UDC 330.341.2

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ECONOMIC DRIVERS OF INNOVATION LINKAGES

Abstract:
This study analyzes the impact of FDI, education, regulatory quality, GDP per capita, and trade openness on innovation linkages across 106 countries. Using System GMM, results show education and regulatory quality significantly enhance linkages, highlighting the role of human capital and institutional support in fostering technology transfer and economic growth.

Keywords:
Innovation linkages, economic drivers, System GMM.

The integration of global economies has accelerated the transfer of technology and knowledge, making innovation linkages critical to economic development. These linkages, which encompass the connections among firms, academic institutions, and government agencies, form the backbone of technological progress by enabling collaboration and the dissemination of expertise across borders. In this context, Foreign Direct Investment (FDI) has emerged as a key driver of these innovation linkages, acting as a conduit through which multinational corporations (MNCs) introduce advanced technologies, managerial practices, and innovation-focused strategies to host countries.

FDI-driven technology transfer is especially significant for developing economies, where the introduction of new technologies by MNCs can propel local firms toward greater productivity and competitiveness. However, the effectiveness of FDI in fostering innovation is not automatic; it is heavily influenced by the host country's absorptive capacity. Absorptive capacity, which encompasses factors such as education, infrastructure, and regulatory quality, plays a decisive role in determining how effectively a country can harness the benefits of foreign technologies and integrate them into the local economy. For FDI to translate into substantial innovation linkages, countries must possess a conducive economic environment that supports adaptation and local innovation.

Recent studies have deepened our understanding of how Foreign Direct Investment (FDI) facilitates technology transfer in developing economies. Over the past 2-3 years, research has increasingly examined how FDI enhances innovation capacity, productivity, and skill development in host countries. For example, Akinci and Yilmaz analyzed how FDI stimulates technological upgrading in local firms by encouraging them to adopt new technologies introduced by multinational corporations (MNCs) [1]. Their study emphasized the importance of local firms' absorptive capacity.

Building on the concept of absorptive capacity, Alfaro-Ureña et al. found that FDI in Costa Rica significantly enhanced local firms' innovation capabilities, particularly in sectors where backward linkages between MNCs and domestic firms were strong [2].

This ties into the broader literature on institutional quality, including the work of Estrin and Uvalic, which noted that the presence of supportive government policies, such as those promoting research and development (R&D) collaborations, is key to maximizing the benefits of FDI [3].

In addition, the importance of education and human capital has been reaffirmed in recent studies. Liu et al. revisited the relationship between education expenditures and FDI, noting that countries with higher investment in education tend to experience greater productivity gains from FDI inflows [4].

Taken together, these studies highlight the interdependence of foreign direct investment, innovation linkages, education, and the quality of the regulatory framework in facilitating technology transfer. They provide valuable information to policy makers seeking to optimize the benefits of FDI in terms of technological progress and economic growth, emphasizing the need for strong institutions and strategic investments in human capital.

This study will use the Generalized Method of Moments (GMM) estimator, a robust econometric technique effective in addressing endogeneity issues through instrumental variables and lagged dependent variables. In particular we will use the Two-Step System GMM to better deal with all specifics of our data. The inclusion of lagged dependent variables allows for capturing dynamic effects, ensuring a more comprehensive analysis of technology transfer over time.

The econometric model can be specified as follows:

$$INVLINK_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 EDEXP_{it} + \beta_3 GDPPC_{it} + \beta_4 TRADE_{it} + \beta_5 REGQUAL_{it} + \gamma_1 INVLINK_{it-1} + \epsilon_{it}$$

where, INVLINK – innovation linkages,
FDI – FDI inflows,
EDEXP – education expenditures as a percentage of GDP,
GDPPC – GDP per capita,
TRADE – trade openness
REGQUAL – regulatory quality

The dependent variable, innovation linkages, is derived from the Global Innovation Index and measures collaboration among firms, universities, and government agencies, which is essential for technology diffusion. These linkages are crucial for understanding the impact of FDI on local innovation ecosystems, beyond traditional metrics like patents.

This study represents 106 countries over a 5-year period from 2018 to 2022. Countries with different incomes are represented from low to high. Number of countries was restricted by the ability to find the data for this particular country. Almost all high-income countries were represented, but the situation with all low-income countries is more tragic. Still, there were such countries as Madagascar, Niger, Burkina Faso, Mali and others that are presented in this study. This will provide a more objective picture of the impact of investment on technology transfer.

Table 1 – Description of variables

Variable	Meaning	Unit	Source
INVLINK	Innovation linkages	Index	Global innovation index
EDEXP	Expenditure on education	% GDP	Global innovation index
FDI	Foreign direct investment, net outflows	Trillions USD	Global innovation index
GDPPC	Gross Domestic Product by capita	USD	World Bank
REGQUAL	Regulatory quality	Index	Global innovation index
TRADE	Trade openness	% GDP	World Bank

Average value suggests that the innovation linkages are moderate. However, the high standard deviation of 15.56 indicates substantial variability. FDI has a little plus on average as some countries have very distinct attractions for the investors. In general, we can say that our data includes many different developed and developing countries so there should be no problem with the lack of data.

Table 2 – Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
INVLINK	530	29,43	15,56	0,00	82,50
EDEXP	530	40,18	17,65	1,80	100,00
FDI	530	3,13	24,39	-394,47	234,25
LNGDPPC	530	9,06	1,38	0,07	11,61
REGQUAL	530	0,33	0,92	0,63	2,23
TRADE	530	93,61	64,86	3,10	402,46

Checking for multicollinearity resulted in the absence of it. Heteroscedasticity is a viable problem, and it forces us to use robust standard error in our model. For checking stationarity Im-Pesaran-Shin tests for each variable were conducted. All variables are stationary at levels, so there is no need to differentiate them. That is why we will utilize System GMM, because difference GMM uses all variables at first difference as an instrument, which would weaken our estimation.

All five variables had endogeneity problems, and to fix this we used lagged values of these variables as all of the lags are exogenous and can be used as GMM-type instruments. These instruments can provide more robust estimates of the causal effects of various factors on innovation linkages. Two-Step System GMM uses the residuals from an initial one-step GMM estimation to improve the weighting matrix, making the two-step estimator generally more efficient and robust, particularly in the presence of heteroskedasticity.

Table 3 – Results of Two-Step System GMM

invlink	Coefficient	Corrected Std. Err.
invlink		
L1.	0,473***	0,09
fdi	-0,506*	0,272
edexp	0,076*	0,039
regqual	5,540***	1,483
lngdppc	0,954	0,736
trade	0,016	0,025
_cons	1,823	6,141

Regarding the post-estimation checks, the three most important for GMM models are Arellano-Bond test for autocorrelation, Sargan and Hansen tests of overidentifying restrictions which assess quality of the instruments. There is no second-order autocorrelation in residuals, satisfying a key assumption for System GMM. Both Sargan and Hansen suggest that our instruments are not correlated with the error term, providing support for their validity in this model.

The first lag of INVLINK is significant, this suggests a moderate level of persistence in INVLINK , meaning that around 47.25% of the previous period's value of INVLINK carries over to the current period. This result is typical in dynamic models, where past values of the dependent variable influence current values. The coefficient for FDI is negative and marginally significant at the 10% level. FDI, while expected to positively impact innovative linkages, showed a marginally negative and weakly significant effect in this model, suggesting that its impact is nuanced and potentially dependent on the economic context of the host country. Education expenditure likely enhances INVLINK by fostering skills and innovation or by signaling investment in human capital, which supports economic growth and development. Regulatory quality can positively impact investment by creating a more stable, transparent, and predictable environment for economic activity, encouraging both domestic and foreign investments.

Although GDP per capita and trade openness were not significant in this model, their broader role in supporting economic stability and openness to foreign partnerships should not be overlooked. The findings underscore the importance of enhancing educational and regulatory frameworks to optimize the benefits of FDI and create a conducive environment for innovation linkages.

For policymakers, these results highlight the need for targeted investments in education and regulatory reform to bolster absorptive capacity. By addressing these areas, countries can enhance their ability to leverage FDI, creating robust innovation networks that contribute to sustainable economic development.

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