

HOW KNOWLEDGE FLOWS IN THE MEDITERRANEAN AREA: A PATENT CITATIONS ANALYSIS

Massimiliano FERRARA
Mediterranean University of Reggio Calabria

Roberto MAVILIA
Universidad Complutense de Madrid and KITeS –
Bocconi University

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Introduction

International technology diffusion involves several different channels and affect significantly the way and the ability of developing countries to learn and innovate

In this paper, we describe technologies trajectories and knowledge flows, using patent citations as an indicator from more technologically advanced South-European countries (SE) to North-Saharan (NS) developing economies and vice versa.

We extract from the EPO Worldwide Patent Statistical Database, all patents taken out in the NS and SE countries, that have been granted from EPO, with priority dates from 1984 to 2003.

We explore first the simple statistics of these data regarding the rate and technological composition of inventions in these countries over time.

Area 1	
North Saharan countries	
Country Code	Name
MA	Morocco
DZ	Algeria
TN	Tunisia
LY	Libyan Arab Jamahiriya
EG	Egypt

Area 2	
South European countries	
Country Code	Name
PT	Portugal
ES	Spain
FR	France
IT	Italy
SI	Slovenia
HR	Croatia
RS	Serbia
GR	Greece
TR	Turkey

Background and literature review

- Coe et al. (1997) examined north–south R&D spillover. They found that total factor productivity in developing countries is significantly boosted by the R&D stock of industrial countries, which they computed as the import-share-weighted sum of the R&D expenditures of a developing country's trading partners in the north. They interpreted this as evidence of north–south R&D spillover. Hu and Jaffe (2003) examined patterns of knowledge diffusion from U.S. and Japan to Korea and Taiwan using patent citations. They found that Korean patents are more likely to cite Japanese patents than U.S. ones, maybe due to their proximity. They also found that both Korea and Taiwan are surprisingly reliant on relatively recent technology.

Background and literature review

- Aboites and Beltran (2008) conclusion were that the patterns of knowledge diffusion from US to Latin American and South East Asian countries are quite different.
They found that the South East had a higher number of patents granted in USPTO than their Latin American counterparts and the technologies registered in Korea and Taiwan were of high technology (Information and Communications, Electric and Electronics, etc.) meanwhile in Latin America (Brazil and Mexico) the technologies registered were of traditional tech fields (mechanical, chemical, etc.). In their studies, they found also that the citations received (forward) by Korea and Taiwan outnumber the citations received by Mexico and Brazil. That means that the value of knowledge in Asian countries.

Background and literature review

- Montobbio and Sterzi (2008) analyzed nature, sources and determinants of international patenting activity in Latin American countries and the extent to which these countries benefit from R&D performed in some developed countries, using a patent citation analysis. They found that that the stock of ideas produced in the US has a strong impact on the international patenting activity of these countries.

Data

- Our source of patent data is a data set constructed and maintained by CESPRI at Bocconi University. This data set (from now on EP-KITES data set) includes all patent applications to the European Patent Office (EPO), from September 2nd 1977 to December 23th 2005. The data set comprises a total of 1,711,662 patents.
- The European Patent Office (EPO) grants European patents for the contracting states to the European Patent Convention (EPC), which was signed in Munich on October 5th 1973 and entered into force on October 7th 1977.
- The data set includes the full set of bibliographic variables concerning each patent application:
 - Priority, application, and publication number;
 - Priority dates, application and grant date;
 - Title and abstract;
 - Designated states for protection;
 - Status of application;
 - Main and secondary International Patent Classification (IPC) codes;
 - Applicant's name and address;
 - Inventors' names and addresses.

Data

- In addition, the data set also contains for each patent all citations made to other EPO patent documents. The data set includes a total of 642,218 citing patents and 834,328 cited patents, corresponding to a total of 1,621,359 citations.
- All patent data were procured from the EPO and elaborated by CESPRI. In particular, bibliographic data on patent applications are derived from the Espace Bulletin CD-R produced by the EPO, while information on patent citations come from the REFI tape also provided by the EPO. Data processing consisted mainly in a thorough work of cleaning and standardisation of rough information provided by the EPO.

Methodology:

Knowledge flows and measuring

Patent citations serve an important legal function, since they delimit the scope of the property rights awarded by the patent.

Thus, if patent B cites patent A, it implies that patent A represents a piece of previously existing knowledge upon which patent B builds, and over which B cannot have a claim.

The applicant has a legal duty to disclose any knowledge of the “prior art,” but the decision regarding which patents to cite ultimately rests with the patent examiner, who is supposed to be an expert in the area and hence to be able to identify relevant prior art that the applicant misses or conceals.

We assume that the frequency with which a given country’s inventors cite the patents of another country is a proxy for the intensity of knowledge flow from the cited country to the citing country.

For further discussion of the limitations of using citations data for this purpose, see Jaffe and Trajtenberg (1999) and Hall et al. (2001). Jaffe et al. (2000) present survey evidence regarding the extent to which citations reflect actual knowledge flows between inventors.

They find that citations are a noisy indicator of knowledge flow, in the sense that knowledge flow is much more likely to have occurred where a citation is made; but many citations also occur in the absence of any knowledge flow.

Technological Field Concentration

- A more systematic measure of the concentration of patenting in these countries across technological fields, also used by Hu and Jaffe (2003), is the the Herfindahl–Hirschman Index (HHI) of patent concentration. As shown by Hall et al. (2001), the HHI measure is biased upward when the number of patents on which it is based is small. Essentially, if there is a modest “true” probability of a random patent being in one of many classes, the true concentration may be low; if very few patents are actually observed, they can only be in a few classes, and the measured concentration will be high. Assuming the unobserved distribution across classes is multinomial, and the observed draws from that distribution are independent, Hall, Jaffe, and Trajtenberg show that an unbiased measure of the true concentration is given by

$$\hat{H} = \frac{N \cdot HHI - 1}{N - 1}$$

where \hat{H} is the bias-adjusted Herfindahl–Hirschman Index, N is the number of patents, and HHI is the traditional Herfindahl–Hirschman Index, calculated as the sum of squared shares across patent classes. As N grows large, \hat{H} converges to the traditional measure, but for small N the adjustment can be quite large. For example, if there are ten patents spread evenly across five classes, the HHI is 0.20, but is about 0.11. If there were only five patents spread across five classes, the HHI would still be 0.20, but \hat{H} is actually zero.

Knowledge diffusion

- Backward citations in patents are the source of the new knowledge. Forward citations on the other hand, reflect the importance of technology. Patents receiving a great number of forward citations reflect that their embedded technology is very valuable. Therefore, an increase of forward citations for some patents is associated with a growing value of knowledge.
- Several dates are included in each European patent document and the choice of one date is important for correctly dating an invention. The so-called priority date, i.e. the date of the earliest filing of an application in any of the patent offices adhering to the Paris Convention, is the date that obviously gets closer to the actual timing of the patented invention and will be adopted in what follows for the purpose of dating patents.

Knowledge diffusion

- This implies that the time lag between the priority date and the publication date may range from 1.5 years, for patents directly filed to the EPO, to 2.5 years, for patents initially filed in a national patent office and later on extended to the EPO. Moreover, for the so-called PCT patent applications, which allow the applicants to delay the decision of filing for an EPO patent until 30 months from the priority date, the time lag between priority and publication may well exceed 2.5 years.
- So patents are typically granted one to three years after application; thus, a citation lag of zero or one implies that the citing patent may well have been applied for before the
- originating patent was actually granted, as pending applications are not public, so in this case the citation would almost have been identified by the patent examiner or that the inventors were in the same R&D team or had a *vis-à-vis* contact.

Knowledge diffusion

- The average citations per patent over all years suggests, obviously, that patents of the SE area are technologically more significant than the NS area patents. However, this comparison is potentially misleading, because it does not control for the age distribution of the patent portfolios. SE area countries has many more older patents, which are more highly cited simply because they have been around longer, while NS area have patent portfolios weighted towards younger patents that are less highly cited. The fall in forward citations seen from 1999 to 2003 is a normal behaviour due to the great proximity to the granting date. Thus at the end of the data period, no patents have received very many citations because very little time has passed in which to observe them.
- The citation lag between a patent and its patent reference is a measure of the time necessary for a firm or inventor to assimilate prior technological information and undertake its invention, thus an indicator of speed of knowledge diffusion.

Table 2
 Distribution of patents granted by tech field and average forward citations to residents in the specific Area

	1984-1988		1989-1993		1994-1998		1999-2003	
	Patents	Cites	Patents	Cites	Patents	Cites	Patents	Cites
Area 1: all classes	39	1,56	47	1,26	68	1,38	124	1,02
Electronics	15,38%	1,67	6,38%	1,00	25,00%	1,82	20,97%	1,00
Tools	17,95%	1,71	14,89%	1,14	10,29%	1,57	15,32%	1,00
Basic Materials Chemistry	43,59%	1,53	31,91%	1,33	17,65%	1,00	13,71%	1,00
Pharmaceutics/Biotech	2,56%	1,00	14,89%	1,57	26,47%	1,22	30,65%	1,05
Industrial processes	10,26%	2,00	14,89%	1,00	7,35%	1,00	13,71%	1,00
Mechanical Elements, Machine tools, Transport	5,13%	1,00	10,64%	1,40	5,88%	1,50	3,23%	1,00
Consumer Goods	5,13%	1,00	6,38%	1,00	7,35%	1,40	2,42%	1,00
Area 2: all classes	29858	1,83	38713	1,74	48410	1,40	66643	1,04
Electronics	16,62%	1,82	17,59%	1,65	19,65%	1,36	21,92%	1,03
Tools	13,32%	1,91	13,07%	1,73	12,48%	1,39	11,96%	1,03
Basic Materials Chemistry	15,74%	2,10	14,96%	2,09	13,48%	1,65	11,41%	1,07
Pharmaceutics/Biotech	5,43%	2,49	6,97%	2,39	8,90%	1,80	10,02%	1,10
Industrial processes	16,26%	1,78	16,57%	1,64	15,67%	1,31	15,15%	1,03
Mechanical Elements, Machine tools, Transport	20,59%	1,59	18,98%	1,54	18,00%	1,27	18,11%	1,02
Consumer Goods	12,05%	1,62	11,85%	1,54	11,82%	1,25	11,44%	1,03

Table 2
Basic patent statistics

		1984-1988	1984	1985	1986	1987	1988	1989-1993	1989	1990	1991	1992	1993
Area 1	Patents #	39	10	9	4	6	10	47	6	10	10	11	10
	Per 100,000 population	0,0073	0,0098	0,0086	0,0037	0,0054	0,0088	0,0077	0,0052	0,0084	0,0082	0,0088	0,0079
	\hat{H}	0,24	0,36	0,19	0,17	0,13	0,27	0,17	0,40	0,11	0,16	0,13	0,24
Area 2	Patents #	29858	4725	5386	5780	6696	7271	38713	7863	7687	7899	7464	7800
	Per 100,000 population	2,5028	2,0110	2,2758	2,4255	2,7910	3,0104	3,1376	3,2299	3,1355	3,2001	3,0044	3,1179
	\hat{H}	0,16	0,16	0,16	0,16	0,16	0,15	0,15	0,15	0,15	0,15	0,15	0,15
		1994-1998	1994	1995	1996	1997	1998	1999-2003	1999	2000	2001	2002	2003
Area 1	Patents #	68	8	6	14	21	19	124	16	24	35	28	21
	Per 100,000 population	0,0100	0,0062	0,0045	0,0104	0,0152	0,0135	0,0167	0,0112	0,0165	0,0236	0,0185	0,0137
	\hat{H}	0,18	0,25	0,07	0,14	0,16	0,23	0,19	0,22	0,23	0,23	0,17	0,15
Area 2	Patents #	48412	8113	8471	9529	10751	11548	66643	12512	13158	13226	13603	14144
	Per 100,000 population	3,7939	3,2213	3,3431	3,7379	4,1915	4,4756	5,0704	4,8206	5,0390	5,0330	5,1436	5,3156
	\hat{H}	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,16

Population source from U.S. Census Bureau, Population Division

Table 4

Forward citation lag average time, in years, from different areas, per technological field

	Citation Lag Average				
	Everywhere	Area 2	Area 1	RoW (except Area 2)	Row
Area 1: all classes	4,1590	4,4653	2,4449	4,1827	4,2420
Electronics	3,9819	-	3,0226	4,0110	4,0110
Tools	4,7113	5,6006	-	4,0645	4,7113
Basic Materials Chemistry	4,9246	4,4370	2,8528	5,5433	5,1219
Pharmaceutics/Biotech	3,3915	4,9654	1,9804	3,1894	3,5755
Industrial processes	3,9726	1,9357	-	4,4253	3,9726
Mechanical Elements, Machine tools, Transport	4,6720	2,2505	-	4,9747	4,6720
Consumer Goods	3,5736	2,4244	-	3,9567	3,5736
	Everywhere	Area 1	Area 2	RoW (except Area 1)	RoW
Area 2: all classes	4,7798	6,0752	4,4778	4,7793	4,7798
Electronics	4,3543	6,3600	4,3001	4,3541	4,3543
Tools	4,7866	7,4205	4,5691	4,7860	4,7866
Basic Materials Chemistry	4,6188	5,2131	4,0283	4,6184	4,6188
Pharmaceutics/Biotech	4,1356	7,0432	3,9967	4,1314	4,1356
Industrial processes	5,2027	2,7132	4,7716	5,2034	5,2027
Mechanical Elements, Machine tools, Transport	5,3012	-	4,8785	5,3012	5,3012
Consumer Goods	5,3823	5,9411	4,9395	5,3822	5,3823

Table 5
Number of citation received, per area and per citation lag

# Citation received	Citation Lag (Year)																			
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Area 1 from:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Area 1	0	0	20	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Area 2	5	0	55	20	15	5	0	0	10	0	10	0	0	0	10	0	0	0	0	0
Everywhere	5	70	180	120	70	20	45	35	40	20	20	5	5	5	10	0	0	0	0	0
RoW (except Area 2)	0	70	105	95	50	15	45	35	30	20	10	5	5	5	0	0	0	0	0	0
RoW	5	70	160	115	65	20	45	35	40	20	20	5	5	5	10	0	0	0	0	0
Area 2 from:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Area 2	3855	24785	60495	47090	34205	25760	19050	15055	11655	9150	7115	5200	4195	3030	1965	1160	800	420	170	35
Area 1	0	10	20	10	20	5	20	30	10	10	20	5	0	5	0	0	0	0	0	0
Everywhere	11105	56835	142485	113915	85685	65485	50520	39815	32190	26110	20240	14495	11915	8410	5475	3520	2135	1140	325	105
RoW (except Area 1)	7250	32040	81970	66815	51460	39720	31450	24730	20525	16950	13105	9290	7720	5375	3510	2360	1335	720	155	70
RoW	7250	32050	81990	66825	51480	39725	31470	24760	20535	16960	13125	9295	7720	5380	3510	2360	1335	720	155	70

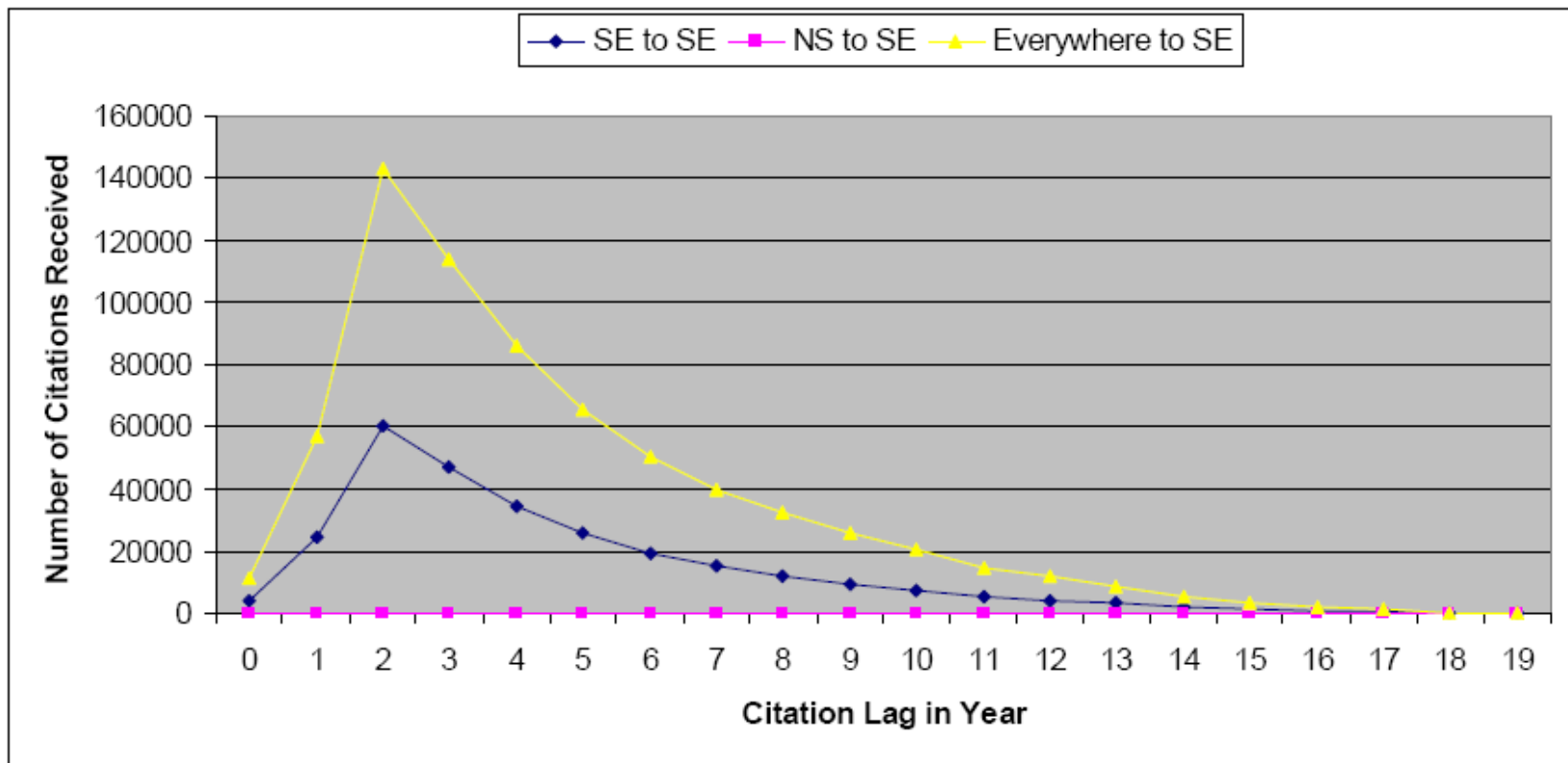


Figure 1 – Number of forward citation to SE area countries, per citation lag

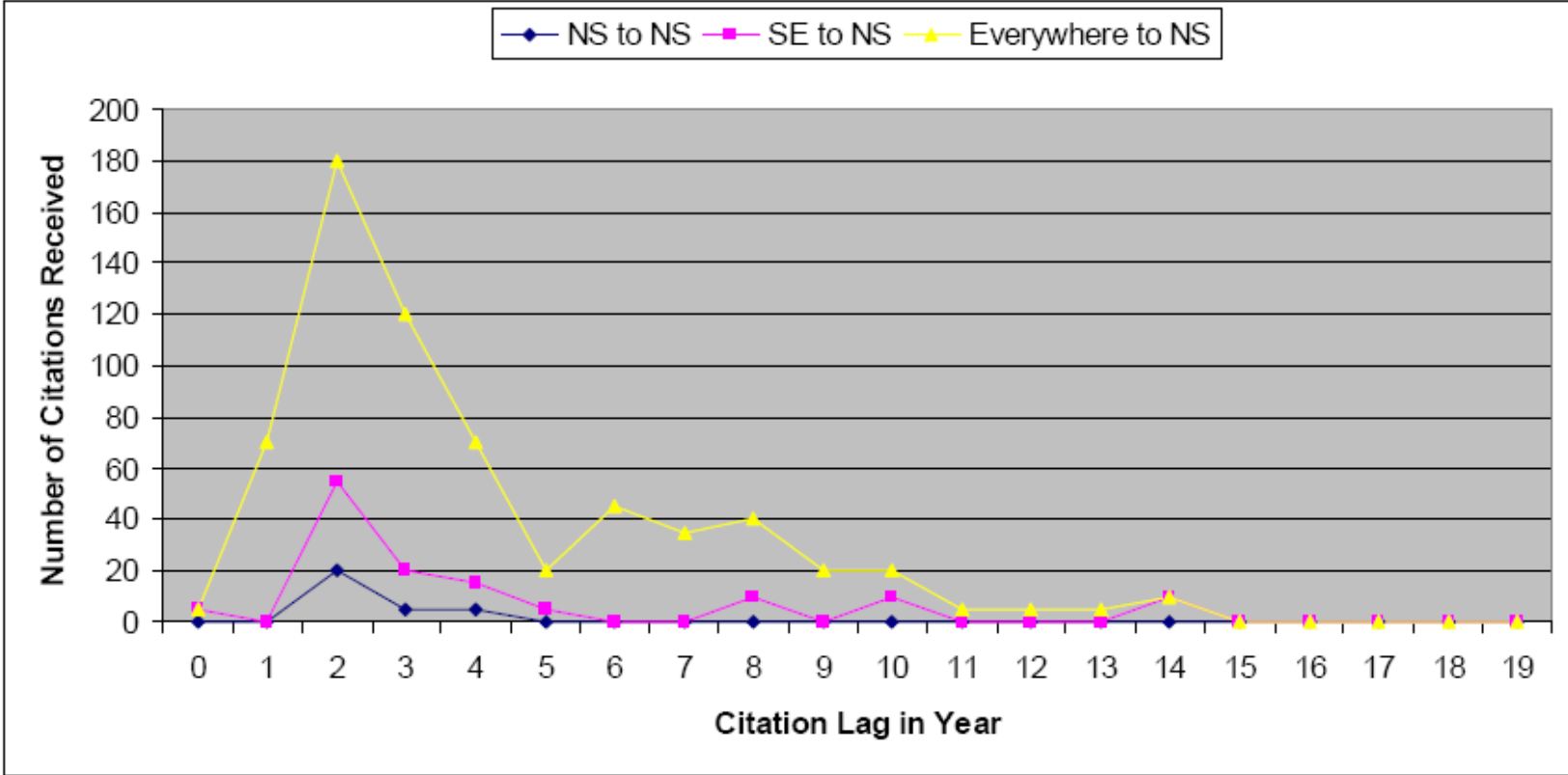


Figure 2 – Number of forward citation to NS area countries, per citation lag

Conclusion

- Our investigation reinforces the importance of understanding the broad network influences on knowledge flows and learning in developing countries. A National Innovation System perspective supports the idea that successful economic development is linked to a nation's capacity to acquire, absorb, disseminate, and apply modern technologies. Thus, technological divides between rich and poor countries may conventionally be
- The patterns of knowledge diffusion for the NS area countries and SE area countries during the 1983-2004 period are quite different. We found that, obviously, the SE area countries had a higher number of patents granted in EPO than the NS area countries. Furthermore, the technologies registered in SE area countries were evenly distributed across sector meanwhile in NS countries the technologies registered were of traditional tech fields and tend to exclude the Mechanical Elements/Machine Tools/Transport and the Consumer goods sectors.
- The citations received (forward) by SE area countries outnumber the citations received by NS area countries. That means that the value of knowledge in SE area countries is more important than the value of NS area countries.
- The other strong finding, to be further investigate, is the extremely high speed of knowledge diffusion seen both in forward and backward citations from/to the NS area countries for the sector of industrial process. This is somewhat surprising given the NS area countries' low patenting activities in this sector, and could be maybe explained in their greediness to learn in this technological field.