

What best transfers knowledge? Capital, goods, and labor in East Asia

Byeongwoo Kang

Inter-disciplinary Studies Center, Institute of Developing Economies (IDE-JETRO)

3-2-2 Wakaba, Mihamaku, Chiba City, Chiba 261-8545, Japan

Byeongwoo_Kang@ide.go.jp

Abstract: This paper compares three knowledge carriers—trade, foreign direct investment (FDI), and labor (inventors)—as knowledge mediums, and investigates their effects on knowledge flow in East Asia from 1996 to 2010.

Keywords: Foreign direct investment, Knowledge flow, Personnel mobility, Trade

JEL classification: F4, J6, O3

1. Introduction

Prior studies investigating determinants of knowledge flow have identified three major mediums associated with embodied knowledge. The first is trade (Coe & Helpman, 1995; Keller, 2002; Falvey et al., 2004; Bitzer & Geischecker, 2006). Because goods are mobile between industries and countries, knowledge contained within those goods is also mobile, and knowledge flows to the extent that the goods are employed by others. The second knowledge medium is foreign direct investment (FDI) (Aitken & Harrison, 1999; Javorcik, 2004; Branstetter, 2006). FDI is investment in the assets and management of an enterprise. Because of this, a whole package of goods and services is transferred together with the knowledge contained within them. The third knowledge medium is personnel mobility (Almeida & Kogut, 1999; Oettl & Agrawal, 2008). Other forms of knowledge, including know-how and skills, are difficult to codify. Such knowledge is usually embodied in human experience and can be transferred together with personnel.

An issue with prior studies is that they do not compare such mediums, instead analyzing them independently using different regression models. This paper aims at incorporating trade, FDI, and inventor mobility in a single regression model to compare their effects on knowledge flow. The comparison analysis will help find an efficient method for knowledge flow. I focus on East Asia because identifying and tracking inventors from their names in this region is relatively easy and more accurate. First, East Asian countries are not as multinational as US. Second, immigration within the region exists but has not been as common

as immigration within Europe. Accordingly, the national origin of a person is easy and accurate to find from his/her name.

2. Model and Results

My econometric model is shown in Eq. (1), which is based on a model proposed by MacGarvie (2005). To her model I have added three variables for trade, FDI, and inventor mobility. All variables other than the three of interest are control variables. Table 1 shows definitions of the variables in Eq. (1). Note that I consider the direction of knowledge flow when applying the model. Knowledge generally flows from developed countries to developing countries and between equally developed countries, and knowledge flow within East Asia is no exception. Hu and Jaffe (2003) and Hu (2009) found that although there are notable preferences such as Korea's high dependence on Japan, knowledge flow within East Asia generally occurs in eight ways: Japan to China, Korea, and Taiwan; Korea to China, Japan, and Taiwan; and Taiwan to China and Korea. I consider only these eight cases in the proposed econometric model.

$$\begin{aligned}
 c_{ijt} = & \beta_0 + \beta_1 Trade_{ijt} + \beta_2 FDI_{ijt} + \beta_3 Inv_{ijt} \\
 & + \beta_4 Trade_{ijt} \times TechProx_{ijt} + \beta_5 FDI_{ijt} \times TechProx_{ijt} + \beta_6 Inv_{ijt} \times TechProx_{ijt} \quad (1) \\
 & + \beta_7 TechProx_{ijt} + \beta_8 Pat_{it} + \beta_9 Pat_{jt} + \beta_{10} Language_{ij} + \beta_{11} Dist_{ij} + \varepsilon_{it}
 \end{aligned}$$

Table 1. Variable definitions and purposes

Variable	Definition/Purpose
c_{ijt}	Log of the number of patent citations made by all applicants in country i to country j in year t (i.e., knowledge flowing from country j to country i). The number of patent citations is used as an indicator of knowledge flow (Jaffe et al., 1993).
$Trade_{ijt}$	The amount of trade (billion US dollars) from country j to country i in year t .
FDI_{ijt}	The amount of FDI (million US dollars) from country j to country i in year t .
Inv_{ijt}	Number of inventors found in country i in year t , where i is different from their country of origin (country j). The country of origin, j , of an inventor is determined based on the address appeared in his/her first patent.
$TechProx_{ijt}$ ¹	Cumulative technological proximity of two countries i and j in year t . This

¹ $TechProx_{ijt} = \frac{V_{it} V'_{ji}}{\sqrt{V_{it} V'_{ii}} \sqrt{V_{jt} V'_{ji}}}$, where i, j, t , and V_{it} are citing country, cited country,

	variable controls for the extent to which technological distributions are similar between two countries, because a new technology tends to have its base in similar technological fields and hence tends to cite more patents from similar technological fields.
Pat _{it}	Log of cumulative number of patents in citing country <i>i</i> in year <i>t</i> . This variable controls for the number of new patents, because newer patents are likely to cite more recent patents.
Pat _{jt}	Log of cumulative number of patents in cited country <i>j</i> in year <i>t</i> . This variable controls for the number of prior patents, because older patents are likely to be cited more by recent patents.
Language _{ij}	(dummy) Whether two countries <i>i</i> and <i>j</i> use the same language (=1) or not (=0). This variable controls for the absence of language and cultural barriers.
Dist _{ij}	Geographic distance (km) between capital cities of two countries <i>i</i> and <i>j</i> . This variable controls for physical barriers to cross borders.

Three databases are used to construct the panel dataset. First, I obtained from PATSTAT patent citations and a list of inventors between 1996 and 2010. I found the inventors by matching their names. In order to remove namesakes, I referred to priority date and technological fields of each patent application. I then retrieved trade data from the World Input–Output Database (WIOD) (Timmer et al., 2015). Finally, I retrieved bilateral FDI data from the FDI database of the United Nations Conference on Trade and Development (UNCTAD). Since some trade and FDI data from the 1990s are missing, the dataset used is an unbalanced panel.

3. Results and Discussion

Table 2 shows my findings. The regression model used in this study is affirmed, because positive and negative effects of control variables in Regression (1) are consistent with previous findings by MacGarvie (2005), the basis for the model in this study. In addition, the effects of the control variables remain the same with statistical significance in Regressions (2)–(5).

The coefficients on trade and the interaction term with technological proximity are positive and negative with significance in Regression (2). However, the signs are reversed with significance in Regression (5). Accordingly, the effect of trade on knowledge flow is difficult to

year, and a vector $V_{it} = [v_{1,it}, \dots, v_{k,it}, \dots, v_{K,it}]$, respectively. $v_{k,it}$ is the cumulative number of patents in country *i* in year *t* in a technological field *k* (Jaffe & Trajtenberg, 1999).

interpret in this model. Nonetheless, a significant correlation is found between knowledge flow and trade.

The coefficients on FDI and the interaction term with technological proximity are respectively positive and negative with significance in Regression (3). In addition, the signs remain the same in Regression (5). This implies that FDI is positively effective with knowledge flow, but the effect decreases as cumulative technological distributions between two countries become more similar. An increase of one million USD in FDI results in 0.01% more patent citations if no cumulative technological distribution between two countries exists (TechProx = 0).

The coefficients on the number of transferred inventors and the interaction term with technological proximity show similar results with the case of FDI; the number of transferred inventors is positively effective with knowledge flow, but the effect decreases as domestic cumulative technological distributions between two countries become more similar. An increase of one transferred inventor is associated with an increase of 2.18% in patent citations if cumulative technological distributions do not exist between two countries (TechProx = 0).

The fifth analysis compares the three independent variables, which is the main purpose of this study. Comparing the independent variables of interest in Regression (5), inventor mobility most affects knowledge flow when the technological portfolios of two countries are completely different (TechProx = 0). The transfer result from one inventor is a 2.18% patent citation increase. However, the effects change with increased technological portfolio similarity. Trade most greatly contributes to knowledge flow when the technological portfolios of two countries are completely identical (TechProx = 0).

Table 2. Regression results

	(1)	(2)	(3)	(4)	(5)
Trade (b USD)		0.0507 [2.55]**			-0.0588 [-1.79]*
FDI (m USD)			0.0001 [4.11]***		0.0001 [3.10]***
Inv				0.0285 [3.95]***	0.0218 [2.32]**
Trade × TechProx		-0.0589 [-1.96]*			0.0819 [1.75]*
FDI × TechProx			-0.0001 [-3.38]***		-0.0001 [-2.55]**
Inv × TechProx				-0.0409	-0.0331

				[-4.02]***	[-2.53]**
TechProx	3.2957	5.1103	6.1217	3.3322	4.9774
	[4.46]***	[6.39]***	[7.21]***	[4.86]***	[5.62]***
PAT _j	1.1074	1.0483	1.0361	1.3454	1.1808
	[16.58]***	[12.72]***	[15.38]***	[14.77]***	[12.59]***
PAT _i	0.5237	0.5351	0.5541	0.5851	0.5679
	[5.78]***	[6.05]***	[7.34]***	[6.70]***	[5.92]***
Language	0.9276	0.7259	0.5338	1.0879	0.751
	[4.14]***	[2.98]***	[2.57]**	[3.54]***	[2.53]**
Dist	-0.0017	-0.0015	-0.0018	-0.0022	-0.0025
	[-7.72]***	[-8.01]***	[-10.02]***	[-9.04]***	[-7.95]***
Constant	-12.3403	-13.6413	-14.2335	-14.9209	-14.2069
	[-12.31]***	[-8.67]***	[-12.22]***	[-12.24]***	[-9.56]***
R ²	0.9094	0.932	0.9392	0.9248	0.9472
N	88	88	88	88	88

* p < 0.1, ** p < 0.05, *** p < 0.01

4. Conclusion

This paper focused on trade, FDI, and inventors as knowledge mediums and investigated their effects on knowledge flow in East Asia from 1996 to 2010. I measured knowledge flow using patent citations as a proxy. My findings are as follows. First, FDI and inventors have positive effects on knowledge flow in East Asia, but their effects decrease when the technological portfolios of two countries are similar. Second, trade functions as a knowledge medium. However, due to inconsistent effects on the knowledge flow between the regression models, this study could not derive a consistent interpretation. Third, when comparing effects of the three mediums, inventor mobility is the most effective for knowledge flow when the technological portfolios of two countries are completely different. Trade is most effective when the technological portfolios of two countries are completely identical.

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