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Abstract

Many countries are interested in strengthening their technological capabilities to achieve high growth rates. Knowledge flow is a key to build technological capabilities. This paper investigates how competition in international trades affects knowledge flow between countries. There are two findings. First, the results in the current paper shows that import is indeed an important avenue for knowledge flow, conforming with the results from the previous literature. Second, what is interesting and new is that export competition in the third market (in our study, the US market) seems to also have a positive impact on the flow of knowledge. The finding from this study contributes to the debate on "learning-by-exporting".

Keywords: International trade, knowledge flow, learning-by-export, East Asia
JEL classification: F14, D83, O53

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I. Introduction

Many countries are interested in strengthening their technological capabilities to achieve high growth rates. Based on the Solow growth model, the long term is only achieved by technological progress (Solow 1956). The interest on technological progress is also high in Southeast Asian countries where many of them are believed to be trapped (or will be trapped) in the middle income trap (Felipe 2012). The policy prescriptions often advocated for countries to avoid middle income trap is to strengthen their technological capabilities.

Then the question is how these countries can strengthen their technological capabilities. Often this is achieved through their own R&D efforts. However, the flow of technologies from one country to another is also an important component. For advanced countries, their focus of R&D will be to develop new technology. New technology is not build from scratch but often it is developed based on the past technologies. Hence, "new" technologies contain elements of past technologies. For developing countries, their focus of R&D (or technological development effort) is often in terms of international technology transfer, focusing more on the assimilation of "advanced" technologies developed in advanced countries. From either perspective, the flow of technology is an important issue for growth. Similar to the interest on the formation of production network, there is now a growing interest in how the knowledge network is forming.[1] In addition to mapping and analyzing how technology and knowledge flow from one country to another, there has been an interest in how such technology flow.

In the international trade literature, trade is often considered to be an important avenue for such flow, especially imports (Fracasso and Vittucci Marzetti 2015;Keller

[1] On knowledge network formation, see Hu, A. G. Z. and Jaffe (2003);Nabeshima, Kang and Kashcheeva (2016).

2010;Nabeshima 2004). By importing products from other countries, an importing country can learn about the characteristics of the product and technologies that are embedded within the product. To the extent that learning comes from the assimilation of technologies embedded in the imported products, the flow of knowledge is also tied to the trade relationship. However, availability of foreign technology by itself is not sufficient. Firms need to have incentives to learn from or assimilate these new technologies. The incentives to learn and assimilate technologies that are embedded within the product comes from the desires of domestic industries to survive in the face of import competition. Thus, it is the competition effect that is an important driver for technological progress. If so, then what kind of competitions do firms face? There are three different types of competition: competition within the domestic market; competition from imports; and competition in the export market. In the past literature (Ito and Pucik 1993;Marvel 1980;Scherer and Huh 1992), they have focused on the first two types of competition: competition within the domestic market and competition against the imports. However, none of the previous study has looked at the effects of competition in the export markets. This paper is to fill in this gap in the literature and consider to whether competition in export markets also lead to learning from the competitors. This export-competition part also relates to the literature on "learning-by-exporting" (Aw, Roberts and Xu 2011). As far as imports (and inward foreign direct investment) are concerned, there is a strong evidence that such trade linkages are conduits for international technology transfer (see for instance, Coe and Helpman 1995;Coe, Helpman and Hoffmaister 1997).[2] There has been a debate as to whether exporting activities itself can contribute to the transfer of knowledge. The issue arises because of selections. Studies have found that exporters are more productive in general (Bernard and Jensen 1999;Clerides, Lach and Tybout 1998;Hallward-Driemeier, Iarossi and Sokoloff 2002). The model by Melitz (2003) also depend on the fact that exporters are more productive than non-exporters. Nonetheless, anecdotal evidence points to the possibility of learning by exporting especially through the interactions with buyers from advanced countries or sophisticated consumers. However, they have overlooked the fact that these firms also face competitions in the export market, not only with the firms in destination market but also the exporters from other

[2] The impact of inward FDI seems to be influenced by the type of FDI. For instance, the results of horizontal FDI are mixed (Aitken, B., Hanson and Harrison 1997;Aitken, B. J. and Harrison 1999). On the other hand, when one considers vertical FDI, the results seem to be more robust (see for instance, Blalock and Gertler 2003).

countries. This can be another source of "learning" for the exporters, which has been neglected in the literature.

It is acknowledged in the literature that tracing the flow of knowledge is extremely difficult. To conduct such kind of research, one needs to rely on a data that documents the flow of knowledge. Some studies utilize increase in the productivity as the indication that the knowledge has been transferred.[3] Other strand of literature has utilized citation data (either patents or academic writings) as the indicator for the flow of knowledge from one entity to another (Hu, A. G. Z. and Jaffe 2003;Hu, A. G. 2009;Jaffe, Trajtenberg and Henderson 1993;Picci 2010). Since the interest of this paper is on the knowledge flow within economic activities, we will use patent citation information as the realization of knowledge transfer from one country to another.

II. Data

There are two main variables of interest for this paper. The first one is patent citation data that indicates the flow of knowledge from one country to another. The other is the data on the exposure of competition in the export markets.

Patent citation data

The patent data we utilize in this paper comes from the US Patent and Trademark Office data from PATSTAT. There are two reasons for using US patents. First, for East Asian countries, the US market is an important market. This is the export market that we use to indicate the exposure to export competition (the actual calculation is explained later). In order to protect their intellectual property that are embedded within the products exported to the US, firms will apply for and register patents in the US, even for firms from developing countries. Second, patent data registered in USPTO result in more patent citations than patent data registered in other patent authorities because of the duty of candor.

In order to track international knowledge flows, we processed the patent data in three steps. The first step was to identify to which country a patent belonged. We used the country of origin of the applicant to determine the nationality of each patent. If a patent was filed by several applicants, we used the nationality of the first applicant.[4] The second step was to measure the directions and amount of knowledge flow. We used patent citations as a proxy

[3] See Keller (2010) for the summary of such approaches.
[4] The first applicant means the applicant whose applicant sequence number in PATSTAT is 1.

for knowledge flow. Patent citations have been widely used as a proxy for knowledge flow (Jaffe, Trajtenberg and Henderson 1993;Kang 2016;MacGarvie 2005). A patent document provides a list of citations on which new inventions in the patent document are based. If an applicant, say A, for a patent cites patents by an applicant, say B, we interpret this as a knowledge flow occurring from applicant B to applicant A. Since we use the country of origin of applicants, we can track international knowledge flow. The last step was to track change over time. Because of continuing patent applications under United States patent law, an identical patent may have different application dates. In order to avoid duplication, we arranged patent data to patent family data. By using the earliest priority year of each patent family, we were able to track changes in international knowledge flows over time.

Each patent document will be assigned technology fields. Since we are interested in the flow of knowledge mediated through trading activities (imports or exports), we need to link this patent information to trade data. We utilize the categorization of Schmoch and others (2003) to group these patents into 44 fields of manufacturing industry. The concordance was done through first linking technology classes (international patent classification, IPC) assigned to a patent to the field (Schmoch and others 2003) and then further linking the field to International Standard Industrial Classification (ISIC) (see Appendix Table 1). The time period covered is from 2001 to 2010 in terms of application year.[5]

Overlap data

Trade data were obtained from UN Comtrade website. The bilateral trade data for each country in East Asia were downloaded, as well as their exports to the United States at the ISIC 4 digit level so that trade data can be linked with the patent citation data. The export market competition in an industry was calculated as the overlap export value of a pair of country for each commodity in the US market as shown below.

$$Overlap_{i,j,k,t} = \min\left\{Exp_{i,k,t}, Exp_{j,k,t}\right\}, \qquad (1)$$

[5] This is the year when the application is submitted. After the examination of the application, the USPTO makes the decision on whether to grant this application as a patent. The number of years it takes for the examination is not fixed, hence using application year is more appropriate. In addition, since we are interested in the flow of knowledge, we use the application year because by this time, the previous arts were known.

where $Exp_{i,k,t}$ ($Exp_{j,k,t}$) is the value of exports (in million US$) from country *i* (*j*) to industry *k* of the US in year *t*. This overlap value for each ISIC 4-digit commodity is then aggregated for each field. This way, we can differentiate which pairs of countries face more competition with each in the US market. To align with the patent data, the data for trade also covers from 2001 to 2010. Table 1 lists the summary statistics for key variables that will be used in the regression analysis. Table 2 shows the correlation among the variables.

Table 1: Summary statistics for key variables

Variable	Obs	Mean	Std. Dev.	Min	Max
citation	68,060	126164.6	4383954	0	4.27E+08
import	68,060	146.4425	791.8076	0	37929.21
overlap	68,060	251.8787	1373.005	0	57468.09

Table 2: correlation matrix

	citation	import	overlap	contiguity	Common language	colony	Distance
citation	1						
import	0.0554	1					
overlap	0.0379	0.1068	1				
contiguity	-0.012	0.0367	0.0088	1			
Common language	-0.0104	0.1007	-0.0187	0.1885	1		
colony	0.245	0.0841	0.0394	-0.0478	-0.0415	1	
distance	-0.0287	-0.0105	0.082	-0.3595	-0.0467	-0.116	1

III. Empirical strategy

The hypothesis is that a country *i* will cite patents of country *j* if country *i* imports goods from country *j* in industry *k*. In addition, we are also interested in the competition in the export market. Therefore, the hypothesis is that country *i* will cite patents of country *j* if country *i*'s exports to industry *k* in the United States have significant overlap with exports of country *j*.

$$Citation_{i,j,k,t} = f\left(IMPORT_{ijkt}, OVERLAP_{ijkt}\right), \qquad (2)$$

Since citation data is a discrete count data, the use of ordinary least square (OLS) will not be appropriate. Instead, we utilize negative binominal regression (where a Poisson is a

special case) which is can naturally take non-negative, count data such as the citation data. Moreover, since the data for citation includes many zeros, there is a concern for over dispersion in Poisson regression. For these reasons, negative binomial model is the most appropriate. In the specification as a control, we also include variables indicating the distance between the capital cities of the country pair, whether they share common borders, whether they use common official language, and whether they were ever in the colonial relationship (Mayer and Zignago 2011).

Table 1 lists the result from running OLS and two different negative binomial models. Even though the OLS estimation is not considered to be appropriate, it is included in as an initial check of the relationship between citation, imports, and export competition. In all three models, the coefficient estimates for imports and export competition are significant and positive. The difference between model 2 and 3 lies in the difference in the variance. For model 3, the variance are clustered using the importing country as an identifier to account for country specific variance structure. Once accounted for differences in variance structure, coefficient estimates loses some significance, but they are still significant at 5% level. Model 1 also includes dummies for each field.[6] In terms of the magnitude, the coefficient estimate for import is about twice as large the one from export competition.

Table 3: Baseline results

	(1) OLS	(2) Negative binomial	(3) Negative binomial with corrections for country specific variances
Main			
Import	242.7***	0.00573***	0.00573**
	(21.77)	(0.000577)	(0.00291)
overlapValue	69.48***	0.00264***	0.00264**
USA			
	(12.59)	(0.000230)	(0.00110)
2.field_no	64607.3		
	(157092.2)		
3.field_no	-13088.3		
	(153158.8)		

[6] These dummies for fields were not included in the negative binomial regression since they fail to converge.

4.field_no	-20888.2 (153827.2)
5.field_no	39943.1 (154508.5)
6.field_no	51809.1 (155565.5)
7.field_no	52394.6 (153801.6)
8.field_no	56033.4 (154246.5)
9.field_no	-35008.1 (157060.4)
10.field_no	51969.1 (154983.7)
11.field_no	67965.3 (159256.2)
12.field_no	61659.1 (156166.5)
13.field_no	82143.6 (154022.1)
14.field_no	60626.5 (155045.4)
15.field_no	40531.1 (154397.5)
16.field_no	60772.4 (158354.7)
17.field_no	34917.0 (153400.3)
18.field_no	84052.8 (154291.6)
19.field_no	-35130.8 (155175.9)

20.field_no	48528.5 (153663.6)
21.field_no	80213.4 (154759.1)
22.field_no	88077.5 (154203.1)
23.field_no	66434.5 (157227.2)
24.field_no	83776.0 (155657.7)
25.field_no	90923.5 (153748.3)
26.field_no	66544.0 (165288.6)
27.field_no	165575.4 (155504.9)
28.field_no	1729207.5*** (155628.8)
29.field_no	79578.4 (154793.1)
30.field_no	53832.9 (155160.4)
31.field_no	182865.5 (156093.1)
32.field_no	102786.8 (155839.6)
33.field_no	64697.1 (155428.6)
34.field_no	992020.6*** (157709.4)
35.field_no	518106.6*** (154897.8)
36.field_no	394220.6**

	(154734.9)		
37.field_no	85570.8		
	(154864.0)		
38.field_no	153697.4		
	(154715.0)		
39.field_no	87660.7		
	(159516.3)		
40.field_no	182133.0		
	(155647.8)		
41.field_no	61641.8		
	(157839.1)		
42.field_no	37088.4		
	(154068.5)		
43.field_no	24712.9		
	(154835.3)		
44.field_no	19233.8		
	(153374.7)		
_cons	-66962.5	7.969***	7.969***
	(108764.8)	(0.117)	(1.039)
lnalpha			
_cons		5.652***	5.652***
		(0.0175)	(0.388)
N	68060	68060	68060
adj. R^2	0.008		

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Similar to the case of trade, it is often assumed and established that knowledge flow decays over distance (Keller 2002;2004). Therefore, closer a country is to the source country, the more knowledge will flow from that country compared to a country that is located farther away. In addition, knowledge flow should be more active between a country pair that are close in culture and relationship, again similar to the rationale for the trade.

Table 4 lists the results from including variables representing distance, use of common official language, and contiguity. In these models, estimated coefficients on imports and export competition are positive and statistically significant. Compared to the results in

the baseline, the magnitudes of imports have decreased slightly. The impact stemming from imports are still twice as large as impacts coming from export competition. The estimated coefficients for distance (between capital cities) are negative and statistically significant as expected.[7] Since the knowledge flow is believed to be attenuated by distance, the results confirm with the general belief and findings from the trade literature. What are different from the trade literature is the estimated coefficients on common official language and contiguity. Given that this data includes only East Asian countries, both indicators are 1 only among developing countries within the region. This is the likely reasons why these estimates come out to be negative rather than positive as in trade literature.

Table 4: Negative Binomial Regression (distance between capital cities)

	(1) citation	(2) citation	(3) citation
citation			
Import	0.00492*	0.00498*	0.00457*
	(0.00276)	(0.00269)	(0.00241)
overlapValue	0.00233***	0.00236***	0.00212***
USA			
	(0.000847)	(0.000854)	(0.000733)
distcap	-0.00129***	-0.00121***	-0.00137***
	(0.000250)	(0.000267)	(0.000244)
1.comlang_off		-5.411***	-1.707
		(1.092)	(1.882)
1.contig			-13.25***
			(1.959)
_cons	10.08***	10.01***	10.57***
	(1.347)	(1.351)	(1.296)
lnalpha			
_cons	5.548***	5.506***	5.376***
	(0.409)	(0.407)	(0.406)
N	68060	68060	68060
adj. R^2			

Standard errors in parentheses

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

[7] Alternatively, distance between most populous cities can be used. The results are qualitatively similar (see Appendix Table 2).

So far, we have tested contemporaneous impacts of imports and export competition. However, it will be natural to consider that there are some gestation periods that are needed to learn from imports or products competing in the export market. In the next set of models, we consider lags (up to 5 years' lag) to see how long the gestation period associated with the imports and export competition.

Table 5 lists the results with 5 years' lags included for import and export competition. In Table 5, model 1 is estimated with distance between capital cities included.[8] In this model, the contemporaneous variables lose their significance. Instead, for imports it is the 5th year lag, for the export competition, the 4th year lag are the ones that have statistically significant and positive. The magnitudes for the 5th year lag of imports are now much larger, and the magnitude for the competition much lower. Model 2, 3, and 4 includes common official language, contiguity and colonial relationship. In model 2 and 3, the estimated coefficients are rather stable, although common official language loses significance when contiguity is included in model 3. In model 4, colonial relationship is positive and statistically significant. In our data set, there is only one country pair that ever had any colonial relationship, which is Japan and Korea. This is highly significant, meaning that Japan and Korea tends to cite patents of others frequently. In model 4, the coefficient estimate for contemporaneous imports is now negative and significant, and 2nd and 4th lags being positive and statistically significant. For export competition, 3rd, 4th, and 5th lags are positive and statistically significant. In model 4, the estimated coefficient for the distance between capital cities are no longer statistically significant.

Table 5: Regression results with 5 year lags

	(1) citation	(2) citation	(3) citation	(4) citation
Citation				
Import	-0.000101	-0.000122	-0.000205	-0.000709*
	(0.000496)	(0.000564)	(0.000456)	(0.000394)
overlapValueUSA	0.00116	0.00121	0.00127	0.00118
	(0.00111)	(0.00112)	(0.00100)	(0.000801)

[8] An alternative specification with distance between most populous cities were also ran. Qualitatively the results are the same (see Appendix Table 3).

l1imp	0.000153	0.000164	0.000283	0.000567
	(0.000291)	(0.000385)	(0.000382)	(0.000765)
l2imp	0.000249	0.000582	0.000524	0.00349***
	(0.000912)	(0.000984)	(0.000954)	(0.00102)
l3imp	-0.000123	-0.000359	-0.000656	-0.000901
	(0.000700)	(0.000540)	(0.000935)	(0.000977)
l4imp	0.0000574	0.00172	0.000720	0.00406***
	(0.000957)	(0.00156)	(0.00130)	(0.00149)
l5imp	0.00909**	0.00692**	0.00830***	0.000948
	(0.00368)	(0.00276)	(0.00317)	(0.00207)
l1over	-0.0000783	-0.000301	-0.000236	0.000355**
	(0.000312)	(0.000311)	(0.000197)	(0.000173)
l2over	0.000217	0.000290**	0.000254	-0.000183
	(0.000238)	(0.000139)	(0.000240)	(0.000253)
l3over	0.0000485	0.000273	0.0000550	0.000467***
	(0.0000612)	(0.000185)	(0.0000792)	(0.000108)
l4over	0.000633**	0.000315	0.000627*	0.000858***
	(0.000259)	(0.000251)	(0.000324)	(0.000322)
l5over	-0.000313	-0.00000118	-0.000412**	-0.00152***
	(0.000323)	(0.000502)	(0.000200)	(0.000400)
distcap	-0.00129***	-0.00121***	-0.00136***	-0.000280
	(0.000214)	(0.000232)	(0.000209)	(0.000316)
1.comlang_off		-5.193***	-2.272	-1.213
		(1.005)	(1.582)	(1.617)
1.contig			-12.49***	-8.792***
			(1.730)	(2.027)
1.colony				7.933***
				(1.092)
_cons	9.872***	9.811***	10.28***	5.037***
	(1.155)	(1.169)	(1.128)	(1.660)
lnalpha				
_cons	5.472***	5.429***	5.301***	5.095***
	(0.403)	(0.402)	(0.400)	(0.397)

N	65244	65244	65244	65244
adj. R^2				

Standard errors in parentheses

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

Finally, we also run regressions with a subset of data. We drop Brunei, Cambodia, Hong Kong, and Myanmar as partner economies since patents from these 4 economies were never cited in our data period. The results are show in Table 6. Qualitatively estimated coefficients for gravity type variables are similar to those in Table 5. However, the estimated coefficients for imports changes greatly. Likewise, the coefficient estimate for imports are similar to the results in Table 5. Coefficient estimates for export competition saw large differences compared to previous results. In model 4, the contemporaneous export competition is now positive and significant, as well as 3rd and 4th lag. The 5th lag is now negative and significant.

Table 6: Regression results excluding Brunei, Cambodia, Hong Kong, and Myanmar as partner economies

	(1) citation	(2) citation	(3) citation	(4) citation
Citation				
Import	-0.000578	-0.000619	-0.000657*	-0.000668***
	(0.000392)	(0.000496)	(0.000398)	(0.000171)
overlapValueUSA	0.00386**	0.00383**	0.00369***	0.00361***
	(0.00173)	(0.00173)	(0.00139)	(0.00126)
l1imp	-0.0000282	-0.00000653	0.000125	0.000118
	(0.000318)	(0.000398)	(0.000421)	(0.000383)
l2imp	-0.000590	-0.000369	-0.000513	0.000955
	(0.000456)	(0.000414)	(0.000356)	(0.000752)
l3imp	0.000275	0.000248	0.000103	-0.000251
	(0.000514)	(0.000487)	(0.000355)	(0.000528)
l4imp	0.00125	0.00209*	0.00143*	0.00360***
	(0.000873)	(0.00112)	(0.000818)	(0.00101)
l5imp	0.00519**	0.00396**	0.00453**	-0.000737
	(0.00205)	(0.00169)	(0.00179)	(0.00102)

l1over	-0.000516*	-0.000648***	-0.000639	-0.000100
	(0.000276)	(0.000109)	(0.000717)	(0.000246)
l2over	0.000383	0.000562***	0.000474	0.000526
	(0.000239)	(0.000214)	(0.000601)	(0.000364)
l3over	0.000399	0.000546**	0.000295	0.000772**
	(0.000399)	(0.000216)	(0.00110)	(0.000326)
l4over	0.000141	0.000115	0.000454	0.000951*
	(0.000308)	(0.000436)	(0.000901)	(0.000526)
l5over	-0.000835	-0.000861	-0.00106*	-0.00216***
	(0.000580)	(0.000829)	(0.000601)	(0.000829)
distcap	-0.00134***	-0.00128***	-0.00142***	-0.000373
	(0.000226)	(0.000240)	(0.000218)	(0.000308)
1.comlang_off		-5.148***	-2.371	-1.261
		(1.009)	(1.756)	(2.002)
1.contig			-12.59***	-8.935***
			(1.687)	(1.789)
1.colony				7.414***
				(1.105)
_cons	10.40***	10.36***	10.90***	5.688***
	(1.232)	(1.246)	(1.161)	(1.571)
lnalpha				
_cons	5.115***	5.072***	4.931***	4.737***
	(0.425)	(0.424)	(0.420)	(0.416)
N	47165	47165	47165	47165
adj. R^2				

Standard errors in parentheses

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

Conclusion

The results in our study shows that import is indeed an important avenue for knowledge flow, conforming with the results from the previous literature. However, what is interesting is that export competition in the third market (in our study, the US market) seems to also have a positive impact on the flow of knowledge. For the full sample, the impact of export competition seems to be about half as large as those from imports. For the subset of

the data, the impact seems to be as large as imports. What this suggest is that exposure to competitions in export market is an important pathway for knowledge transfer, which has been completely neglected in the literature. This finding also contributes to the debate on "learning-by-exporting" (Aw, Roberts and Xu 2011). In this literature, the learning is often estimated as increase in productivity stemming from export activities (controlling for possible endogeneity). However, the "learning-by-exporting" literature has not considered competition effect nor the patent aspect, to the authors' knowledge. The finding from this study contributes to the debate on "learning-by-exporting" and what it means by "learning". In our study, the "learning" is more concretely specified as citation to patents rather than increase in productivity and such "learning" occurs because of the competition, which can be measured through trade data.

Although our results indicate that export competition is a possible pathway for knowledge flow, the data we utilized in this study only includes economies in East Asia. To make our finding more general, we need to expand our data set both in terms of the geographical coverage and time periods. In addition, we would need to control for the innovation activities that are conducted in the country by including R&D spending of each economy, and also to control for another important avenue for technology transfer, foreign direct investment (Branstetter 2006;Saggi 2006;Smeets 2008).

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Appendix Table 1: Correspondence between Field and ISIC

Field no	NACE	ISIC	Code	Description
1	15	15	1511	Production, processing and preserving of meat and meat products
1	15	15	1512	Processing and preserving of fish and fish products
1	15	15	1513	Processing and preserving of fruit and vegetables
1	15	15	1514	Manufacture of vegetable and animal oils and fats
1	15	15	1520	Manufacture of dairy products
1	15	15	1531	Manufacture of grain mill products
1	15	15	1532	Manufacture of starches and starch products
1	15	15	1533	Manufacture of prepared animal feeds
1	15	15	1541	Manufacture of bakery products
1	15	15	1542	Manufacture of sugar
1	15	15	1543	Manufacture of cocoa, chocolate and sugar confectionery
1	15	15	1544	Manufacture of macaroni, noodles, couscous and similar farinaceous products
1	15	15	1549	Manufacture of other food products n.e.c.
1	15	15	1551	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials
1	15	15	1552	Manufacture of wines
1	15	15	1553	Manufacture of malt liquors and malt
1	15	15	1554	Manufacture of soft drinks; production of mineral waters
2	16	16	1600	Manufacture of tobacco products
3	17	17	1711	Preparation and spinning of textile fibres; weaving of textiles
3	17	17	1712	Finishing of textiles
3	17	17	1721	Manufacture of made-up textile articles, except apparel
3	17	17	1722	Manufacture of carpets and rugs
3	17	17	1723	Manufacture of cordage, rope, twine and netting
3	17	17	1729	Manufacture of other textiles n.e.c.
3	17	17	1730	Manufacture of knitted and crocheted fabrics and articles
4	18	18	1810	Manufacture of wearing apparel, except fur apparel
4	18	18	1820	Dressing and dyeing of fur; manufacture of articles of fur
5	19	19	1911	Tanning and dressing of leather
5	19	19	1912	Manufacture of luggage, handbags and the like, saddlery and harness
5	19	19	1920	Manufacture of footwear
6	20	20	2010	Sawmilling and planing of wood
6	20	20	2021	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board and other panels and boards
6	20	20	2022	Manufacture of builders' carpentry and joinery
6	20	20	2023	Manufacture of wooden containers
6	20	20	2029	Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials
7	21	21	2101	Manufacture of pulp, paper and paperboard
7	21	21	2102	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard
7	21	21	2109	Manufacture of other articles of paper and paperboard
8	22	22	2211	Publishing of books, brochures, musical books and other publications
8	22	22	2212	Publishing of newspapers, journals and periodicals
8	22	22	2213	Publishing of recorded media
8	22	22	2219	Other publishing

8	22	22	2221	Printing
8	22	22	2222	Service activities related to printing
8	22	22	2230	Reproduction of recorded media
9	23	23	2310	Manufacture of coke oven products
9	23	23	2320	Manufacture of refined petroleum products
9	23	23	2330	Processing of nuclear fuel
10	24.1	241	2411	Manufacture of basic chemicals, except fertilizers and nitrogen compounds
10	24.1	241	2412	Manufacture of fertilizers and nitrogen compounds
10	24.1	241	2413	Manufacture of plastics in primary forms and of synthetic rubber
11	24.2	2421	2421	Manufacture of pesticides and other agro-chemical products
12	24.3	2422	2422	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
13	24.4	2423	2423	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
14	24.5	2424	2424	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
15	24.6	2429	2429	Manufacture of other chemical products n.e.c.
16	24.7	243	2430	Manufacture of man-made fibres
17	25	25	2511	Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres
17	25	25	2519	Manufacture of other rubber products
17	25	25	2520	Manufacture of plastics products
18	26	26	2610	Manufacture of glass and glass products
18	26	26	2691	Manufacture of non-structural non-refractory ceramic ware
18	26	26	2692	Manufacture of refractory ceramic products
18	26	26	2693	Manufacture of structural non-refractory clay and ceramic products
18	26	26	2694	Manufacture of cement, lime and plaster
18	26	26	2695	Manufacture of articles of concrete, cement and plaster
18	26	26	2696	Cutting, shaping and finishing of stone
18	26	26	2699	Manufacture of other non-metallic mineral products n.e.c.
19	27	27	2710	Manufacture of basic iron and steel
19	27	27	2720	Manufacture of basic precious and non-ferrous metals
19	27	27	2731	Casting of iron and steel
19	27	27	2732	Casting of non-ferrous metals
20	28	28	2811	Manufacture of structural metal products
20	28	28	2812	Manufacture of tanks, reservoirs and containers of metal
20	28	28	2813	Manufacture of steam generators, except central heating hot water boilers
20	28	28	2891	Forging, pressing, stamping and roll-forming of metal; powder metallurgy
20	28	28	2892	Treatment and coating of metals; general mechanical engineering on a fee or contract basis
20	28	28	2893	Manufacture of cutlery, hand tools and general hardware
20	28	28	2899	Manufacture of other fabricated metal products n.e.c.
21	29.1	2911	2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
21	29.1	2912	2912	Manufacture of pumps, compressors, taps and valves
21	29.1	2913	2913	Manufacture of bearings, gears, gearing and driving elements
22	29.2	2914	2914	Manufacture of ovens, furnaces and furnace burners
22	29.2	2915	2915	Manufacture of lifting and handling equipment
22	29.2	2919	2919	Manufacture of other general purpose machinery
23	29.3	2921	2921	Manufacture of agricultural and forestry machinery
24	29.4	2922	2922	Manufacture of machine-tools
25	29.5	2923	2923	Manufacture of machinery for metallurgy

25	29.5	2924	2924	Manufacture of machinery for mining, quarrying and construction
25	29.5	2925	2925	Manufacture of machinery for food, beverage and tobacco processing
25	29.5	2926	2926	Manufacture of machinery for textile, apparel and leather production
25	29.5	2929	2929	Manufacture of other special purpose machinery
26	29.6	2927	2927	Manufacture of weapons and ammunition
27	29.7	293	2930	Manufacture of domestic appliances n.e.c.
28	30	30	3000	Manufacture of office, accounting and computing machinery
29	31.1	311	3110	Manufacture of electric motors, generators and transformers
30	31.2	312	3120	Manufacture of electricity distribution and control apparatus
30	31.3	313	3130	Manufacture of insulated wire and cable
31	31.4	314	3140	Manufacture of accumulators, primary cells and primary batteries
32	31.5	315	3150	Manufacture of electric lamps and lighting equipment
33	31.6	319	3190	Manufacture of other electrical equipment n.e.c.
34	32.1	321	3210	Manufacture of electronic valves and tubes and other electronic components
35	32.2	322	3220	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy
36	32.3	323	3230	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
37	33.1	3311	3311	Manufacture of medical and surgical equipment and orthopedic appliances
38	33.2	3312	3312	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
39	33.3	3313	3313	Manufacture of industrial process control equipment
40	33.4	332	3320	Manufacture of optical instruments and photographic equipment
41	33.5	333	3330	Manufacture of watches and clocks
42	34	34	3410	Manufacture of motor vehicles
42	34	34	3420	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
42	34	34	3430	Manufacture of parts and accessories for motor vehicles and their engines
43	35	35_353	3511	Building and repairing of ships
43	35	35_353	3512	Building and repairing of pleasure and sporting boats
43	35	35_353	3520	Manufacture of railway and tramway locomotives and rolling stock
43	35	35_353	3530	Manufacture of aircraft and spacecraft
43	35	35_353	3591	Manufacture of motorcycles
43	35	35_353	3592	Manufacture of bicycles and invalid carriages
43	35	35_353	3599	Manufacture of other transport equipment n.e.c.
44	36	36	3610	Manufacture of furniture
44	36	36	3691	Manufacture of jewelry and related articles
44	36	36	3692	Manufacture of musical instruments
44	36	36	3693	Manufacture of sports goods
44	36	36	3694	Manufacture of games and toys
44	36	36	3699	Other manufacturing n.e.c.

Source: Created by the authors based on Schmoch and others (2003).

Appendix Table 2: Negative Binomial Regression (distance between most populous cities)

	(1) citation	(2) citation	(3) citation	(4) citation
citation				
import	0.00492*	0.00498*	0.00457*	0.00451**
	(0.00276)	(0.00269)	(0.00241)	(0.00178)
overlapValueUSA	0.00233***	0.00236***	0.00212***	0.00163**
	(0.000847)	(0.000854)	(0.000733)	(0.000672)
dist	-0.00129***	-0.00121***	-0.00137***	-0.000215
	(0.000250)	(0.000267)	(0.000244)	(0.000329)
1.comlang_off		-5.411***	-1.707	-0.582
		(1.092)	(1.882)	(1.663)
1.contig			-13.25***	-9.135***
			(1.959)	(1.962)
1.colony				8.111***
				(1.132)
_cons	10.08***	10.01***	10.57***	4.954***
	(1.347)	(1.351)	(1.296)	(1.721)
lnalpha				
_cons	5.548***	5.506***	5.376***	5.153***
	(0.409)	(0.407)	(0.406)	(0.403)
N	68060	68060	68060	68060
adj. R^2				

Standard errors in parentheses

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

Appendix Table 3: Regression results with lags (distance between most populous cities)

	(1) citation	(2) citation	(3) citation	(4) citation
citation				
import	-0.000101	-0.000122	-0.000205	-0.000709*
	(0.000496)	(0.000564)	(0.000456)	(0.000394)
overlapValueUSA	0.00116	0.00121	0.00127	0.00118
	(0.00111)	(0.00112)	(0.00100)	(0.000801)

l1imp	0.000153	0.000164	0.000283	0.000567
	(0.000291)	(0.000385)	(0.000382)	(0.000765)
l2imp	0.000249	0.000582	0.000524	0.00349***
	(0.000912)	(0.000984)	(0.000954)	(0.00102)
l3imp	-0.000123	-0.000359	-0.000656	-0.000901
	(0.000700)	(0.000540)	(0.000935)	(0.000977)
l4imp	0.0000574	0.00172	0.000720	0.00406***
	(0.000957)	(0.00156)	(0.00130)	(0.00149)
l5imp	0.00909**	0.00692**	0.00830***	0.000948
	(0.00368)	(0.00276)	(0.00317)	(0.00207)
l1over	-0.0000783	-0.000301	-0.000236	0.000355**
	(0.000312)	(0.000311)	(0.000197)	(0.000173)
l2over	0.000217	0.000290**	0.000254	-0.000183
	(0.000238)	(0.000139)	(0.000240)	(0.000253)
l3over	0.0000485	0.000273	0.0000550	0.000467***
	(0.0000612)	(0.000185)	(0.0000792)	(0.000108)
l4over	0.000633**	0.000315	0.000627*	0.000858***
	(0.000259)	(0.000251)	(0.000324)	(0.000322)
l5over	-0.000313	-0.00000118	-0.000412**	-0.00152***
	(0.000323)	(0.000502)	(0.000200)	(0.000400)
dist	-0.00129***	-0.00121***	-0.00136***	-0.000280
	(0.000214)	(0.000232)	(0.000209)	(0.000316)
1.comlang_off		-5.193***	-2.272	-1.213
		(1.005)	(1.582)	(1.617)
1.contig			-12.49***	-8.792***
			(1.730)	(2.027)
1.colony				7.933***
				(1.092)
_cons	9.872***	9.811***	10.28***	5.037***
	(1.155)	(1.169)	(1.128)	(1.660)
lnalpha				
_cons	5.472***	5.429***	5.301***	5.095***
	(0.403)	(0.402)	(0.400)	(0.397)
N	65244	65244	65244	65244

adj. R^2	

Standard errors in parentheses

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