criterion (Table 5-1). The OLS estimate of α_1 is 2.7078 and is statistically significant at 5% significance level. Thus, an increase in trade by one percentage point of GDP results in an increase in per capita FDI of \$2.7078. The elasticity of FDI with respect to trade is 0.8348, which means a 1% increase in the trade –GDP ratio will result in an around 0.83% increase in FDI per capita. This shows FDI per capita is inelastic with respect to trade.

The impact of public spending on education (%GDP) on FDI per capita can be estimated by the following two equations:

$$F / P = \beta_0 + \beta_1 PS + \varepsilon_2 \quad (2)$$

$$TRD = \gamma_0 + \gamma_1 PS + \varepsilon_3. \quad (3)$$

The direct negative impact (β_1) is not significantly different from zero at 5% significance level, while the indirect positive impact passed onto FDI through trade ($\alpha_1 \times \gamma_1$) is significant and larger than its direct negative counterpart. The resulting estimate is calculated as $\hat{\beta}_1 + \hat{\alpha}_1 \times \hat{\gamma}_1$ (Table 5-2), which is equal to 0.4532. So, we expected that an increase in public spending on education by one percentage point of GDP will cause a FDI per capita increase by around \$0.45. The elasticity of FDI with respect to public spending on education is 0.0068, which indicates a less than one basic point increase in FDI per capita when the ratio of public spending on education to GDP increases by 1%.

Similarly, we estimate the influence of GDP per capita on FDI per capita using equation (4) and (5),

$$F / P = \varphi_0 + \varphi_1 G / P + \varepsilon_4 \quad (4)$$

$$TRD = \phi_0 + \phi_1 G / P + \varepsilon_5 \quad (5)$$

The direct positive component of the influence from GDP is significantly different from zero at 5% significance level, while the indirect negative component is insignificant and smaller than the direct positive part. The sum of these opposite effects is calculated as $\hat{\varphi}_1 + \hat{\alpha}_1 \times \hat{\phi}_1$ (Table 5-3), equaling to 0.0487. It means, when GDP per capita increase by \$1, FDI per capita will increase by around five cents. The elasticity of FDI with respect to GDP is 0.8656, which means a 1% increase in GDP will induce an around 0.86% increase in FDI.

Literacy rate exerts its impact on FDI per capita through both trade and GDP per capita, so the estimate of its impact has two components. Running the following regressions,

$$TRD = \delta_0 + \delta_1 LIT + \varepsilon_6 \quad (6)$$

$$G / P = \lambda_0 + \lambda_1 LIT + \varepsilon_7. \quad (7)$$

we derive the estimate for the impact as $\hat{\alpha}_1 \times \hat{\delta}_1 + \hat{\lambda}_1(\hat{\phi}_1 + \hat{\alpha}_1 \times \hat{\phi}_1)$ (Table 5-4), which equals to 9.4055. Both of the two components are significantly different from zero at 5% significance level. The number 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 1% increase in literacy rate will result in a 2.82% increase in FDI per capita. Thus, FDI is elastic with respect to literacy rate.

Following the same steps, we can calculate the estimate for the impact of poverty level on FDI (Table 5-5), and it is -5.9158. The indirect impact passed onto FDI through trade is not significantly different from zero at 5% significance level, while the one passed onto FDI through GDP per capita is significant. Thus, if people under the poverty line 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%.

Without back door problem, the calculation for the impact of tax rate, communism social system, battle related death and unemployment rate is relatively straightforward.

Applying OLS to equation (8), (9), (10) and (11),

$$TRD = \eta_0 + \eta_1 TAX + \varepsilon_8 \quad (8)$$

$$TAX = \mu_0 + \mu_1 CO + \varepsilon_9 \quad (9)$$

$$LIT = \rho_0 + \rho_1 BA + \varepsilon_{10} \quad (10)$$

$$POV = \tau_0 + \tau_1 UE + \varepsilon_{11} \quad (11)$$

we can compute the estimate for tax rate as $\hat{\alpha}_1 \times \hat{\eta}_1 = -1.8884$ (Table 5-6), for communism social system as $\hat{\alpha}_1 \times \hat{\eta}_1 \times \hat{\mu}_1 = -25.6863$ (Table 5-7), for battle related death as $\hat{\rho}_1[\hat{\alpha}_1\hat{\delta}_1 + \hat{\lambda}_1(\hat{\phi}_1 + \hat{\alpha}_1\hat{\phi}_1)] = -0.0442$ (Table 5-8) and for unemployment rate as $\hat{\tau}_1[\hat{\alpha}_1\hat{\upsilon}_1 + \hat{\omega}_1(\hat{\phi}_1 + \hat{\alpha}_1\hat{\phi}_1)] = -3.7512$ (Table 5-9). All these estimates are significantly different from zero at 5% significance level. According to these numbers, one percentage point increase in the tax rate reduces FDI per capita by \$1.89, and the FDI per capita for communism countries are expected to be less than that for non-communism countries by \$25.69. One more battle related death is expected to reduce FDI per capita by five cents, while 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 tax rate, communism social system, battle related death and unemployment rate are -0.2841, -0.0147, -0.0330 and -0.1750 respectively. We can see that FDI is inelastic with respect to all of these variables.

To sum up, for developing countries, FDI per capita is expected to be positively affected by public spending on education, GDP per capita, trade and literacy rate, while it is negatively influenced by the tax rate, poverty level, battle related death, communism social system and unemployment rate. Homicide rate is reduced as more FDI inflows in to the host country, and infrastructure construction in energy, water, transportation industries is speeded up by inward investments, which improve financial market and social stability as well. 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 the other causal variables.

Results for developed countries

The correlation matrix is reported in Table 4. GDP per capita (0.67) has positive and strong correlation with FDI per capita. Market capitalization (0.50) and trade (0.40) show modestly strong but also positive correlation with FDI per capita. Most variables that are negatively connected with FDI per capita have correlation coefficients of acceptable magnitudes, which ensure that significant causal flows can be found with this group of data.

After removing edges based on the zero conditional correlation criteria, the resulting pattern for developed countries is showed in Figure 3. There are only two variables connected directly with FDI per capita, which are market capitalization as its causal variable and GDP per capita as its effect variable. Since developed countries play roles as investment safe harbors especially during an economic turmoil year like 2008, investors' seeking for safety directs the flow of FDI to these countries. The capitalization of stock market can be used as a rough indicator of the economic condition of that region, and thus it is reasonable to expect a positive causal impact of market capitalization on FDI.

The finding that GDP per capita is a variable affected by FDI level conforms to the findings of most previous literatures, and this measure represents a different causal pattern from the one found for developing countries, where GDP is expected to be a causal variable to FDI. The difference is well explained by Michie (2001) that the government of developing country implements beneficial policies and enhances local economy to attract inward investment while developed country treats FDI as an component contributing to the local economy.

Besides market capitalization, trade (% GDP), public spending on education (% GDP), tax rate, poverty level, unemployment rate, homicide rate and battle related death all have causal relationship with FDI per capita, only that they work through market capitalization. Trade is again an important intermediary that works together with market capitalization to pass the influence of other variables onto FDI per capita. Also, trade is the only variable that has indirect but positive causal relationship with FDI.

Compared with the causal measures we get for developing countries, the causal measures for developed countries are different to a large extent, and these differences can be summarized as four points. First, as we explained in the previous paragraph, GDP is an effect variable for developing countries while it is a causal variable for developing markets. Secondly, market capitalization affects FDI positively and directly for developed economies, while it is indirectly impacted by FDI for developing countries. This represents the difference between developed and developing worlds from the perspective of financial market. 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 market is not well organized or operated. Its development relies partially on the capital accumulation effect of FDI, which make it an effect factor of FDI. Third, public spending on education only has an indirect relationship with FDI through other variables for developed countries, which leaves its impact indirect and negative. But, for developing economies, public spending on education interacts with FDI directly as well as through the intermediary variable—trade, thus this variable may have positive impact

on FDI if its indirect influence exceeds the direct counterpart. Fourth, the exchange rate does not have a significant relationship with any other variables for developed markets, while it 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 due to strong currencies of developed countries.

OLS regression is used to numerically estimate the relationships between FDI and its causal variables. The patterns for developed countries are less complicated than those for developing countries and neither back-door criteria nor front-door criteria are needed in the regressions. All the calculations follow Appendix 1-1 and 1-2. Table 6 reports the results for regression of FDI per capita on alternative causal variables, and all the reported numbers are statistically significant at 5% significance level. As reported, a \$1 increase in market capitalization is accompanied with an increase of \$0.45 in FDI per capita. Trade increasing by one percentage point of GDP will cause a \$121.75 increase in FDI per capita. One percentage point decrease in population below poverty line or tax rate can bring FDI per capita up by \$870.23 or \$488.58 respectively. Unemployment rate affects FDI through both tax rate and poverty level, and its combined influence gives a \$3446.67 increase in FDI per capita when there is one percentage point decrease in unemployment rate. As homicide rate reduces by one person in every 100,000 population or battle related death declines by one person, FDI per capita is expected to increase by \$2225.09 or \$21.58 respectively.

Comparing these coefficients with the ones we obtain in developing countries estimation, an unit increase in trade (% GDP) for developed countries has much larger impact on FDI per capita (121.75) than that for developing countries (2.7078). Examining

more carefully, for both developed and developing countries, trade works as a vital 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, while 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 influence of all the other causal variables on FDI is exaggerated significantly through stock market (market capitalization). For example, compared to a \$1.89 and \$5.92 increase of FDI per capita in developing countries, a 1% decrease in tax rate and unemployment rate can result in a \$488.58 and \$3446.67 increase of FDI per capita respectively through the amplifying effect of market capitalization. This amplifying effect makes developed countries harvest huge success in attracting FDI and enhancing domestic economy by improving their fundamental variable moderately.

Elasticity of FDI with respect to all the causal variables is 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). Five out of seven elasticities are greater than one. This shows 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 of that for developing countries (-0.1750). The FDI elasticity with respect to tax rate for developed countries (-1.5557) is more than five times of the one for developing economies (-0.2841). The elasticities of FDI with respect to trade and poverty level for developed countries are both almost twice as much as those for developing countries. These comparisons between the two models further prove the conclusion we obtain in the last paragraph. With the help of stock market (market capitalization), a small change in the causal variable of FDI can have a much larger impact of FDI inflows.

5. Conclusion

We adopt methods of directed acyclic graph to investigate causal patterns between FDI inflows and several other measures of economic and political relevance. Cross section measures of FDI per capita from 61 developing countries and 27 developed countries are examined by a series of conditional independence tests with respect to those variables selected from economic, political and social domains. Measurement of causal patterns for developing countries and developed economies are conducted separately. Two common points can be found for these two groups. First, FDI per capita is closely connected with trade, poverty level and tax rate in both developing and developed models. Secondly, trade serves as the intermediary between FDI per capita and other FDI causal variables. Poverty level, tax rate, unemployment rate and battle related death all exert their impacts on FDI per capita through trade for both country groups.

The differences between developing and developed models are more obvious. First, GDP per capita (economic growth) is an effect variable for developing countries while it

is a causal variable for developing economies. Next, market capitalization affects FDI positively and directly for developed economies, while it is an indirect effect variable of FDI for developing countries. Third, public spending on education does not have indirect relationship with FDI through any other variables for developed countries, while it interacts with FDI through their intermediary variable—trade for developing markets. Fourth, exchange rate does not have significant relationship with any other variables for developed markets, while it is the causal variable of real interest rate and the effect variable of tax rate, literacy rate and unemployment rate for developing economies. Last, market capitalization (stock market or financial market) has significantly amplifying effect for developed countries. Through this effect, a subtle improvement in fundamental variables, such as trade, tax rate, unemployment rate and poverty level, can boost FDI inflows to a large extent.

Compared with those previous literatures asserting that FDI promotes economic growth either directly by itself or indirectly via its interaction terms (Li and Lin, 2004; Carkovic and Levine, 2002), this paper shows support to the direct connection between FDI and economic growth. Moreover, our results indicate that FDI promotes economic growth in developed countries, while economic growth increases FDI inflows in developing economies. This opposite relationship and other differences between measures for developed and developing countries suggest that the role of FDI in host economies is country-specific or regional specific, as reported in Zhang (2001), Chowdhury and Mavrota (2006) and Asiedu (2001).

In addition, some consistency is found between the results of our paper and those of previous studies regarding causal patterns between FDI and variables except for GDP,

such as unemployment rate (Grahame, 2001), market capitalization (Claessens, Klingebiel, and Schumkler, 2001; Chanda and Sayek, 2003; Hermes and Lensink, 2003), education level (Borensztein, De Gregorio and Lee, 1995), and trade (Balasubramanyam, Salisu, and Sapsford, 1996).

Our findings suggest that developing countries trying to attract more FDI inflows should fund more education or training programs so as to increase the number of skillful workers, which in turn stimulate trade and FDI inflows. Also, developing countries should expand investments in infrastructure, such as energy, telecommunication, transportation and water projects. This expansion can not only further stabilize the macro economy, also facilitate the establishment of a sound and efficient financial market, whose development can amplify the benefit of effective policies.

For a developed country, government should reasonably relax regulations on the domestic stock market so as to encourage more firms to list their securities on the stock exchanges of the host country. For example, relaxing minimum capital requirement or allowing foreign issuers to file their financial statements according to their local or international accounting principles is beneficial for the growth of domestic stock market, and in turn boosts the inward investment and economic prosperity. Furthermore, less interference on import and export trade from government is recommended. Working with stock market, trade is an important intermediary passing to FDI the effectiveness of governmental regulation on tax rate, unemployment rate, poverty level and other fundamental factors. Thus, a flexible trading environment is a crucial complement for domestic stock market development, as well as an important factor in attracting FDI.

A major qualification is in order. This study is based on a cross-section of data for one year. Thus, the results should be cast in a context of understanding relationships between FDI, growth, and other variables, *across countries*, and not necessarily causal relationships among variables or their responses within a country over time. This is a severe limitation of the results, and thus further work along this line should be conducted with more comprehensive panel datasets.

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Table 1. FDI related variables and acronyms

Variable	Acronyms
FDI per capita	F/P
GDP per capita	G/P
Unemployment rate	UE
Tax rate	TAX
Trade	TRD
Literacy rate	LIT
Public spending on education	PS
Exchange rate	EX
Real interest rate	RI
Market capitalization	CAP
Energy investment	EN
Telecommunication investment	TL
Transportation investment	TR
Water investment	WT
Gini index	GI
Poverty level	POV
Homicide rate	HO
Battle related death	BA
Communism social system	CO

Table 2. Countries studied

<i>Developing</i>		<i>Developed</i>
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		

Table 3. The correlation matrix for developing countries

	F/P	G/P	UE	TAX	TRD	LIT	PS	EX	RI	CAP	GI	POV	EN	TL	TR	WT	HO	BA	CO
F/P	1.00																		
G/P	0.63	1.00																	
UE	-0.26	-0.35	1.00																
TAX	-0.11	0.03	-0.11	1.00															
TRD	0.20	-0.05	-0.17	-0.31	1.00														
LIT	0.46	0.52	-0.28	0.15	0.26	1.00													
PS	-0.13	-0.05	0.10	0.09	0.41	0.07	1.00												
EX	-0.12	-0.17	0.67	0.15	-0.19	0.04	0.02	1.00											
RI	0.09	0.16	-0.60	-0.12	0.05	0.00	-0.06	-0.87	1.00										
CAP	-0.09	0.00	-0.11	0.34	-0.19	0.04	-0.20	-0.04	0.05	1.00									
GI	-0.24	-0.04	0.26	0.06	-0.16	-0.02	0.07	0.09	0.07	0.09	1.00								
POV	-0.35	-0.41	0.57	-0.08	-0.24	-0.24	-0.03	0.29	-0.19	-0.20	0.39	1.00							
EN	-0.09	0.08	-0.18	0.35	-0.30	-0.02	-0.14	-0.06	0.25	0.58	0.09	-0.19	1.00						
TL	-0.09	0.22	-0.18	0.26	-0.39	-0.02	-0.09	-0.07	0.27	0.34	0.04	-0.12	0.87	1.00					
TR	-0.10	0.09	-0.17	0.35	-0.22	0.02	-0.18	-0.05	0.19	0.82	0.16	-0.21	0.80	0.66	1.00				
WT	-0.01	0.11	-0.18	0.15	0.03	0.16	-0.19	-0.05	0.09	0.53	0.18	-0.23	0.53	0.29	0.63	1.00			
HO	-0.26	-0.13	0.32	0.01	-0.18	-0.16	0.05	0.19	-0.16	-0.02	0.46	0.41	-0.01	0.07	-0.03	-0.03	1.00		
BA	-0.14	-0.16	-0.03	0.02	-0.27	-0.32	-0.17	-0.03	0.01	0.02	-0.14	-0.01	0.17	0.14	0.06	-0.02	-0.05	1.00	
CO	-0.16	-0.06	-0.05	0.30	-0.12	0.09	0.11	-0.06	0.09	0.34	0.11	0.07	0.22	0.18	0.27	0.13	0.11	-0.11	1.00

Table 4. The correlation matrix for developed countries

	F/P	G/P	UE	TAX	TRD	LIT	PS	EX	RI	CAP	GI	POV	HO	BA
F/P	1.00													
G/P	0.67	1.00												
UE	-0.02	-0.26	1.00											
TAX	-0.32	-0.27	0.56	1.00										
TRD	0.40	0.20	-0.31	-0.53	1.00									
LIT	0.08	0.42	-0.03	0.28	-0.59	1.00								
PS	-0.23	0.19	-0.17	-0.03	-0.43	0.51	1.00							
EX	-0.05	-0.28	-0.24	-0.14	-0.04	-0.01	-0.15	1.00						
RI	-0.15	-0.45	0.40	0.21	-0.01	-0.26	-0.49	0.02	1.00					
CAP	0.50	0.35	-0.26	-0.47	0.65	-0.32	-0.33	-0.12	-0.13	1.00				
GI	-0.06	-0.43	0.15	-0.18	0.37	-0.65	-0.46	-0.09	0.44	0.28	1.00			
POV	-0.16	-0.41	0.59	0.30	-0.46	0.02	0.02	0.08	0.39	-0.34	0.11	1.00		
HO	0.01	-0.17	0.13	-0.06	-0.16	-0.06	0.09	0.10	0.12	-0.09	0.42	0.48	1.00	
BA	-0.05	-0.19	0.10	-0.11	-0.13	-0.11	0.21	-0.06	0.09	-0.06	0.33	0.39	0.77	1.00

Table 5. Regressions of FDI per capita on alternative causal (independent) variables for developing countries. (The numbers in the parentheses are p-values; * indicates the coefficient is statistically significant at 5% significance level)

No.	Causal pattern	Regressions	Coefficient	Estimation	Elasticity at mean
1		<p>According to back-door criteria, $F / P = \alpha_0 + \alpha_1 TRD + \alpha_2 G / P + \alpha_3 PS + \varepsilon$</p>	$\hat{\alpha}_1 = 2.7078^*$ (0.0026)	$\frac{\partial F / P}{\partial TRD} = \hat{\alpha}_1 = 2.7078$	0.8348
2		<p>According to Appendix 1-3, $F / P = \beta_0 + \beta_1 PS + \varepsilon_2$ $TRD = \gamma_0 + \gamma_1 PS + \varepsilon_3$.</p>	$\hat{\beta}_1 = -25.4848$ (0.3152) $\hat{\gamma}_1 = 9.5790^*$ (0.0012)	$\frac{\partial F / P}{\partial PS} = \hat{\beta}_1 + \hat{\alpha}_1 \hat{\gamma}_1 = 0.4532$	0.0068
3		<p>According to Appendix 1-3, $F / P = \varphi_0 + \varphi_1 G / P + \varepsilon_4$ $TRD = \phi_0 + \phi_1 G / P + \varepsilon_5$</p>	$\hat{\phi}_1 = 0.0498^*$ (0.0000) $\hat{\phi}_1 = -0.0004$ (0.7290)	$\frac{\partial F / P}{\partial G / P} = \hat{\phi}_1 + \hat{\alpha}_1 \hat{\phi}_1 = 0.0487$	0.8656
4		<p>According to Appendix 1-2, $TRD = \delta_0 + \delta_1 LIT + \varepsilon_6$</p> <p>According to Appendix 1-3, $G / P = \lambda_0 + \lambda_1 LIT + \varepsilon_7$.</p>	$\hat{\delta}_1 = 0.7411^*$ (0.0412) $\hat{\lambda}_1 = 151.9243^*$ (0.0000)	$\frac{\partial F / P}{\partial LIT} = \hat{\alpha}_1 \frac{\partial TRD}{\partial LIT} + \frac{\partial G / P}{\partial LIT} \frac{\partial F / P}{\partial G / P}$ $= \hat{\alpha}_1 \hat{\delta}_1 + \hat{\lambda}_1 (\hat{\phi}_1 + \hat{\alpha}_1 \hat{\phi}_1)$ $= 9.4055$	2.8228

No.	Causal pattern	Regressions	Coefficient	Estimation	Elasticity at mean
5	POV → TRD → F/P	According to Appendix 1-2, $TRD = \nu_0 + \nu_1 POV + \varepsilon$	$\hat{\nu}_1 = -0.5116$ (0.0665)	$\frac{\partial F/P}{\partial POV} = \hat{\alpha}_1 \frac{\partial TRD}{\partial POV} + \frac{\partial G/P}{\partial POV} \frac{\partial F/P}{\partial G/P}$ $= \hat{\alpha}_1 \hat{\nu}_1 + \hat{\omega}_1 (\hat{\phi}_1 + \hat{\alpha}_1 \hat{\phi}_1)$ $= -5.9158$	-0.5671
	POV → G/P → F/P	According to Appendix 1-3, $G/P = \omega_0 + \omega_1 POV + \varepsilon$	$\hat{\omega}_1 = -93.0295^*$ (0.0010)		
6	TAX → TRD → F/P	According to Appendix 1-2, $TRD = \eta_0 + \eta_1 TAX + \varepsilon_8$	$\hat{\eta}_1 = -0.6974^*$ (0.0157)	$\frac{\partial F/P}{\partial TAX} = \hat{\alpha}_1 \hat{\eta}_1 = -1.8884$	-0.2841
7	CO → TAX → TRD → F/P	According to Appendix 1-2, $TAX = \mu_0 + \mu_1 CO + \varepsilon_9$	$\hat{\mu}_1 = 13.6020^*$ (0.0203)	$\frac{\partial F/P}{\partial CO} = \hat{\mu}_1 \frac{\partial F/P}{\partial TAX} = \hat{\alpha}_1 \hat{\eta}_1 \hat{\mu}_1$ $= -25.6863$	-0.0147
8	BA → LIT → G/P → F/P	According to Appendix 1-2, $LIT = \rho_0 + \rho_1 BA + \varepsilon_{10}$	$\hat{\rho}_1 = -0.0047^*$ (0.0132)	$\frac{\partial F/P}{\partial BA} = \hat{\rho}_1 \frac{\partial F/P}{\partial LIT} = \hat{\rho}_1 [\hat{\alpha}_1 \hat{\delta}_1 + \hat{\lambda}_1 (\hat{\phi}_1 + \hat{\alpha}_1 \hat{\phi}_1)]$ $= -0.0442$	-0.0330
9	UE → POV → G/P → F/P	According to Appendix 1-2, $POV = \tau_0 + \tau_1 UE + \varepsilon_{11}$	$\hat{\tau}_1 = 0.6341^*$ (0.0000)	$\frac{\partial F/P}{\partial UE} = \hat{\tau}_1 \frac{\partial F/P}{\partial POV} = \hat{\tau}_1 [\hat{\alpha}_1 \hat{\nu}_1 + \hat{\omega}_1 (\hat{\phi}_1 + \hat{\alpha}_1 \hat{\phi}_1)]$ $= -3.7512$	-0.1750

Table 6. Regressions of FDI per capita on alternative causal (independent) variables for developed countries. (The numbers in the parentheses are p-values; * indicates the coefficient is statistically significant at 5% significance level)

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)
CAP → F/P	CAP	0.4517* (0.0077)	0.4517	1.7362
TRD → CAP	TRD	269.5301* (0.0002)	121.7467	1.5987
POV → TRD	POV	-7.1479* (0.0157)	-870.2332	-1.0657
TAX → TRD	TAX	-4.0130* (0.0046)	-488.5695	-1.5557
UE → TAX	UE	3.6646* (0.0026)	-3446.6396	-2.0445
UE → POV		1.9032* (0.0012)		
HO → POV	HO	2.5569* (0.0114)	-2225.0993	-0.3517
BA → HO	BA	0.0097* (0.0000)	-21.5835	-0.0595

Figure 1. Complete undirected graph on nineteen FDI related variables

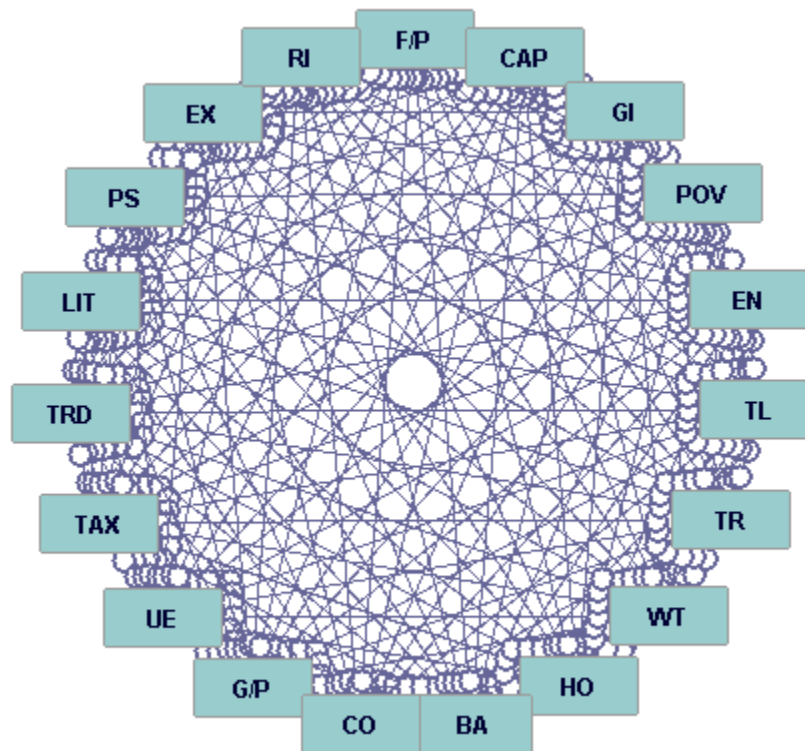
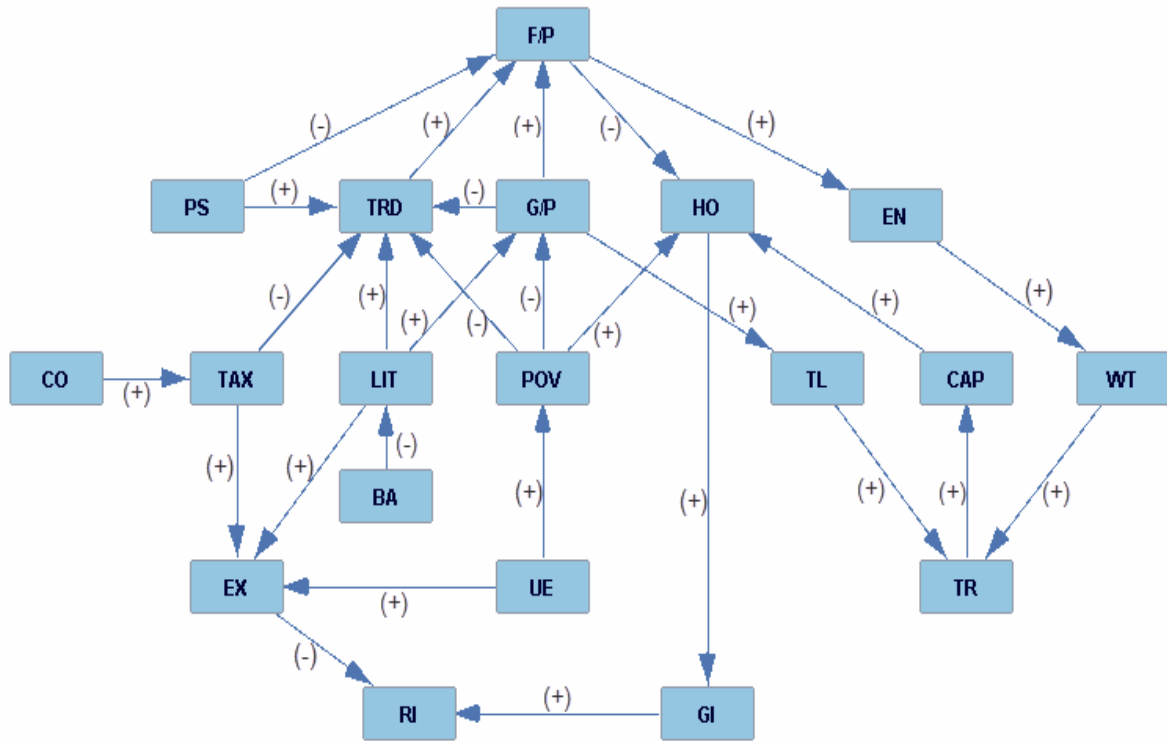


Figure 2. Pattern on nineteen FDI related variables, found with TETRAD II algorithm on 2008 cross section data from sixty-one developing countries



Appendix 1

When estimate the parameters in a directed acyclic graph, we divide the graph into several units, with each unit consists of two or three variables. In this appendix, we illustrate how parameters are estimated in various causal patterns.

Assume X, Y and Z are three variables

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