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GEOGRAPHY, INTERNATIONAL TRADE AND TECHNOLOGICAL DIFFUSION

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Abstract

International trade has been considered as a mechanism for knowledge diffusion that offers the opportunity to improve technological capabilities of importing countries. By importing capital goods from developed countries, developing countries could achieve their economic development despite their insufficient investments in technology. Many studies dealing with this subject provide strong empirical evidence of technological externalities contributing to the economic openness of these countries. In this paper, we suppose first that, regardless of prices and policy tariffs, imports could also be explained by geographic factors. We try to explain the intensity of knowledge diffusion by the geographic location of importing countries with regard to their trading partners. Under the hypothesis that the knowledge diffused has the characteristic of a public good, our estimations show that importing from the nearest G6 countries allows more knowledge spillovers for some developing countries, however we conclude that geographic location of importing countries is not the only factor that determines the intensity of technological diffusion. Knowledge spillovers also depend on the evolution of the geographic structure of imports for these countries and on the kind of goods they import (knowledge intensive or not).

1. Introduction

The contribution of technological diffusion to economic growth has focused on the role of international trade. Following Coe and Helpman (CH), and Coe, Helpman and Hoffmaister (CHH), developing countries could benefit from technological spillovers generated by imports from developed countries. Empirical results obtained by the authors also confirm the positive effect that these spillovers had on economic growth. In this literature, however, little has been said about the intensity of technological diffusion. Should we consider technological diffusion that benefits developing countries to be of a uniform intensity? According to recent studies, this is not the case. Gravitational models show that imports, supposed to be a mechanism for technological diffusion, could be influenced by geographical factors and particularly by physical distance separating importers and exporters (Frankel & ali., 1996; Frankel and Romer, 1999). Technological diffusion also depends on the geographic location of knowledge diffusers and receivers. From this point of view, it seems that knowledge diffusion could be limited to a little geographic area (Eaton & Kortum, 1996; Keller, 2001). Hence, the link between geography, technological diffusion, trade and growth is worth exploring much further.

In his classical contribution, P.Krugman (1991) already stressed the importance of geography in explaining the dynamics of international trade. Transport costs are considered as a factor that determines not only the inter-regional trade but also the economic growth of importing countries. Using a Harrod-Domar growth model with imports of capital goods, Gallups, Sachs and Mellinger show that as far as developing countries are from "core economies", transport costs increase the cost of importing which reduces the economic growth of these countries (Gallups & ali., 1998, p18-20).

Other studies provide strong empirical evidence for the existence of localization effects, which are considered as a major determinant for technological diffusion. A. Marshall was a pioneer in expressing this idea.[1] Inspired by the Marshall-Arrow-Romer approach, many empirical studies have since shown the existence of localized technological diffusion that contributes to the innovative activity of firms located in big American agglomerations (D.Audretsch & M.Feldman, 1996; V.Henderson, 1997, L.Anselin, & alii, 1997). Although the kind of knowledge diffused remains a public good, geographic proximity seems to play an important role in explaining technological diffusion.[2]

Technological diffusion explained by geographic location is also expressed through the contributions of A. Jaffe (1989) and A. Jaffe, M.Trajtenberg and R.Henderson (1992). By examining the correlation between patent citations and the geographic location of inventors, the authors show that technological diffusion is limited to an intra-industry level. At the level of countries, Branstetter (1996) consider that technological diffusion is much more intense inside United-States and Japan than it is between the two countries. Using patent deposits as a measure of technological diffusion, Eaton and Kortum (1996) show that bilateral imports between OCDE countries do not significantly contribute to patenting activity. However, physical distance between OCDE countries explains this activity. According to the authors' estimations, technological diffusion is minimal by a distance of 10.000 km (J.Eaton et S.Kortum, 1996, p265-266).

In an NBER working paper, W.Keller (2001) estimates the contribution of technological diffusion to Total Factor Productivity (TFP) growth using 1970-1995 panel data for 8 industrial sectors in the G7 countries. In his paper, Keller studies separately the explanatory power of physical distance and bilateral imports to technological diffusion and then compares their effect on TFP. Using a non linear model[3], three main results were stressed by the author: first, the stock of knowledge diffused decreases by half when the distance separating G7 countries exceeds 1.600 km. Second, technological diffusion seems to be less localised in the period 1983-1995. Third, physical distance predominates imports in explaining the effect of technological diffusion on TFP growth.

From this literature, we could argue that technological spillovers would benefit developing countries depending on their imports structure and especially on their geographic location. For this reason, this paper re-examines the CH and CHH contributions to the knowledge spillovers literature by allowing for geographic factors and particularly for physical distance. In doing so, we will attempt to obtain more accurate estimation of knowledge spillovers generated by international trade and their effects on developing countries' growth.

The remainder of this paper is organized as follows. In section two, we use a gravitational model to estimate the effect of geographic factors on imports using a sample of 42 countries trading with G6 countries. Section three examines the impact of geographic proximity to technological diffusion by considering four regional groups of countries[4] and by using panel data covering the period 1982-1995. The CHH model is then applied to get estimations of the impact of

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[1] Cited by P.Krugman, Marshall notes that: "Because information flows locally more easily than over a greater distance, an industrial centre generates what we would now call technological spillovers" (Krugman, 1991, p37-38).

[2] Tacit knowledge should be invariant to geographic proximity.

[3] The model also includes foreign direct investment and language communication. The econometric specification used is inspired from Hanson (1998).

[4] The regional groups of countries studied are Mediterranean countries, MENA countries, Central and South America countries and South East Asia countries.

technological diffusion on growth for each regional group of countries. Comments on the results obtained and conclusions are presented in section four.

2. Imports and Geographic Factors

We use the Frankel and Romer approach to explain the geographic determinants of imports. Our approach and estimations are nevertheless quite different from those of the authors because the sample of countries considered is different and, most importantly, the endogenous variable explained is not bilateral trade but only unilateral imports.[5]

Using a gravitational model, we explain the imports realized by 42 countries (see annex) from G6 countries.[6] The explaining variables considered are physical distance and two measures of size of importing countries: country population and area. The use of these measures of country size could be correlated to imports for two reasons. First, the more important the country population is, the higher its level of its imports would be. Choosing area as a measure of size is explained by the fact that the larger the country area is, the more important local trade should be compared to imports (Frankel & Romer, 1999). Therefore, we expect a negative sign for the coefficients of both distance and country area whereas country population is expected to be positively correlated to imports.

The log linear specification of the model we use is written as follows:

$$\text{Log } M_{ij} = \alpha_0 + \alpha_1 \text{LogD}_{ij} + \alpha_2 \text{Log } P_i + \alpha_3 \log S_i + e_{ij} \qquad (1)$$

M_{ij} = Imports of country i from country j (country j belongs to G6)

D_{ij} = Physical distance separating country i from country j

P_i = Population of country i

S_i = Area of country i

e_{ij} = residual term

Equation 1 is estimated for the years 1982 and 1995. Results reported in table 1 confirm the expected signs of the coefficients. Imports are decreasing when distance increases, the estimated elasticity of imports with respect to distance is by –0.658 for 1982 and by –0.456 for 1995. Country population and area have contradictory effects on imports and it seems that population effect predominates area effect in explaining imports.

The contribution of geographic factors in explaining imports could not be limited to the estimations we obtain with equation 1. In order to evaluate the explaining power of the geographic factors considered, a constructed indicator of imports is defined according to equation 1. Let's note M_{ij}^C this indicator:

$$M_{ij}^C = \exp(\alpha_0 + \alpha_1 \text{LogD}_{ij} + \alpha_2 \text{Log } P_i + \alpha_3 \log S_i) \qquad (2)$$

$$\Rightarrow M_{ij}^C = [\exp(\alpha_0)] * (D_{ij}^{\alpha 1} * P_i^{\alpha 2} * S_i^{\alpha 3}) \qquad (3)$$

$$\Rightarrow M_i^C = \sum_j M_{ij}^C \qquad (4)$$

Using equation 4, we regress for the two years 1982 and 1995 the observed level of imports for all 42 countries (M_i) on the constructed indicator M_i^C. Estimations are done following equation 5[7]:

$$\text{Log}(M_i) = \beta_0 + \beta_1 \log(M_i^C) + u_i \qquad u_i \text{ is a residual term} \qquad (5)$$

Results reported in table 2 show a significant correlation between M_i^C and M_i. The value of the adjusted R squared is near 0.3 for both 1982 and 1995 years. This result suggests that the constructed indicator of imports M_i^C contains sufficient amount of information on the observed levels of imports realized by the 42 countries considered.

On the basis of these estimations, we can argue that geographical factors have some influence on imports. In the particular case of physical distance, we found a negative and significant effect of this variable on imports. We try now to focus on the link between *geographical structure* of imports and physical distance.

For this purpose, four regional groups of countries were formed and basic statistics on the geographic structure of imports for each regional group are used and confronted with physical distance statistics.[8] As shown in table 3, south Mediterranean (SMED) and MENA countries trade more with European G6 countries. At the same time, these two regional groups of countries are geographically located near European G6 countries. It is also the case for Central and South America countries (CSA) and South East Asia countries (SEA) whose imports are mostly realized respectively from United States and Japan. The correlation between distance and geographic structure of imports for the four regional groups of countries seems to be evident. Could the factor of geographic

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[5] Frankel and Romer explain bilateral trade (imports and exports) between 150 countries.

[6] The G6 countries considered are: United States, Japan, Germany, France, Italy and United Kingdom. Canada was not considered.

[7] M_i^C represents fitted values of imports computed under the hypothesis that the residual term e_{ij} is homoscedastik.

[8] According to Hanson (2001), two methods could be used to estimate distance separating two points A and B. The first method is based on the computed value of the minimal distance of the arc linking the two points. The second method is based on a hub-and-spoke measure of distance between A and B with point C considered as a "hub point". Using the ICAO statistics, our measures of physical distance are exclusively based on the second method.

proximity that underlies imports be of some influence on technological diffusion? We will try to answer this question in the following section.

3. Imports, Technological Diffusion and Growth

As noticed earlier, the CHH model does not take into account the geographic factors that explain imports and particularly the physical distance. Trade is only considered as an exogenous variable that contributes to TFP growth *via* knowledge spillovers. The re-examination of the CHH hypothesis on knowledge spillovers will be done according to three approaches: The first approach allows us to estimate the contribution of technological diffusion to growth regardless of the geographic structure of imports of the four regional groups of countries formed (3.1). The second approach takes into account the geographic proximity underlying imports and estimates its influence on the intensity of technological diffusion (3.2). The third approach aims to study the "geographic proximity effect" on technological diffusion over time (3.3).

3.1 Imports and the Intensity of Technological Diffusion

Equation 6, inspired from the CHH model, is used to estimate the contribution of imports to growth *via* technological diffusion. Imports are measured in Million Dollars (M$) and the foreign stock of knowledge is computed using R&D spending data (M$) for the G6 countries considered as reported in the Main Science and Technology Indicators (MSTI) data base (OCDE, 1999). An interaction term between the two variables is also considered.

Panel data for SMED, MENA, CSA and SEA countries is used and covers the period 1982 to 1995.

$$\text{Log TFP}_{it} = \lambda_0 + \lambda_1 \log M_{it} + \lambda_2 \log M_{it} * \log(\sum_j S_{ijt}) + \mu_{ijt} \qquad (6)$$

TFP_{it} = Total Factor Productivity[9] of country i for year t.

M_{it} = Imports of country i from G6 countries

S_{ijt} = Foreign stock of knowledge benefiting country i proportionately to its imports from country j at year t.

μ_{ijt} = residual term

The foreign stock of knowledge is measured according to the Keller's approach, which integrates a depreciation ratio of knowledge capital:

$$S_{j1981} = D_{j1981} / (\tau + \delta) \qquad (7)$$ [10]

$$S_{jt} = D_{jt} + (1 - \delta) S_{jt-1} \quad ; t = \{1982, \ldots\ldots., 1995\} \qquad (8)$$

$$S_{ijt} = [M_{ijt} / M_{it}] * S_{jt} \qquad (9)$$

Equation 7 allows us to compute the stock of knowledge of country j belonging to the G6 group just for the year before the period considered in our estimations. The stock of knowledge of country j for the year 1981 is equal to country j R&D spending for the year 1981 (noted D_{j1981}) divided by the sum of country j R&D spending growth ratio (noted τ) for the period 1981-1995 and a knowledge capital depreciation ratio (noted δ) fixed at 0.1. Country j R&D stock is then computed for the period 1982-1995 using equation 8. Foreign stock of knowledge that benefits importing countries is assumed to be in proportion to their imports and is computed using equation 9.

Results are reported in table 5. The specification tests used show that for Mediterranean countries, knowledge spillovers benefit only some of the countries considered if we take in account the fixed effects specification (column 3). The estimated elasticity of TFP with respect to imports (E_m) ranges between 0.85 and 0.89 meaning that a 1 percent increase in SMED countries imports generates a mean increase in TFP by 0.87 percent for the period 1982-1995. Although SMED countries imports are no more important than those of MENA or CSA countries[11], technological diffusion effects benefiting the former seem to be much stronger. The results we obtain show that a 1 percent increase in MENA countries imports generates a mean increase in TFP by 0.75 percent for the same period whereas no technological diffusion benefit to CSA countries *via* imports. Our estimations show also that SEA countries are the countries that benefit most from technological diffusion (column 8, table 5).

By the first approach we use, we show that technological diffusion generated by imports does not have the same intensity. It is also interesting to note that the level of imports does not always explain the intensity of technological diffusion.

3.2 Geographic Location and the Intensity of Technological Diffusion

If the level of imports does not influence technological diffusion, then geographic location of importers with respect to exporters should be considered. We will try now to see if the "geographic proximity effect" could be stronger than "imports effect" in the estimation of technological diffusion intensity. For this purpose, we use the same model specification given by equation 6. The only difference introduced concerns the imports variable. Instead of including all the

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[9] TFP is computed assuming a Cobb-Douglas production function with constant returns to scale: $Y = A.K^{\alpha} L^{(1-\alpha)}$ with $\alpha = 0.4$.

[10] Data on countries R&D spending reported in the Main Science and Technology Indicators Data Base starts at the year 1981.

[11] Using the International Trade Statistical Year Book, the values reported in table 9 and weighed by the percentages of table 3 give an idea on the importance of imports for each regional group of countries.

imports from G6 countries, we just consider the imports emanating from the principal trading partner for each regional group of countries. For example, we include SMED and MENA imports from European G6 countries, CSA imports from United States and SEA imports from Japan. In doing so, we obviously modify the level of foreign stock of knowledge supposed to benefit to each country. This last variable is then recomputed for all importing countries.

The estimations used follow in equation 10, which should be considered as an illustration of the way we get SMED countries estimations:

$$\text{Log TFP}_{it} = a_0 + a_1 \log I_{(i/Eur),t} + a_2 \log I_{(i/Eur),t} * \log[\sum R_{(i/Eur),t}] + r_{(i/Eur),t} \quad (10)$$

TFP_{it} = Total Factor Productivity at time t of country i belonging to the south Mediterranean region.

$I_{(i/Eur),t}$ = Imports realized from European G6 countries at time t by country i belonging to the south Mediterranean region.

$R_{(i/Eur),t}$ = Foreign stock of knowledge benefiting at time t country i proportionately to its imports from European G6 countries. Country i belongs to the south Mediterranean region.

$r_{(i/Eur),t}$ = residual term

The same model specification is then reapplied for MENA, CSA and SEA countries using the appropriate measure of I and R for each country. Results are reported in table 6. As a matter of comparison, we use the new computed value of TFP elasticity with respect to imports noted E_I and compare it to the preceding E_m value. After testing for the appropriate econometric specification, the results we obtain confirm the existence of a "geographic proximity effect" that concerns some of the SMED countries. For these countries, the value of E_I is more important than E_m which means that a 1 percent increase in their European imports has more effects on TFP than their imports from all G6 countries. The mean increase in TFP is estimated by 0.95 percent (column 3 and 4, table 6), which is significantly different from the earlier 0.87 percent estimation.

However, the "geographic proximity" between importers and exporters does not play any role in determining the intensity of technological diffusion for MENA, CSA and SEA importing countries. The Keller's argument about technology level of exporting countries in enhancing TFP growth could be sustainable[12] here, particularly in the case of MENA countries. In fact, as shown in table 3, the geographic structure of imports of MENA countries was clearly changing. During the period 1982 to 1995, MENA countries have been importing more from "less technology advanced" exporters and decreasing their imports from "technology advanced exporters" such as European countries. One should also consider the changing structure of imports in terms of the kinds of goods imported by MENA countries during this period.

3.3 Geographic Location and Technological Diffusion over Time

We now try to evaluate the contribution of the geographic proximity to technological diffusion over time. For this purpose, we estimate equation 10 on the periods 1982-1988 and 1989-1995 for each regional group of countries. As shown in tables 7-a and 7-b, technological diffusion is changing in intensity over time if we consider the value of E_I from one period to another. From table 7-a, we note an important contribution of geographic proximity to technological diffusion generated by imports particularly for SMED, MENA and SEA countries on the period 1982-1988. The negative sign of the coefficient a_1 should be interpreted with some caution. In fact, the level of foreign stock of knowledge linked to imports seems to be insufficient in order to enhance TFP growth so that, technological diffusion should have an indirect effect on TFP (Rezgui & Salah, 2001).

The results reported in table 7-b show that with the exception of SEA countries, technological diffusion has been no more significant for the SMED and the MENA countries for the period 1989-1995.[13] The results we obtain are quite close to those obtained by Keller (2001) for the case of developed countries.[14] For recent periods, technological diffusion seems to be less localized, which means that physical proximity does not play any role in intensifying knowledge spillovers. For the case of SMED and MENA countries, our results also confirm the idea that increasing imports from the nearest trading partners (European countries) does not always allow much more knowledge diffusion to importing countries.

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[12] Keller notes: "the composition of imports matters. Productivity growth in a typical developing country might not depend too much on whether 50 percent of its imports come from the United States and 30 percent from Japan, or 30 percent from the United States and 50 percent from Japan. But productivity is likely to be much lower if the country were too significantly to reduce the share of its imports from both United States and Japan while increasing its share of imports from other developing countries that are not world technology leaders" (Keller, 2000, pp 36).

[13] SEA countries were observing an accelerated technological diffusion effect from one period to another, which is confirmed by the EI value. For some of these countries, a one percent increase in imports from Japan contributes to 1.54 percent increase in TFP on the first period and to 1.69 percent on the second one. This result could be explained by the importance of local R&D capabilities of SEA countries, which offer larger possibilities of dynamic learning compared to those of the other regional groups of countries considered in this study.

[14] In the case of the technology frontier' countries, Keller found that the distance variable is negatively and significantly correlated to technological diffusion for the period 1970-1982 whereas no significant correlation is observed for the period 1983-1995. The author concludes at the absence of any "localized effect" for knowledge diffusion between the G7 countries (Keller, 2001, p19-20).

4. Concluding Remarks

Economic geography has been a main extension to growth analyses and especially to endogenous growth theories integrating knowledge spillovers as a means to achieve economic development. By using a gravitational model, our paper aimed first to show that imports could not be considered as an exogenous mechanism for knowledge spillovers as was the case in the CHH analysis. In a preliminary empirical work, we show that geographic factors and particularly physical distance separating importing countries from G6 exporting countries have important and significant influence on imports. Although subject to some criticism[15], the use of a gravitational model allows us to demonstrate that imports explained by geographic factors explain, in some part, the observed levels of imports for the sample of countries considered.

The preceding results justify the opportunity to re-examine the CHH hypothesis on knowledge diffusion generated by international trade. By showing that geographic location could have some influence on imports, the second step of our empirical investigations led us to three main results for the case of developing countries:

- Regional groups of countries with high levels of imports from G6 countries do not necessarily benefit more from knowledge diffusion . This is the case for MENA and CSA countries in comparison with SMED countries.
- Geographic location of importing countries is not be the only factor that determines the intensity of technological diffusion. Knowledge spillovers also depend on the evolution of the geographic structure of imports for these countries and on the kind of goods they import (knowledge intensive or not).
- Geographic proximity of importing countries to “core economies” does not always contribute to more technological diffusion in favour of the former. An amplified technological gap coupled with an increase in importing prices of new knowledge intensive goods may limit the knowledge transfer. The access to new technologies may also become more difficult because, over some periods, local learning capabilities of importing countries may not be sufficiently able to integrate these technologies even by mean of externalities.

On technical grounds, our paper is based on a log linear model of estimation with a classical measure of TFP. By using this econometric model, the study of physical proximity effects on knowledge diffusion does not directly integrate the distance variable, which could be done with a non-linear model specification[16] in further investigations. Finally, we consider that a suitable measure of TFP for the international comparisons made in this study should be the one proposed by Caves, Christensen and Diewert[17] (1982), which consists in the computation of a superlative TFP index. However, this method requires a precise measure of factor costs for all the countries included in the sample.

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[15] The use of a gravitational model lead to the exclusion of many other variables relative to the policy trade of each country. These variables should be crucial for the explanation of imports especially in developing countries.

[16] Following the Hanson (1998) model specification.

[17] Caves, D.W., L.R. Christensen and W.E. Diewert. 1982. “Multilateral Comparisons of Output, Input, and Productivity Using Superlative Index Numbers”, *The Economic Journal*, Vol.92: 73-86

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Table 1: Geographic Factors and Imports, [Dependent variable: Imports of country i from country j (Mij)]

Estimators	Year 1982	Year 1995
$\alpha 0$	3.210**	0.310
	(1.571)	(1.796)
$\alpha 1$	-0,658***	-0.456***
	(0,125)	(0.138)
$\alpha 2$	0.657***	0,845***
	(0.106)	(0.124)
$\alpha 3$	-0,226***	-0.339***
	(0.072)	(0.084)
Observations Number	252	252
Adj.R2	0.21	0.24
F Statistic	23.2	27.6

Notes: Standard error in parenthesis corrected by applying the White's test (1981)
*** Significant at 1% ** significant at 5%

Table 2: Correlation Between Observed Levels of Imports (M_i) and the Constructed Indicator of Imports (M_i^C) for the 42 Countries Considered in the Sample

Estimators	Year 1982	Year 1995
b_0	0.521	0.964
	(1.723)	(2.236)
b_1	0.989***	0.953***
	(0.243)	(0.294)
Observations Number	42	42
Adj.R2	0.291	0.284
F Statistic	17.83	17.30

Notes: Standard error in parenthesis corrected by applying the White test (1981)
*** Significant at 1% ** significant at 5%

Table 3: Regional Groups of Countries and their Imports Proportion from G6 Countries (values in percent)

Regional groups/G6 countries	Years	United States	Japan	Europe
South Mediterranean countries	1982	7	5	26
(SMED)	1995	4	2	21
Middle-East and North Africa	1982	23	28	55
(MENA)	1995	8	4	29
Central and South America	1982	42	12	18
(CSA)	1995	45	7	20
South-East Asia	1982	32	58	20
(ASE)	1995	46	87	44

Source: International Trade Statistical Year Book (1982, 1995)
Notes: *** Significant at 1% ** significant at 5%

Table 4: Physical Distance (in km) Separating Countries Considered From G6 Countries*

Regional groups/G6	United-States	Japan	Europe
SMED	5795 - 9234	9289 - 11607	578 - 3682
MENA	5795 - 10629	9209 - 12031	578 - 5092
AMECS	2540 - 10677	12286 - 18892	7470 - 12149
ASE	11070 - 18623	1227 - 5837	8552 - 12110

Notes: * We just consider minimal and maximal distance separating the countries considered and each G6 country.

Table 5: Imports, Technological Diffusion and Growth (Dependent Variable: LogTFP)

Regions	**SMED**	**SMED**	**SMED**	**MENA**[1]	**MENA**	**CSA**	**SEA**
Estimators /specifications	LS	FE	RE	FE	RE	FE	FE
λ_0	2.332	-	2.811***	-	2.83***	-	-
	(0.118)***	-	(0.15)	-	(0.138)	-	-
λ_1	-0.095	-0.296***	-0.28***	-0.244***	-0.24***	-0.022	-0.52***
	(0.113)	(0.08)	(0.079)	(0.06)	(0.06)	(0.05)	(0.08)
λ_2	0.042	0.096***	0.091***	0.08***	0.079***	0.001	0.197***
	(0.043)	(0.028)	(0.027)	(0.021)	(0.021)	(0.017)	(0.027)
Observations Nbr.	98	98	98	126	126	224	98
Adj.R2	0.02	0.77	0.75	0.94	0.94	0.95	0.99
Fisher test: FE vs LS ($F_{1\%}$)	6.62 [6.94]			46.3 [5.14]		114.8 [3.81]	152.2[6.94]
LR test: FE vs LS ($\chi_{2;5\%}^2$)		10.22 [5.99]		25.6 [5.99]		26.33 [5.99]	31.0 [5.99]
Hausman test: FE vs RE ($\chi_{2;5\%}^2$)			5.39 [5.99]		1.86 [5.99]	129.6 [5.99]	9.87 [5.99]
$E_m^{(.)}$	-	0.89	0.85	0.76	0.74	-	2.02

Standard error in parenthesis

(.)$E_m = \Delta \log TFP / \Delta \log M$

LS= Least Squares; FE = Fixed Effects; RE = Random Effects

Notes: *** Significant at 1% ** significant at 5%

[1] Missing data for Kuwait and Oman obliged us to not include these two countries in MENA estimations.

Table 6: Geographic Proximity and Technological Diffusion (period 1982-1995) (Dependent variable: Log TFP)

Regions	**SMED**	**SMED**	**SMED**	**MENA**	**CSA**	**SEA**	**SEA**
Estimators /specifications	LS	FE	RE	FE	FE	FE	RE
a_0	2.388	-	2.945***	-	-	-	2.706***
	(0.114)	-	(0.152)	-	-	-	(0.042)
a_1	-0.124	-0.366***	-0.341***	-0.272***	-0.01	-0.377***	-0.358***
	(0.133)	(0.091)	(0.089)	(0.065)	(0.052)	(0.077)	(0.08)
a_2	0.053	0.119**	0.112***	0.089***	-0.002	0.145***	0.138***
	(0.052)	(0.032)	(0.031)	(0.023)	(0.018)	(0.026)	(0.001)
Observations Nbr.	98	98	98	126	224	98	98
Adj.R2	0.02	0.76	0.76	0.94	0.95	0.99	
Fisher test: FE vs LS ($F_{1\%}$)	6.96 [18.0]			47.8[10.9]	121.59 [6.7]	101.98 [18.0]	
LR test : FE vs LS ($\chi^2_{2\,;5\%}$)		10.48 [5.99]		25.46[5.99]	26.8[5.99]	27.65 [5.99]	
Hausman test: FE vs RE ($\chi^2_{2\,;5\%}$)			3.51 [5.99]	17.6[5.99]	39.18 [5.99]		accepted[1]
$E_I^{(.)}$	-	0.97	0.92	0.72	-	1.32	1.25

Standard error in parenthesis

(.)E_I is computed using the mean value of Log(Rj) , j = (USA, JAP, EUR)

$E_I = \Delta \log TFP / \Delta \log I$

Notes: *** Significant at 1% ** significant at 5%

[1] The m statistic of the Hausman test is near zero, we then accept the RE specification.

Table 7: Geographic Proximity and Technological Diffusion Over Time: Estimations for the Period 1982-1988, (Dependent variable: Log TFP)

Regions	**SMED**	**SMED**	**MENA**	**MENA**	**CSA**	**SEA**	**SEA**
Estimators/ specifications	FE	RE	FE	RE	FE	FE	RE
a_0	-	3.146***	-	2.973***	-	-	2.492***
	-	(0.188)	-	(0.165)	-	-	(0.134)
a_1	-0.491***	-0.485***	-0.342***	-0.321***	-0.14**	-0.418***	-0.411***
	(0.1)	(0.099)	(0.079)	(0.083)	(0.072)	(0.055)	(0.058)
a_2	0.162***	0.161***	0.114***	0.108***	0.037	0.173***	0.171***
	(0.039)	(0.038)	(0.033)	(0.035)	(0.027)	(0.019)	(0.02)
Observations Nbr.	49	49	63	63	112	49	49
Adj. R2	0.94	0.94	0.97		0.97	0.99	
Fisher test: FE vs LS ($F_{1\%}$)	42.6 [18.0]		125.88 [10.9]		223.7[6.7]	355.45 [18.0]	
LR test: FE vs LS ($\chi^2_{2\ ;5\%}$)	21.73 [5.99]		33.84 [5.99]		57.08[5.99]	36.3[5.99]	
Hausman test: FE vs RE ($\chi^2_{2\ ;5\%}$)		0.248 [5.99]		accepted	22.98[5.99]		accepted
$E_I^{(.)}$	1.29	1.28	0.9	0.85	-	1.55	1.54

(.)E_I is computed on the basis of the mean value of Log(Rj) , j = (USA, JAP, EUR) for the period 1982-1988.

Notes: *** Significant at 1% ** significant at 5%

Table 8: Geographic Proximity and Technological Diffusion Over Time: Estimations for the Period 1989-1995, (Dependent variable : Log TFP)

Regions	**SMED**	**SMED**	**SMED**	**MENA**	**MENA**	**CSA**	**SEA**	**SEA**
Estimators/ specifications	LS	FE	RE	FE	RE	FE	FE	RE
a_0	2.236***	-	2.414***	-	2.564***	-	-	2.492***
	(0.08)	-	(0.148)	-	(0.162)	-	-	(0.134)
a_1	-0.01	-0.052	0.013	-0.046	-0.012	-0.015	-0.508***	-0.411***
	(0.166)	(0.139)	(0.121)	(0.112)	(0.112)	(0.155)	(0.131)	(0.058)
a_2	0.014	0.015	-0.004	0.015	0.003	-0.003	0.184***	0.171***
	(0.066)	(0.049)	(0.044)	(0.04)	(0.04)	(0.055)	(0.044)	(0.02)
Observations Nbr.	49	49	49	63	63	112	49	49
Adj. R2	0.11	0.84	0.84	0.98		0.96	0.99	
Fisher test: FE vs LS ($F_{1\%}$)	10.9 [18.0]			163.8 [10.9]		159.1 [6.7]	384.25 [18.0]	
LR test: FE vs LS ($\chi^2_{2;5\%}$)		13.04 [5.99]		36.16 [5.99]		51.8 [5.99]	36.8[5.99]	
Hausman test: FE vs RE ($\chi^2_{2;5\%}$)			accepted		accepted	13.39 [5.99]		accepted
$E_I^{(.)}$	ns	ns	ns	ns	ns	ns	1.72	1.66

Notes: (.)E_I is computed on the basis of the mean value of Log(Rj) , j = (USA, JAP, EUR) for the period 1989-1995.

ns = not significant

*** Significant at 1% ** significant at 5%

Table 9: Imports from G6 countries (in M$) realized by the 42 countries considered

Years	United-States	Japan	Europe
1982	62384	45971	54639
1995	209149	167087	139267.2

Source: International Trade Statistical Year Book (1982,1995)

Table 10: List of 42 Countries Considered in the Sample

Algeria	Ecuador	Madagascar*	Senegal*
Argentina	Egypt, Arab Rep.	Malaysia	Singapore
Bahrain	El Salvador	Mexico	Sudan*
Bangladesh*	Guatemala	Morocco	Syrian Arab Rep.
Bolivia	Hong Kong	Oman	Thailand
Brazil	Indonesia	Pakistan*	Tunisia
Cameroon*	Jamaica	Panama	Turkey
Central Africa Rep.*	Jordan	Paraguay	Uruguay
Chile	Kenya*	Peru	Venezuela
Colombia	Korea, Republic	Philippines	
Costa Rica	Kuwait	Saudi Arabia	

* Countries not considered in the regional groups of countries formed.