The Linear and Nonlinear Causality between FDI, Economic Growth, Human Capital and Export: The Case of China

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Keywords: FDI, causality, nonlinear, economic growth, China

Abstract. Employing panel data spanning 1992-2016 and covering 29 Chinese provinces, this article examined the causal relationships between foreign direct investment (FDI), economic growth, human capital (HC) and export. Utilizing linear Granger causality, nonlinear nonparametric Hiemstra-Jones and nonlinear parametric Buckley models, we find that when using different spillover channels, FDI would exhibit both linear and nonlinear relationships with economic growth. Similarly, either linear or nonlinear causalities are also detected between FDI and HC/export.

1. Introduction

Although it is expected by policy makers that FDI inflows could serve as a channel of transferring foreign capital and knowledge to promote domestic economic growth, the FDI-growth relationship remains a debate in empirical studies [1][2]. Trying to explore this controversial relationship, recent research [3] examined the interrelationship between FDI-growth nexus and HC and argued varying FDI-growth relationships across regions with heterogeneous HC levels. Sun [4] suggested that FDI receipts vary from their exporting capabilities to materialize FDI knowledge spillover. Liu and Agbola [5] suggested that FDI may go through different channels to affect economic growth.

Although the importance of the inter-connection between FDI-growth nexus and these mediating factors was recognized, their causality relationships are not yet settled well. The motivation for conducting this research is two-fold. First, there is less research to explore the long-run nonlinear equilibrium features between FDI and economic growth in China. Second, we incorporate Toda and Yamamoto's [6] model into conducting a nonlinear Granger causality test, as this model is powerful of minimizing the risks from incorrectly identifying the order of unit root tests and co-integrating relationships among variables [7].

2. Methodology

Based on the theoretical framework in Liu and Agbola [5], the empirical analysis utilizes the following model.

$$\mathrm{EC_{it}} = \mathrm{f}\,(\mathrm{FDI_k},\ \mathrm{HC}, \mathrm{Ex}) \tag{1}$$

Where EC_{it} denotes economic growth of province i at time t. k denotes FDI spillover channels, namely, foreign capital (*FC*) and a number of foreign-invested enterprises (*FIEs*). *HC* is human capital. *Ex* is export. The analysis employs annual data spanning 1992-2016 and divided into 29 provinces to control for administrative segmentation across China. Tibet and Ningxia provinces are excluded due to data limitations. The data are adjusted for inflation using GDP deflator and finally expressed in logarithm (Table 1). The unit root and cointegration tests confirm the data being stationary.

  DOI: 10.25236/ic3er.2019.039

Table 1. Definition of the variables

Variables	Measurement
EC	The growth rate of GDP
FC	Registered foreign capital
FIEs	The number of foreign-invested enterprises (FIEs)
Export	Exports from a province.
HC	The number of tertiary graduates.

Source: *China Statistical Yearbook* by National Bureau of Statistics, China.

Linear Granger causality test

Given a cointegrated relationship between the variables, a panel-based Granger causality test, a variation of the test proposed by Engel and Granger [8], is performed by estimating the following equations.

$$\Delta Y_{it} = \alpha_{1i} + \lambda_{1i}\varepsilon_{1it-1} + \sum_{K}\beta_{1ik}\Delta X_{it-k} + \sum_{K}\varphi_{1ik}\Delta Y_{it-k} + \mu_{1it} \tag{2}$$

$$\Delta X_{it} = \alpha_{2i} + \lambda_{2i}\varepsilon_{2it-1} + \sum_{K}\beta_{2ik}\Delta Y_{it-k} + \sum_{K}\varphi_{2ik}\Delta X_{it-k} + \mu_{2it} \tag{3}$$

Where Y and X are a vector of co-integrated variables, Δ denotes the first difference of the variables, $i = 1,\ldots N$ denote provinces, k is the lag length and ε_{1it} and ε_{2it} are error correction terms. Given that the causality analysis is sensitive to the lag length, this study follows Bradshaw and Orden [9] by selecting the optimal length using the minimum Schwarz information criterion (SIC) method.

Nonlinear Granger causality test

To test for whether the variables has a nonlinear relationship between each other, we first employ Hiemstra and Jones [10] model in nonparametric nonlinear Granger causality test and applies the estimated residuals from the VAR models to the linear Granger causality test.

To conduct the nonlinear Granger causality test, the key is to get residuals from the VAR model. We employ an augmented model proposed by Toda and Yamamoto [6] which involves the estimation of a VAR model in levels. In a bivariate case the model considers the following equations:

$$Y_{it} = \alpha_1 + \sum_{K}\beta_{1i}X_{it-k} + \sum_{j=K+1}^{d_{\max}}\beta_{1j}X_{it-j} + \sum_{K}\varphi_{1i}Y_{it-k} + \sum_{j=K+1}^{d_{\max}}\varphi_{1j}Y_{it-j} + \mu_{1t} \tag{4}$$

$$X_{it} = \alpha_2 + \sum_{K}\beta_{2i}Y_{it-k} + \sum_{j=K+1}^{d_{\max}}\beta_{2j}Y_{it-j} + \sum_{K}\varphi_{2i}X_{it-k} + \sum_{j=K+1}^{d_{\max}}\varphi_{2j}X_{it-j} + \mu_{2t} \tag{5}$$

Where Y and X are a vector of correlated and co-integrated variables. k is the lag length. d_{max} is the maximum order of integration. μ_{1it} and μ_{2it} are error-correction terms. The optimal length is selected using the SIC method too. The tests for integration and cointegration above suggest that the maximum order of integration is one, while the lag length selected by the SIC is two. Therefore, we run the VAR model with lag intervals at three to obtain the residuals.

As a supplement, we also employ a parametric nonlinear Granger causality test through making a square of the explanatory variable, the method used in Buckley et al. [11]. Hence, X in Equation (2) becomes X^2 and Y in Equation (3) becomes Y^2. The SIC method is also used.

3. Empirical Results and Analyses

Table 2 summarizes the results of both the linear and nonlinear Granger causality tests. For the Granger causality from foreign capital to economic growth, a linear relationship could not be found, but a nonlinear relationship is found in both the nonparametric and parametric models. In contrast, only a linear, not nonlinear, causality relationship is found from FIEs to economic growth. We also found both a linear and nonlinear Granger causality relationship from economic growth to foreign capital and FIEs. In the past, China strengthened liberalization for foreign investors, leading to massive FDI inflows. This article suggests different channels through which FDI yielded effects on economic growth. Simultaneously, economic growth would attract more FDI flows that enter China using different forms - capital and foreign presence.

Table 2. Results of Linear and nonlinear Granger causality tests

Pairs	Linear Granger causality test	Nonlinear Granger causality test	
		Nonparametric model	Parametric model
FC → EC	1.275 (0.282)	2.580* (0.053)	3.210** (0.023)
EC → FC	9.343***(0.000)	0.049 (0.986)	6.959***(0.000)
FIEs → EC	2.815** (0.039)	1.736 (0.159)	1.222 (0.301)
EC → FIEs	15.44***(0.000)	0.276 (0.843)	12.92***(0.000)
Export → EC	3.251***(0.007)	0.662 (0.576)	5.654***(0.001)
EC → Export	14.27***(0.000)	3.180** (0.024)	14.73***(0.000)
HC → EC	2.388** (0.027)	0.256 (0.857)	1.409 (0.239)
EC → HC	9.660***(0.000)	3.346** (0.019)	6.629***(0.000)
FIEs → FC	3.053** (0.028)	5.170***(0.002)	5.438***(0.001)
FC → FIEs	1.533 (0.205)	2.978** (0.031)	5.978***(0.001)
Export → FC	4.052***(0.007)	3.648** (0.013)	2.687** (0.046)
FC → Export	6.292***(0.000)	1.035 (0.377)	7.852***(0.000)
HC → FC	12.13***(0.000)	1.166 (0.322)	11.10***(0.000)
FC → HC	2.326* (0.074)	0.373 (0.772)	1.632 (0.181)
Export →FIEs	9.111***(0.000)	3.205** (0.023)	4.893***(0.002)
FIEs →Export	4.742***(0.003)	0.718 (0.541)	2.567* (0.054)
HC → FIEs	10.69***(0.000)	0.675 (0.568)	10.85***(0.000)
FIEs → HC	2.492* (0.059)	0.884 (0.449)	0.905 (0.439)
HC →Export	1.354 (0.256)	0.280 (0.840)	1.498 (0.214)
Export →HC	5.647***(0.001)	0.586 (0.624)	1.310 (0.270)

Notes: Arrows represent causality directions. *F*-statistics are reported with p-values in parentheses. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 2 indicates a linear causality relationship between HC / export and economic growth. A nonlinear causality relationship is found from economic growth to human capital and export in both the nonparametric and parametric models. On the contrary, a nonlinear causality relationship is found in the parametric model from export to economic growth, but not found from human capital. This reaffirms that an increase in human capital and export is capable of providing the impetus for economic growth in the CEI, and vice versa. However, human capital and export may have different mechanisms impacting on economic growth.

A linear causality relationship is also detected between export and the FDI spillover channels. Additionally, a nonlinear causality relationship is detected from export to FDI in both the nonparametric and parametric models, and from FDI to export in the parametric model. This suggests that utilizing the nation as an export platform may be the main purpose behind many foreign investors into China [4], and export may have different impacting mechanisms to attract foreign investors to increase capital investment and presence in China. In turn, the entry of foreign investors and firms is capable of providing the impetus for export growth.

Human capital appears to have both linear and nonlinear causality relationships with foreign capital and FIEs, affirming the argument [12] that endowment of human resources in China is attractive for foreign investors. This study suggests that there exist both linear and curvilinear forms that human capital attracts FDI inflows. Both linear and curvilinear causal relationships are found from the FDI variables to human capital, implying the impact of FDI on HC-augmentation which may happen through different FDI spillover channels and impacting forms.

4. Conclusion

This paper analyses both the linear and nonlinear Granger causality relationships between FDI, human capital, export and economic growth in China over the period of 1992-2016. Empirical results indicate that when going through different spillover channels, FDI exhibits heterogeneous causality relationships with economic growth, human capital and export. This suggests that the difference between linearity and nonlinearity, especially the specific types of nonlinearities, should be fully considered in future FDI-growth research.

Acknowledgment

This research was supported by National Social Science Fund [Grant number 17BJL115] and Guangdong Science and Technology Project in Soft Science [Grant number 2019A101002101].

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