40th Congress of the European Regional Science Association

26th Meeting of Regional Studies of the Spanish Association of Regional Science

"EUROPEAN MONETARY UNION AND REGIONAL POLICY"

Barcelona (SPAIN), 30th August–2nd September, 2000

Level and diffusion of technology in the Andalusian industry (1980–1995)

Thematic Area 2: Economic growth and production factors

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ABSTRACT

The degree of economic development of any region is usually related to different factors. One of the most important is the technological level associated to the productive sectors. The technological level must be measured, not only by the appearance of new products and production processes (generation), but also by the possibility of including these products and processes inside the firm (adoption/diffusion). This idea means that both, generation and diffusion of technology occupy a central position in the production system of any region, and especially in some places where the SME´s are a relevant majority.

One of the main targets of technological policy is the development of the technological level of the firms and by extent of the region as a whole. So it is relevant to design and study the evolution of an indicator that measures this objective.

There are several ways to study the technological level of a region or of a specific economic sector. In this paper, we will follow the methodology of Input-Output Analysis that make possible a more detailed study. In this paper we are interested in investigating the relationship between the industries at the regional level of Andalusia and compared with the country as a whole. The period of analysis is 1980-1995.

Our first target is to specify the input side in the innovation process by means of variables such as R&D spends, industrial employment in the R&D activities, human

capital, etc., both as a whole and as share of GPD. The second step is related to the analysis of output data, characterised mainly by technological indexes (Saez, 1992) and de evolution of potentially innovative industrial sectors, which include sectors that use mainly high technological inputs and spread technology among the whole economy. The third step is concerned with study of the evolution of the Intermediate Input Requirements and Employment Requirements of every industrial sector and of the regional economy.

1. INTRODUCTION

This paper pretends to analyse the result of the Andalusian Science-Technology-Industry System (STIS) that is constituted by the Regional innovative system (PRADAS, 1998). We will begin by the analysis of the Andalusian R&D system effort and will be compared with the Spanish and European levels. We will follow with other two aspects that are useful to characterise the Andalusian STIS: the technological level of our region and the level of technological diffusion among the economic system in Andalusia. To reach this aim we will use two different tools. The Technological Content Index (TCI) and the Intermediate Inputs Requirements (IIR) that can be obtained form the Input-Output tables, which are the most important tools for our analysis.

The origin of the development of a specific field to impel the R&D activities at the regional level can be found in two different sources. On one hand, the industrial crisis of the 70´s, on the other hand the autonomic organisation adopted by the Kingdom of Spain after the end of the Francoist Regime. Regional policies had the objective of contribution to the development poor parts of the country. The objective of these policies was to substitute old firms and declining industrial sectors for new and innovative companies that could contribute to create employment and economic development. Regions, that traditionally had no principal roll to develop in these high-tech economic sectors, have a especial interest in a kind of policies that give the opportunity of developing this field. These policies pretend a modernisation of old firms and contribute to generate new products and employment in poor regions and countries.

From the Andalusian point of view, R&D Policies appear relatively late[1]. We can illustrated this fact by two simple facts. First, R&D Policies do not considered these kind of policies until 1987 (*Programa Andaluz de Desarrollo Económico*). Second, Scientific Policy is also a late development. The first plan for Research in our region

appears only in 1990 (*I Plan Andaluz de Investigación 1990-1993*) and can be considered a translation of the First National Plan for Scientific Research and Technological Development. *(Primer Plan Nacional de Investigación científica y desarrollo tecnológico*). The objective of the regional plan was to equip Andalusia with scientific infrastructures where R&D activities could be developed. The Second Andalusian Plan for Scientific Develop only appears in 1996 ending in 1999. The main objectives of this second plan were to strengthen the infrastructures built in the First Plan and to incentive firms to be connected to R&D activities. The Third Andalusian Plan (2000-2003) has just been approved and pretend to integrate the Andalusian system into the national and European systems[2].

The study of the STIS in Andalusia that follows is focussed at the macroeconomic level. Data for spending in R&D activities will be used as a measure of the research effort made by the Andalusian system. The Technological Content Index will measure the technological level. Finally, the Intermediate Input Requirements are used as a measure of the diffusion of technology within the economic system.

The data that we need in order to calculate these variables are obtained from the official statistical instruments available: the Input-Output Tables for the Andalusian Economy 1980, 1990 and 1995 and the Official Statistics of the National Bureau of Statistics (INE).

2. METHODOLOGY

As we have just said, the first target of our work is to characterise the Andalusian STIS. We will use two different indicators. First, the percentage distribution of the regional spends in R&D activities among the different economic agents (Private Firms, Universities and Public Administration). Second, the Research Effort (RE) in which we distinguish between the total regional spending and those corresponding to private firms. RE is calculated as the percentage of the Gross Value Added that is related to spends in R&D activities.

$$RE = \frac{\text{R \& D Spendings}}{\text{GVA}} \times 100 \qquad [1]$$

The selection of the Potentially Innovative Sectors (PIS) among the whole economy is needed in order to calculate the Technological Content Index (TCI). We have followed the criteria by Buesa and Molero (1992) and García, Martin and Palma (1994) that appear in Table 1.

TABLE 1. POTENTIAL INNOVATIVE SECTORS

SECTORS R56	TIOAN 1980	TIOAN 1990	TIOAN 1995
4 Mining	5	10	7 a 11
6 Electricity	7	12	47
7 Prod. & distribution of gas	8	13	48
8 Water	9	14	49
M 9 Primary metal manufactures	19	15	34
10 Primary non–metallic manufactures	10, 13, 15	16, 19	32,33
M 14 Basic chemistry	16	21	28p
M 15 Fertilizers & agricultural chemistry	17	22	28p
M 16 Other chemical products	18	23, 24	29
17 Metal products	20 a 23	25	35
M 18 Non-electrical machinery	24	26	36
H 19 Electric and electronic machinery	25, 26	27	37,38,39
M 20 Motor vehicles and components	27	28	41
21 Shipbuilding and repairing	28	29	42
M 22 Other transport equipments	29	30	43
M 42 Rubber and plastics products	50	53	40,45
M 43 Other manufacturing	51	31, 54,55	50p,51p
44 Building and related activities	52	56	50p,51p
45 Civil Engineering	53	57	30
49 Transportation	57	63 a 65	58 a 62
50 Communications	58	66	63
51 Finance institution	59	67	64,66
52 Insurance	60	68	65

Source: Buesa and Molero (1992), García, Martín and Palma (1994) and Fundación COTEC (1997).

On the other hand, COTEC (1997) classifies the different industrial sectors into three groups, according to the technological intensity of its products. These sectors are named *High*, *Medium* and *Low technological intensity sectors*. Combining both criteria we show in Table 1 the Potentially High Innovative Sectors (H) and the Potentially Medium Innovative Sectors (M). In this way, we get three different TCI. First, the Global Index of Technological Content; second the Medium–High Technological Content Index and finally the High Technological Content Index. These kinds of inputs have two different origins: the whole economy or the region that we are studying. Combining the origin of the inputs and his technological intensity we obtain six different indicators. The formula can be settled as follows:

1. Global Technological Content Index of Total Inputs

$$TCI_G^{IT} = \frac{\text{Inputs from PIS}}{\text{Total Inputs}} \times 100 \quad [2]$$

2. Regional Global Technological Content Index

$$TCI_G^{IR} = \frac{\text{Inputs from regional PIS}}{\text{Total Inputs}} \times 100 \quad [3]$$

3. High–Medium Technological Context index of Total Inputs

$$TCI_{HM}^{IT} = \frac{\text{Inputs from high PIS} + \text{Inputs from MediumPIS}}{\text{Total Inputs}} \times 100 \quad [4]$$

4. High–Medium Technological Context index of Regional Inputs

$$TCI_H^{IIT} = \frac{\text{Inputs from regional high PIS} + \text{Inputs from regional MediumPIS}}{\text{Total Inputs}} \times 100 \quad [5]$$

5. High Technological Content Index of Total Inputs

$$CTI_H^{IT} = \frac{\text{Inputs from High PIS}}{\text{Total Inputs}} \times 100 \quad [6]$$

6.. High Technologicl Content Index of Regional Inputs

$$TCI_H^{IIR} = \frac{\text{Inputs from regional High PIS}}{\text{Total Inputs}} \times 100 \quad [7]$$

The calculus of Intermediate Inputs Requirement (IIR) follows the classical Leontief model developed by Carter (1970) and applied to the Spanish economy by Fanjul et al (1975) and Segura and Restoy (1986) and to the Andalusian economy by Garcia, Palma and Martin (1994) and Palma, García and Rodriguez (1997). This method gives us the volume of IIR of the different productive sectors in order to satisfy the Final Demand according to the equation:

$$Q_t = (I - A_t)^{-1} \cdot (Z_t - M_t) - Z_t + M_t \quad [8]$$

where year of reference is noted like t; Q_t is the Matrix of Intermediate Goods Requirements; $(I\text{-}A_t)^{-1}$ is the Leontief Inverse Matrix; Z_t is the Vector of Final Demand

Transformed in a Diagonal Matrix and Mt is the Importation matrix of the whole Economy.

The difference Q_t-Q_{t-1} can be explained by different causes: changes due to a new technological structure of the economy, changes in the structure of the final demand or changes in the volume of the final demand. We are interested in changes due to the first cause. So a new matrix is needed where Final Demand and Importations are fixed and only changes the Interindustrial flux matrix, and so the Leontief inverse.

$$Q^*_{t-1} = (I - A_{t-1})^{-1} \cdot (Z_t - M_t) - Z_t + M_t \qquad [9]$$

The difference Q_t-Q^*_{t-1} can be explained only by changes in technology, while changes Q^*_{t-1}-Q_{t-1} show us the effects of changes in Final Demand (Structure and Volume)

3 RESEARCH AND DEVELOPMENT EFFORT OF THE ANDALUSIAN SCIENCE TECHNOLOGY INDUSTRY SYSTEM.

In order to define the main characteristics of the Andalusian Innovation System, it is important to compare the results of the European and Spanish System. The situation in Europe was characterised by CIAMPI Report, presented to the European Council in June 1995, which main objective was to emphasise the necessity of co-ordination of national policies. The report informs that despite the improvement of competitiveness of the European Industry that can explain the reduction of the deficit of importation from USA and Japan, there still persists important weaknesses. Among them, the report shows the followings:

- Small European specialisation in high-tech goods and in markets of important growth
- reduced presence of the European industry in geographical areas of high potential growth
- Not sufficient productivity of the R&D effort.
- European companies seem to be less able to develop new products or services from R&D activities than Japanese or American companies.

Following the indicator of Spending in R&D as a percentage of the GDP, we can see that there is an important lag of Spain with respect to the main countries of OECD or the EU. For example, spending represent more than 2% of the GDP since 1981 in Germany, United Kingdom and France. USA spends over 2.5% and Japan spends more than 3% in years 1990,1991 and 1992. Spain, during the same period has not reached 1%.

In general, Spain is 2 points below Japan and USA, 1.5 below Germany, France and U.K., and 1 point below the average of the EU. For example in 1995 the situation was as follows: U.E. (1.85%) Japan and USA (more than 2.5%) Spain (0.85%) and Andalusia (0.67%).

TABLE 2. DISTRIBUTION OF R&D SPENDS (PORCENTAGE) (1983–1995)
In parenthesis, the position of Andalusia among the 17 Spanish Autonomic Communities

YEAR	ANDALUSIA			SPAIN		
	Firms	Universities	Public Administ.	Firms	Universities	Public Administ.
1983(*)	(14) 14,97	(4) 85,03		51,79	48,21	
1986	(10) 41,03	(8) 27,79	(7) 31,18	58,62	15,23	26,15
1987	(12) 35,91	(4) 26,88	(6) 37,20	57,29	15,52	26,31
1988	(12) 37,59	(8) 32,13	(7) 30,27	56,79	19,24	23,18
1989	(12) 34,99	(6) 38,16	(7) 26,86	56,33	20,41	22,73
1990	(12) 33,41	(6) 41,61	(9) 24,98	58,14	20,48	20,83
1991	(12) 31,12	(8) 43,77	(9) 25,11	56,29	22,33	21,38
1992	(13) 26,73	(7) 52,52	(7) 20,75	50,80	29,08	20,12
1993	(14) 21,76	(3) 60,15	(9) 18,09	48,22	31,58	20,20
1994	(13) 24,27	(5) 54,97	(8) 20,75	46,76	31,58	20,70
1995	(11) 26,66	(9) 51,95	(8) 21,39	48,23	33,15	18,62

(*) 1983. Agregate Figure for Universities and Public Adminstration..
Source: INE Research and Development Activities Statisitcs, Contabilidad Regional de España del INE., C. Martín and L. R. Romero (1988), C. Martín, L. Moreno and L. R. Romero (1990).

TABLE 3. RESEARCH EFFORT (1983-1995): R&D SPENDS AS PERCENTAGE OF GVA
In parenthesis, the position of Andalusia among the 17 Spanish Autonomic Communities.

YEAR	TOTAL EFFORT OF THE REGION		FIRMS EFFORT	
	Andalusia	Spain	Andlausia	Spain
1983	(7) 0,2789	0,4623	(9) 0,0417	0,2394
1986	(8) 0,3653	0,6166	(8) 0,1499	0,3614
1987	(7) 0,3604	0,6537	(7) 0,1294	0,3745
1988	(8) 0,4319	0,7665	(10) 0,1624	0,4353
1989	(8) 0,4779	0,8072	(9) 0,1672	0,4547
1990	(8) 0,4929	0,9015	(9) 0,1647	0,5242
1991	(8) 0,5010	0,9275	(9) 0,1559	0,5221
1992	(12) 0,5670	0,9995	(12) 0,1515	0,5135
1993	(7) 0,6896	0,9787	(11) 0,1503	0,4815
1994	(10) 0,5663	0,9209	(11) 0,1374	0,4306
1995	(5) 0,6654	0,9161	(9) 0,1774	0,4418

Source: Estadísticas sobre Actividades de I+D del INE, Contabilidad Regional de España del INE, C. Martín y L. R. Romero (1988), C. Martín, L. Moreno y L. R. Romero (1990).

From another point of view, we can consider the different sources of spending in R&D activities: Private Firms, Universities and Public Administration. This can be seen in Table 2 and Table 3. While in the EU firms develop more then 60% of the spending in R&D activities, Spanish firms has never reached this figure (58% in 1990, 48% in 1995). It is clear that the Andalusian effort is smaller than the Spanish average especially at the level firm. This means that the participation of the other agents, Universities and Public Administration is extraordinary high specially the former that represents more than 50% of the regional spending in R&D.

From both Tables we can conclude that the research effort and spending in R&D of private firms show a cyclical behaviour. It seems that the Andalusian and Spanish firms effort can be explained by the evolution of their economic results instead of the improvement of technology and investment in competition.

4. TECHNOLOGICAL LEVEL AND DIFFUSION OF TECHNOLOGY.

After this short evaluation of the spending in R&D, we will focus on the evaluation of the Technological Content Index and the evolution of the IIR. As Table 4 shows, there exists certain stability, with small decrease in the technological content since 1980-1995, accompanied by growth of technological content incorporated by the Andalusian economy in the regional inputs. This means that there has been a tendency to reduce the technological content incorporated to the productive system and a substitution of imported technology by regional technology, which is weaker and late [3].

TABLE 4. TECHNOLOGICAL CONTENT INDEX AND INTERMEDIATE INPUT REQUIREMENT IN ANDALUSIA. (1980-1995)

TECHNOLOGICAL CONTENT INDEX (1)		**1980**	**1990**	**1995**
* GLOBAL:	TOTAL	52,46	51,20	52,11
	REGIONAL	25,15	31,01	29,17
* MEDIO-ALTO:	TOTAL	11,73	14,58	20,95
	REGIONAL	4,05	4,44	6,76
* ALTO:	TOTAL	1,80	3,34	3,27
	REGIONAL	1,00	1,80	0,36
INTERMEDIATE INPUT REQUIREMENTS		3.964.272	7.387.937	8.898.737
VARIATION OF REQUERIMENTS (2)		**1980 to 1990**		**1990 to 1995**
* TOTALS		3.423.656 (86,36%)		1.510.800 (20,45%)
* TECHNOLOGICAL STRUCTURE		-590.877 (-14,91%)		1.159.822 (15,7%)
* FINAL DEMAND		4.014.532 (101,27%)		350.973 (4,75%)

Percentage
Millions of pesetas. 1990.
SOURCE: INPUT OUTPUT TABLE ANDALUSIA 1980, 1990 and 1995.

Two different periods can be found. First, 1980-1990 when the phenomena mentioned above are very intensive, specially the substitution of the inputs potentially innovative. On the contrary, years 1990-1995 shows a change in this tendency and the technological content of intermediate inputs is recovered.

Looking to the evolution of the IIR we can also see two different periods. From 1980-1990 there is an increase of almost 90% in the volume of the requirements. This growth is due almost exclusively to changes in the structure and volume of final demand. (The technological component -changing the productive structure- is negative) On the other hand, during the period 1990-1995 the process has changed deeply, because both, changes of final demand and of productive structure (technology) are positive. The latter are responsible for the 20% of growth in the volume of IIR.

This means that during the first period, the change in the productive structure has reduced the Intermediate Input Requirement for any Peseta of the final demand, and has weaken the relations among productive sectors. On the contrary, during the period 1990–1995, the change was made on the contrary way, increasing the necessities of intermediate inputs and generating a better integration in the productive network.

As a result of this analysis we can conclude that during the period 1980-1990 there exists a reduction in the process of diffusion of technology in the Andalusian economy accompanied by the effective reduction of the Technological Content Index. During the period 1990-1995 there exists a recovery in the diffusion of technology.

Nevertheless, these data must be clarified. The evolution of the Technological Content Indexes during the 80´s show an increase in the technology of the economy through the use of inputs coming from economic sectors of medium and high technological intensity (specially from abroad). This tendency continues during the beginning of the 90´s, with some differences. On one hand, the tendency grows, as shows the high-medium index. On the other hand, the high index seems to stabilise. This behaviour is due to the substitution of inputs coming from abroad.

A relevant contradiction seems to appear when these results are compared with those obtained from the analysis of Global Technological Content Indexes. This problem can be solved if we look to the calculus of TCI. These indexes are obtained as a percentage of Inputs with different technological intensity, over Total Intermediate

Inputs. In this way, when High and medium technological inputs grow, low technological intensive inputs decline and this makes up the former increment.

If we consider both instruments, we can conclude that during these years, it took placed an important effort of modernisation and technological innovation in the Andalusian economy. During the decade of the 80´s there was a significant change in the Andalusian productive structure that was translated to the reduction of IIR. The final result of these years was the impossibility of spreading technical innovations among the whole economic system. This tendency is dramatically reversed between 1990 and 1995 when a deep change occurs. The new productive structure made possible a remarkable recovery in the diffusion of technology, and stabilised the TCI at similar levels of 1980.

TABLE 5. EVOLUTION OF TECHNOLOGICAL CONTENT INDEX AND INTERMEDIATE INPUTS REQUERIMENTS. SPAIN (1980-1994)

TCI (1)		**1980**	**1990**	**1994**
* GLOBAL:	TOTAL	62,45	58,24	55,96
	INTERIOR	49,73	47,09	43,57
* HIGH-MEDIUM:	TOTAL	23,35	17,99	17,45
	INTERIOR	17,88	11,51	9,42
* HIGH	TOTAL	2,76	3,77	3,72
	INTERIOR	1,43	2,03	1,62
IIR (2)		30.357.998	46.590.081	50.729.747

VARIATIONS OF REQUIREMENTS (2)	**1980 TO 1990**	**1990 TO 1994**
* TOTALES	16.232.073 (53,47%)	4.139.666 (8,89%)
* TECHNOLOGICAL STRUCTURE	-5.504.556 (-18,13%)	-1.413.882 (-3,03 %)
* FINAL DEMAND	21.736.629 (71,60%)	5.553.544 (11,92%)

(1) Percentage.
(2) Millions of pesetas. 1990.
Source: INPUT OUTPUT TABLE SPAIN 1980, 1990 and 1994.

We can compare Andalusian and Spanish results in Table 5. We can discover a similar evolution en the decade of the 80´s. The IIR have grown only due to the variations of the Final Demand. Changes in the national productive structure have determined a reduction in the requirements, something similar to what happened in the Andalusian case. The positive effect of the final demand is not so intensive, while the reduction, due to technology, is bigger. The final result is the same evolution in Spain and Andalusia, but at a lower level in the first case.

The levels of the Spanish TCIs are higher than the Andalusian although they present a similar evolution. We can see a reduction in the Global Technological Content Index between 1980 and 1990, despite the effort developed by to incorporate a higher

portion of high technological intensity intermediate inputs. In a different way of what has happened in Andalusia, the Spanish economy the participation of inputs coming from medium technological intensity declines. On the other side In Spain it doesn't exists a substitution between national and imported inputs, as it shows the stability of the difference between the national and the total indexes.

The Spanish and the Andalusian Productive structure have changed during the decade of the 80´s. This change has generated a reduction of intermediate relations among different productive sectors. This can be considered as a sing of the reduction of the diffusion of technology among the economic system. The results of the effort developed in order to improve the technological content of inputs incorporated to the productive system, seem to have been very weak.

In Andalusia, this evolution have been corrected during the beginning of the 90´s by means of a bigger effort of the use of high and medium technological content. The effect of this process has been to spread this effect all over the economic system. On the contrary, in the case of the Spanish economy the analysis suggests the continuity of the decay in the interindustrial flows, as shows the negative evolution of the IIR due to changes in the technological structure. This fact has pressed in a negative way on the capacity of spreading new technologies over the whole system. In this way, there has been a reduction of the Global Technological Content Indexes while High and Medium–High indexes are stable, and there exists a substitution of national inputs for imported one.

TABLE 6. TCI AND IIR INDUSTIRAL SECTORS ANDALUSIA (1980-1995)

TECHNOLOGICAL CONTENT INDEX (1)		**1980**	**1990**	**1995**
* GLOBAL:	TOTAL	53,76	49,70	48,86
	REGIONAL	18,13	21,50	17,29
* HIGH-MEDIUM	TOTAL	9,77	15,10	23,81
	REGIONAL	3,61	4,45	7,60
* HIGH:	TOTAL	1,42	2,69	1,97
	REGIONAL	0,46	1,20	0,25
INTERMEDIATE INPUT REQUIREMENT (2)		2.209.022	3.726.872	4.220.554
VARIATION OF REQUERIMENTS (2)		**1980 TO 1990**		**1990 TO 1995**
* TOTALS		1.517.850 (68,71%)		493.682 (13,25%)
* TECHNOLOGICAL STRUCTURE		-985.342 (-44,61%)		942.741 (25,30%)
* FINAL DEMAND		2.503.192 (113,32%)		-449.059 (-12,05%)

(1) Percentage
(2) Millions of pesetas 1990.
Source: INPUT OUTPUT TABLE ANDALUSIA 1980, 1990 and 1995.

With the objective of comparing this results with those obtained if we consider only the industrial sectors instead of the whole economy, we can see Tables 6 and 7, where TCI and IIR in Andalusia and Spain are presented.

TABLE 7. TCI AND IIR. INDUSTRIAL SECTORS SPAIN (1980-1994)

TECHNOLOGICAL CONTENT INDEX (1)		**1980**	**1990**	**1994**
* GLOBAL:	TOTAL	63,37	56,96	55,22
	INTERIOR	43,33	38,04	34,10
* HIGH-MEDIUM:	TOTAL	30,77	24,29	23,99
	INTERIOR	22,71	13,42	10,33
* HIGH	TOTAL	2,31	4,11	4,20
	INTERIOR	1,14	2,10	1,82
INTERMEDIATE INPUT REQUERIMENTS (2)		12.628.779	19.711.578	21.754.083
VARIATIONS OF REQUERIMENTS (2)		**1980 a 1990**		**1990 a 1994**
* TOTALS		7.082.789	(56,09%)	2.042.505 (10,36%)
* TECHNOLOGICAL STRUCTURE		-3.161.289	(-25,03%)	148.591 (0,75 %)
* FIANL DEMAND		10.244.077	(81,12%)	1.893.910 (9,61%)

(1) Percentage
(2) Millions of Pesetas 1990.
Source: INPUT OUTPUT TABLE SPAIN 1980, 1990 and 1994.

From the data in Tables 6 and 7 we can extract several interesting conclusions. First: Global TCI, corresponding to Industrial Sectors, is lower than to those calculated for the whole economy. This happens both for national and regional economy. Second: the difference grows if we only consider Regional inputs; that's means that Industrial Sectors tend to use, more intensively, technology from abroad. Third: there exists a convergence in High and medium technological content between the national and the regional economy. Forth: the main difference between the evolution of the national and regional economies appears in the High Technological Content Index. The analysis shows that in Spain, industrial sectors incorporate a higher level of inputs with high technological intensity than the economy as a whole, while in Andalusia it happens exactly the opposite.

From these data we can conclude two important facts. First, Industrial Sectors tend to incorporate inputs with a higher technological content than the rest of the economy. These sectors have a higher propensity to import these kinds of inputs. Industrial Sectors have a higher capacity to incorporate innovations generated abroad and can spread them among the whole economy. Second, the Andalusian Industrial Sector has not been able to incorporate inputs of high technological intensity at the same speed than the Spanish Industry. This fact represents an important challenge to the

design of industrial and technological regional policies in Andalusia, due to the supremacy of the Small and Medium Enterprises Sector in the productive network. This idea is strengthened when we follow the evolution of the difference of TCI between Andalusia and Spain since 1980 to 1995. In this way, while global index has fallen from 10 to 7 percent point and the difference in High-medium technological Index has been reduced in 20 points during the same period, the difference in the High Index has grown continuously from 1 to 2.5 p.p. during these years.

We will finish this part of the paper looking to the evolution of IIR. We want to remark two interesting ideas. During the period 1980-1990 the evolution of IIR due to the technological structure in industrial sector was negative but of higher intensity than the economy as a whole. In a different way, during the period 1990-1995, the evolution of industrial sectors was positive because they grew with a higher speed than the entire economy. On the other hand, there is a reduction of the participation of the industrial sector in the IIR of the whole economy. This is caused by the lost of weigh of the industrial sectors during these years, while the service sector is growing dramatically.

5 EMPLOYMENT REQUIREMENTS

One of the most important problems of the Andalusian economy is the high rate of unemployment that presents. So, the study of the functioning of the labour market may be useful to understand the reasons that can explain this high rate of unemployment. By means of the Input-Output Tables it is possible to calculate the evolution of the Employment Requirements (ER) of different economic sectors. The comparative analysis of the ER can explain the evolution of the employment structure of the Andalusian economy. It is also possible to remark the 3 causes of this evolution: a) changes in the structure of Final Demand; b) Changes in the Volume of Final Demand; c) Changes due to the technological factor.

Variation in ER can be calculated as follows:

$$\mathbf{R}(t_1) - \mathbf{R}(t_2) \qquad [10]$$

Where $\mathbf{R}(t)$ is the matrix of ER, define as:

$$\mathbf{R}(t) = \mathbf{K}(t)\,\mathbf{Z}(t) \qquad [11]$$

Z(*t*) means the diagonal matrix derived from the Vector of Final Demand, (constant pesetas 1990). **K**(*t*) can be noted as follows:

$$\mathbf{K}(t) = \mathbf{N}(t)\left[\mathbf{I} - \mathbf{A}_R(t)\right]^{-1} \quad [12]$$

$\mathbf{A}_R(t)$ is the matrix of regional technical coefficients, **I** is the matrix identity and **N**(*t*) is the diagonal matrix derived from the transformation of vector **n**(*t*) of direct coefficients of employment which characteristic element is calculated from the following equation:

$$n_j = l_j / X_j \quad [13]$$

l_j is the number of workers employed in sector j and X_j represents the total output of the same sector (constant pesetas of 1990).

Total variations of ER calculated by equation [10] can be derived from different causes that we can summarise into only two[4]:

a) Variations due to changes in the technological structure while the structure and volume of final demand stays constant. This can be measure by the following equation:

$$\left[\mathbf{K}(t_2) - \mathbf{K}(t_1)\right]\mathbf{Z}(t_2) \quad [14]$$

b) Variation due to changes in volume and structure of final demand, while the technological structure stays constant. This can be measure by the following equation.

$$\mathbf{K}(t_1)\left[\mathbf{Z}(t_2) - \mathbf{Z}(t_1)\right] \quad [15]$$

Table 8 shows the variations of employment needed to satisfy the Final Demand. We can define two periods. During 1980-1990, the reduction of ER is 6%. On the opposite, during 1990-1995, ER increases 12%. So the final result of this period is 5.5%.

If we look to the determinants of this evolution we can conclude that during the two periods, changes in the technological structure of the economic system has originated an important reduction in the employment requirements needed to satisfy the final demand. On the other side, changes in the volume and structure of final demand can be translated in an increment of employment needed.

An important change in the technological structure of the Andalusian productive system takes place during the period 1990-1995. This change tends to reduce the needed of employment, while the evolution of economic activity and the regional wealth tend to reduce this effect. The final effect is a very light increment of the employment needs (only 5,5%).

TABLE 8. VARIATIONS IN EMPLOYMENT LEVELS AND PRINCIPAL DETERMINANTS

THE WHOLE ECONOMY			
EMPLOYMENT REQUERIMENTS	**1980**	**1990**	**1995**
	1.733.444	1.634.155	1.828.386
VARIATIONS	**1980/90**		**1990/95**
• **TECHNOLOGICAL**	-1.264.579		-287.353
• **FINAL DEMAND**	1.165.290		481.584
• **TOTAL**	-99.289		194.231
INDUSTRIAL SECTORS			
EMPLOYMENT REQUERIMENTS	**1980**	**1990**	**1995**
	523.023	401.696	327.086
VARIATIONS	**1980/90**		**1990/95**
• **TECHNOLOGY**	-302.747		-78.341
• **FINAL DEMAND**	181.420		3.731
• **TOTAL**	-121.327		-74.610

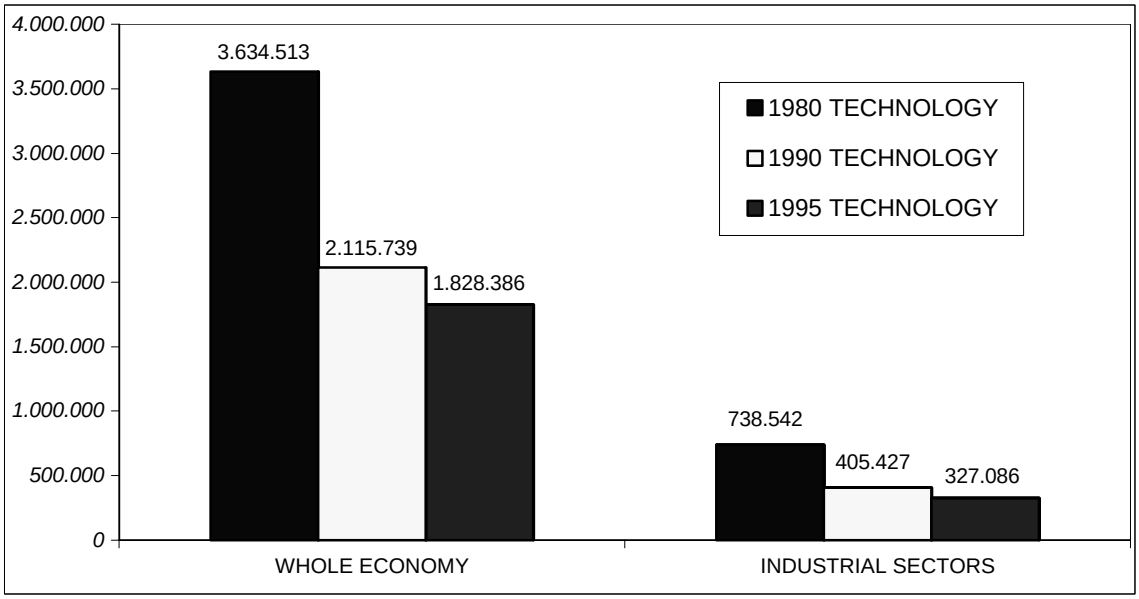
Source: INPUT OUTPUT TABLE ANDALUSIA 1980, 1990 and 1995.

Now, we can also look to the evolution of the requirement of employment corresponding exclusively to Industrial Sectors. The first thing that we want to consider is the constant reduction of industrial requirements over the total employment of the whole economy. In 1980 they represented 30%; in 1990 represented 25%, in 1995 represented only 18%. This is caused by the weak effect of the final demand and by the growing importance of the service sector.

The total reduction of requirements is very important during the period 1980-1990 and of the same tendency, but weaker, during 1990-1995. Another interesting point is the evolution of the intensity of the technological effect. There exists a different behaviour between the evolution of the whole economy and the evolution of industrial

sectors. The process of substitution of primary inputs and save of labour has occurred with some delay in the industrial sector.

FIGURE 1. EMPLOYMENT REQUIREMENTS NEEDED TO SATISFY 1995 FINAL DEMAND WITH DIFEERENT TECHNOLOGICAL LEVELS



Source: INPUT OUTPUT TABLE ANDALUSIA 1980, 1990 and 1995.

We can conclude this short analysis with Figure 1 that represents the evolution of total ER and industrial sectors ER needed to satisfy Final Demand corresponding to 1995 with technological levels corresponding, respectively to 1995, 1990 and 1980. Table 9 represents the average accumulate annual rate of variation of ER needed to satisfy final demand of 1995 with technologies of 1980, 1995 and 1995.

TABLE 9. AVERAGE ACCUMULATE ANNUAL RATE OF VARIATION IN ER

PERIOD	WHOLE ECONOMY	INDUSTRIAL SECTORS
1980–1990	– 5,6%	– 6,2%
1990–1995	– 1,5%	– 2,2%

Source: INPUT OUTPUT TABLE ANDALUSIA 1980, 1990 and 1995.

6. FINAL REMARKS

The Theory of Geographical Innovation establishes that the appearance of "economies of agglomeration" is associated to spatial concentration of R&D activities. In this way, co-operation among different agents, which take place in the innovation process (vertical and horizontal) in a transitional context, has a crucial importance. This process can be translated into an improvement in the technological level of the productive process, and take advance of the R&D effort[5]. On the other hand, as these

activities need a great amount of financial resources, activities of supporting innovation become critical elements in SME´s and in the evolution of regions and countries where these firms are stabilised.

The lack of own funds makes SME´s, looking for goods and services external, obtained in near places. In this way, innovation spreads all over the economic system through the goods sold. This fact gives a special interest to the TCI of intermediate inputs and to the IIR specially those preceding from sectors with a higher technological intensity, as a measure of vertebration of the productive process, and in this way, the diffusion of activities.

Andalusian Industrial Sector has not been able to incorporate inputs of high technological intensity at the same speed than the Spanish Industry, despite a big effort in technological development. This fact represents an important challenge to the design of industrial and technological regional policies in Andalusia, due to the supremacy of the Small and Medium Enterprises Sector in the productive network.

The effect of changes in technical structure on employment has been a continuous reduction in ER (labour input required per unit of output). This reduction is more intensive in the first period (1980–1990) than in the second (1990–1995), and more intensive in the industry than in the other productive sector, for both periods.

We think that the indicators analysed in this paper are a measure of two interesting facts, the global result of the process of innovation, and the roll played by the productive network in a certain territory in relation to the spread of technological innovations. But there are also some problems with the indicators such as the limited information given because they are not able to separate different behaviour of important agents and factors.

This idea is near to COOMBS (1988, p.296) hypothesis. R&D is not the unique resource for innovation. Beside this, there exist other sources of innovation are related to the firm size, the economic sector to which the firm belongs, informal activities that are usually are found in innovation activities, especially in SME´s.

With respect to the different index of technological content we can conclude that the global are more adequate to measure the technological level of the economy.

Nevertheless, High-medium Indexes are more adequate to measure the research effort, by means of the R&D expenses.

[1] For example BANCA CATALANA (1978), PAYNO et al (1983), CASTELL et al (1992), GALAN, CASILLAS y MORENO (1993), MARTIN Y PALMA (1993), JORDA (1994).

[2] A more detailed analysis of the evolution of the public policies of R&D in Andalusia can be found in PALMA, GARCIA y RODRIGUEZ (1997) or DURAN et al, (1999).

[3] PALMA, MARTIN and RODRIGUEZ (1992); PALMA MARTIN and VILLAR (1992), PROGRAMA INDUSTRIAL DE ANDALUCIA (1992)

4 Sáez, F. (1992) pág. 97.

5 Cooperation in R&D activities in Andalusian firms can be found in AGUADO (1999).

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