

Serrano, Guadalupe; Cabrer, Bernardí

Conference Paper

Technological "Catch-Up" And Trade Flows. A Panel Data Approach.

40th Congress of the European Regional Science Association: "European Monetary Union and Regional Policy", August 29 - September 1, 2000, Barcelona, Spain

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Serrano, Guadalupe; Cabrer, Bernardí (2000) : Technological "Catch-Up" And Trade Flows. A Panel Data Approach., 40th Congress of the European Regional Science Association: "European Monetary Union and Regional Policy", August 29 - September 1, 2000, Barcelona, Spain, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/114816>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

40th European Congress. Barcelona 2000.
European Monetary Union and regional policy.

Technological “catch-up” and trade flows. A panel data Approach.

Bernardí Cabrer Borrás. Guadalupe Serrano Domingo.
Universidad de Valencia.

Bernardí Cabrer Borrás
Guadalupe Serrano Domingo
Departamento de Análisis Económico.
Campus del Tarongers. Edifici Departamental Oriental.
Av. del Tarongers, s/n
46022 València. Spain.
Tel. 34. 96. 382.82.43 – 34. 96. 382.87.89
Fax. 34. 96. 382.82.49.
e-mail: bernardi.cabrer@uv.es; guadalupe.serrano@uv.es;

Summary. The present paper is focused on an empirical analysis about the existence of sectoral technological catch-up process in the Spanish regions. We test the role of international trade flows as one of its sources. Technological knowledge diffusion among regions may be encouraged by goods trade, because each imported good incorporates technological advances that can be imitated. Sectoral technology level in one region is measured by the total factor productivity (TFP). This variable includes individual aspects of sectoral technology in each region that held fixed in time, as well as the specific local technology of each sector corresponding to its specific location. Results show that there exists a diminishing sectoral technological gap among regions. Moreover, imported goods in each region contribute to reduce the differences in sectoral technological progress among regions.

1. Introduction.

From pioneering studies of Barro and Sala-i-Martin (1991, 1992) about the convergent trend of the economies, many papers focused on testing both σ -convergence and β convergence hypothesis have been published. The existence of σ -convergence implies the second one but not necessarily this relationship can be established inversely. Numerous empirical studies try to find the different sources of convergence. The topic that technological knowledge diffusion and technological "catch-up" are variables influencing the convergence process is generally accepted in literature. In fact, there exist wide empirical evidence about this subject (Coe and Helpman (1995), Barro and Sala-i-Martin (1995), De la Fuente (1995, 1996)).

The idea that underlies in our paper is previous to convergence analysis. Actually, our interest is focused on testing the existence of a sectoral technological catch-up process, favoured by interregional goods trade. The imported goods from advanced regions incorporate technological knowledge that less developed regions can imitate. In this way, the technical progress of the imitating regions is greater than the innovative region's one. So, accepting this idea would imply the possibility of conditional convergence process among regions.

We show empirical evidence that supports the idea that there does indeed exist a link between trade and technological convergence among countries or regions.

2. Sectoral technology measurement.

Continuing with the idea explained in the previous paragraph, less developed regions at the beginning of the period should reach, or at least should approach, the leader's technology. The leader region must be purely a goods exporting region, and must show a higher productivity and technological knowledge. Its technological level must be measured once the interregional differences in factor endowments have been considered. This concept can be approximated by the total factor productivity (TFP).

It is considered that technological capital can be accumulated in the same way that physical capital. Technological capital or other forms of intangible capital will contribute to output increase. Nevertheless, technical progress is not directly computable, but it can be measured in an indirect way by means of the total factor TFP growth. Thus, the residual of neoclassical production function can be understood as the existence of an intangible capital accumulation that contributes to the tangible factor's productivity growth (Dagum and Fontela (1997) and Solow (1994)). Then, technological progress will be measured through the TFP^i growth whether in the case that production is technically efficientⁱⁱ or in the case that its inefficiency does not vary at any point in time.

We have computed TFP for each sector and each region in the growth accounting framework. It is supposed that sector j in region R production is obtained through a Cobb-Douglas production function with constant returns to scale both in labor and in physical capital. The TFP is obtained through the equation:

$$PTF_{jRt} = \frac{y_{jRt}}{(z_{jRt})^{\phi_j}} = \Lambda A_{jR} n_{jRt}^{\mu} \quad (1)$$

where y_{jRt} and z_{jRt} are output and capital per employee of sector j in region R , in the period t ; ϕ_j is the return of capital, different for each sector; A_{jR} is the technological parameter that includes specific sectoral and regional aspects of technology, and holds fixed along time; n_{jRt} is the level of sector's technology associated with technological externalities which vary at each point in time according to interregional and intersectoral knowledge diffusion. Equation (1) shows that TFP will not be the traditional technological measure. This variable will include two different technological factors. First, the term A_{jR} will approximate the individual characteristics of sector's technology in determinated location. Second, n_{jRt} will be associated with technological externalities derived from knowledge diffusion. Thus, from the quantitative computation, it is not trivial to calculate the TFP of each sector and region according to the equation (1), since it does not exist information about variables that determine n_{jRt} . So we have approximated its effects through variables that indicate specific characteristics of economic activity in each sector and region: the sectoral specialization pattern, the degree of competition in industry, and the diversity of economic activities in the region. Thus, the TFP will be computed according to equation (2):

$$PTF_{jRt} = \frac{y_{jRt}}{(z_{jRt})^{\phi_{jRt}}} \quad (2)$$

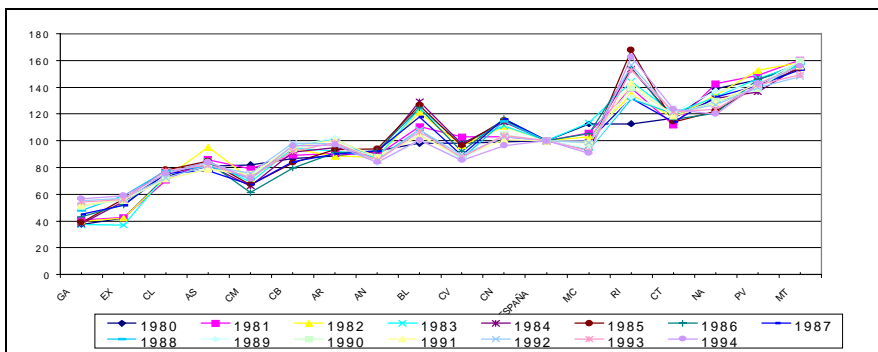
where neither the technological external economies, nor the individual characteristics of each sector and region A_{jR} , are considered explicitly. Because of that, the observed capital return, ϕ_{jRt} , will change at each sector, region and each point in time. Thus, the PTF_{jRt} values have been obtained according to the equation (2), where y_{jRt} is the labor productivityⁱⁱⁱ; z_{jRt} is the capital-labor ratio; ϕ_{jRt} is the share of labor cost on GAV for each sector and region.

3. Does a technological catch-up exist in the Spanish regions?

Sector's diffusion of the technology, from one region to the rest, would have to compensate the diminishing returns of the capital factor, reinforcing the region's growth rate. Geographic climatic and orographic disparities between regions can condition their productive system. In the same way, the initial conditions from which regional economic development starts can explain the

absence of regional homogeneity in per capita income levels and technology even in the long run. Nevertheless, it is possible to have a growth rates equalization as a result of the sectoral knowledge diffusion from more developed region to the least one. In the long run, less developed region would catch-up more developed region's technological progress. Under these conditions, regions would show small oscillations over a common trend, where each of them would frequently change its relative position.

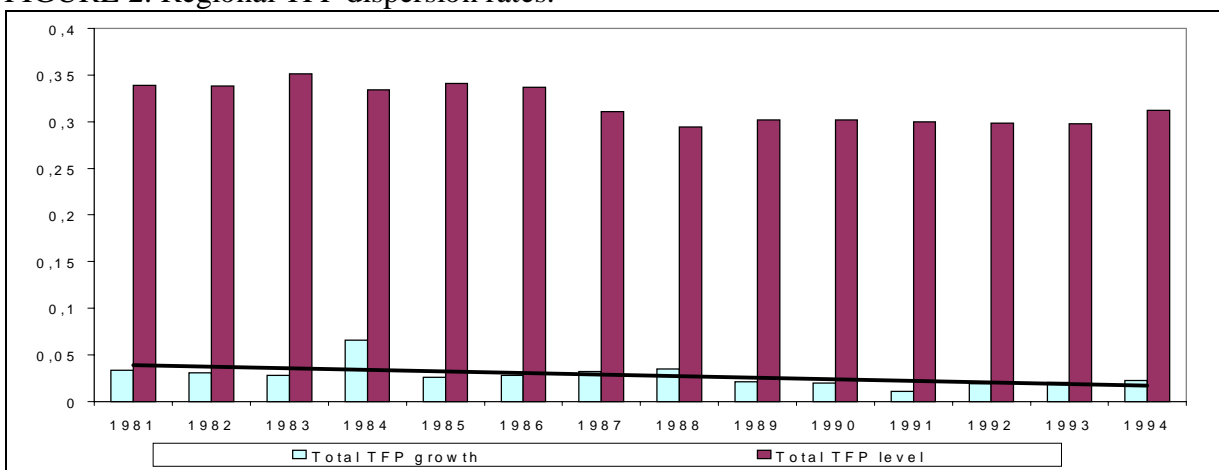
FIGURE 1. Spanish regions ranking according to their relative TFP positions.



Note. Regions are ordered from the smaller TFP value to the greater one in 1980. Normalized data: Spain TFP =100.

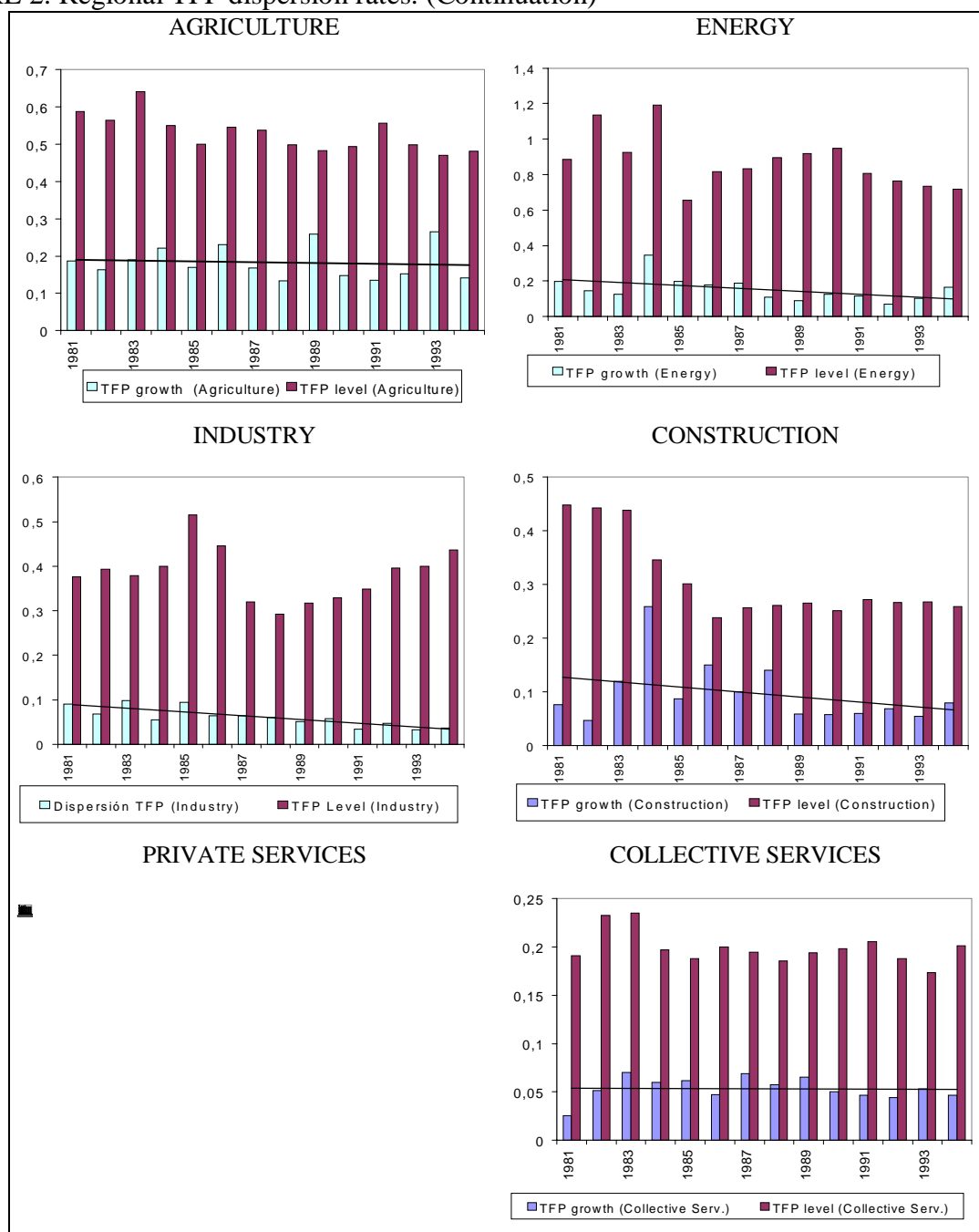
Once TFP values have been obtained according to equation (2), they have been normalized taking as 100 the TFP of sector's national average. Figure 1 shows the TFP obtained values, ordered from minor to greater level in each year. It is observed that regions do not show large oscillations over the trend. Furthermore, if we compare region's position in the ranking in each year it is possible to see frequent changes of their relative positions. Concretely, regions with mid TFP level in 1980 -Aragón, Baleares, Comunidad Valenciana, Canarias and Murcia- show changes in their relative positions from low levels to be above the national average at the end of the eighties.

FIGURE 2. Regional TFP dispersion rates.



Furthermore, to complete the descriptive analysis of sectoral TFP in the Spanish regions we have obtained the regional dispersion rate for each one of the six sectors: agriculture, energy, industry, construction, private services and collective services. In the same way that in Figure 1 dispersion rate is obtained both for TFP levels and growth rates. Figure 2 shows the greater dispersion obtained for the data in levels respect those in growth rates for each sector as well as for the aggregate.

FIGURE 2. Regional TFP dispersion rates. (Continuation)



As for the evolution of TFP growth disparities in the Spanish regions, note that the dispersion in the growth rates presents a soft decreasing trend in energy, industry and construction. In agriculture and services, both in private and collective services, we can observe an almost linear trend for the dispersion along the analyzed period. Nevertheless, it can be appreciated a falling trend around the end of the eighties.

Thus, it is possible to accept a process of technological catch-up in the analyzed sectors, as well as for the total TFP in the Spanish regions. Nevertheless, the behavior of the regional disparity in agriculture and industry presents greater oscillations. This result is due to the region's specialization in the agricultural sector, applying new technologies in the productive process and the number of occupiers fall. In the energy case, there exist regions with nuclear energy production and regions in which practically does not exist energy production.

4. Econometric approach.

The previous results can be analyzed from an econometric point of view. First of all, we must describe the theoretical framework. Recent endogenous growth theories explain the sources of technological progress. Romer(1987,1990,1994), Grossman and Helpman (1991b,1994), Aghion and Howitt(1992), Barro y Sala-i-Martin (1995). These models are developed within a bisectoral framework. Output of final goods sector, which operates under perfect competition, is obtained through a Dixit & Stiglitz (1977) production function, where intermediate sector provides inputs for final goods production. Intermediate goods sector, that is the innovative one, operates under imperfect competition. Technological progress is due to the introduction of new varieties in the market.

Innovation provides external economies that are associated with the technological diffusion, to the rest of the economy that generates increasing returns to scale. So these models obtain a sustained growth rate but loose the conditional convergence idea (growth rates are unequal since they depend on the different regional parameters in each economy).

Studies by Barro and Sala-i-Martin (1995) show that, in a model with two countries and two sectors, one of them under imperfect competition, the international diffusion of technology allows conciliating sustained growth implications and conditional convergence.

Cabrer & Serrano (1999) developed a theoretical model in which these ideas are studied. It is considered a national economy in which two regions are interrelated. In both regions two sectors produce. Technological progress is endogenous, associated with increase of varieties in the intermediate goods sector. Moreover, in the analysis the effect of factors accumulation in each

sector is considered. The rates of invention, capital accumulation in the innovative sector and productive structure in the economy will determine the regional growth rate.

For knowledge diffusion between regions, the key element is that imitation is cheaper than invention. So, most regions will prefer copying rather than inventing. How is the imitation process driven? To answer this important question in this analysis it is supposed that this process is established through the final goods trade between the two regions. Interregional trade will allow knowledge to flow from technologically advanced region to the follower ones. The region B has the possibility of imitating the existing varieties in A, the technology of region A, since its technology is incorporated in the products that region A sells to B.

However, to adapt the varieties produced in A to the productive environment of the region B, that is to imitate the region A technology implies a cost. As we have considered, imitation is more attractive than innovation for the region B since first cost is lower than the second one. In this way, at each point in time the number of varieties to imitate is determined according to the existing varieties in A, being a finite number. The region B will only be able to copy those varieties of region A that have already been developed.

The final goods bought from the advanced region allow the follower to imitate the leader's technology. It is obtained that imitation costs are increasing^{iv} with imitated varieties of inputs. Because of this result it is obtained that technological progress in region B is faster than in region A at the beginning of the process. As the imitation cost increases the imitation rate decreases, and technological progress in B will approximate to the leader's one^v. Then, results indicate that interregional trade flows tend to equalize technological progress rate among regions, a technological "catch-up" from the less developed region to the more advanced ones.

If the technology of j sector in R region in t period is defined as TFP_{jRt} , the technological distance between regions A and B, being A the innovative region and B the imitative one, will be:

$$d_{jBA}(t) = \left[\frac{PTF_{jBt}}{PTF_{jAt}} - 1 \right] \quad (3)$$

and its evolution will depend on the existing distance in the period t with respect to its value on stationary state:

$$\ln \Delta d_{jBA}(t) = -\theta \left[\ln \left(\frac{PTF_{jBt}}{PTF_{jAt}} \right) - \ln \left(\frac{PTF_{jBt}}{PTF_{jAt}} \right)^* \right] \quad (4)$$

In the long run period, when the knowledge diffusion and the imitation process have just been exhausted, the relative technology level in both regions is held constant. Thus, the relative TFP, once controlled by the relative prices and the quantity of used factors it will also be constant.

If it is considered that the relative technology level is going to depend on the technological characteristics on each sector in each region (A_{jB}/A_{jA}), and on the knowledge diffusion externalities (n_{jBt}/n_{jAt}), we obtain:

$$\begin{aligned}\left(\frac{PTF_{jBt}}{PTF_{jAt}}\right)^* &= \ln \Lambda + \ln \left(\frac{A_{jB}}{A_{jA}}\right) + \mu \ln \left(\frac{n_{jBt}}{n_{jAt}}\right)^* \\ \left(\frac{PTF_{jBt}}{PTF_{jAt}}\right)^* &= \lambda_i + \mu \ln \left(\frac{n_{jBt}}{n_{jAt}}\right)^*\end{aligned}\quad (5)$$

where λ_i is the individual effect of the sector in each region, that collects the differences between the stationary states in both regions. The individual effect will be determined not only by the technological initial conditions, but also by regional factor endowments, climatic conditions and institutional conditions. Then, substituting equation (5) in (4), and considering that technological distance growth can be approximated by the differences in the growth of the sectoral TFP in each region, we obtain:

$$\frac{\dot{PTF}_{jBt}}{PTF_{jBt}} - \frac{\dot{PTF}_{jAt}}{PTF_{jAt}} = -\theta \ln \left(\frac{PTF_{jBt}}{PTF_{jAt}}\right) - \lambda_i - \mu \ln \left(\frac{n_{jBt}}{n_{jAt}}\right)^* \quad (6)$$

Then, we can define the TFP in the t period, as such variable in the previous period plus its growth rate:

$$\ln \left(\frac{PTF_{jBt}}{PTF_{jAt}}\right) = \ln \left(\frac{PTF_{jB(t-1)}}{PTF_{jA(t-1)}}\right) + \Delta \ln \left(\frac{PTF_{jBt}}{PTF_{jAt}}\right)$$

and according to the definition of this variable in equation (1), the relative TFP growth will depend on the differences in the specific technology evolution in each sector and region. Thus, equation (6) is

$$\frac{\dot{PTF}_{jBt}}{PTF_{jBt}} - \frac{\dot{PTF}_{jAt}}{PTF_{jAt}} = -\theta \left[\ln \left(\frac{PTF_{jB(t-1)}}{PTF_{jA(t-1)}}\right) + \mu [\Delta \ln n_{jBt} - \Delta \ln n_{jAt}] \right] - \lambda_i - \mu \ln \left(\frac{n_{jBt}}{n_{jAt}}\right)^* \quad (7)$$

According to the theoretical ideas that we have previously explained, the growth of sectoral technological gap between regions will depend on the specific external economies in each sector and region deviated from the knowledge diffusion process.

We assume the hypothesis that the knowledge diffusion is verified through final goods trade between the regions (the imitation cost is positive and increases with the amount of copied technology). Thus, the sectoral technological gap between the two regions will be greater when smaller the capital accumulation devoted to the sector j in the imitative region is, z_{jBt} . Equally, $(\Delta \ln n_{jBt} - \Delta \ln n_{jAt})$ will decrease with the amount of imported goods from the more developed region to the imitative ones. The greater that importation is, IC_{jBA_t} , the greater knowledge diffusion is too,

and smaller the technological progress differentials among regions will be. Equally, an increase in region B's relative prices will increase region B's goods importation, therefore it will reduce the technological differences among regions.

According to Glaeser et al. (1992), local technological progress (the local technology) is approximated by the sector external economies in each region. Concretely we have considered the specialization externalities, $E_{jR}(t)$, and diversity externalities, $D_{jR}(t)$. We measure external economies according to the literature: Glaeser et al. (1992), Henderson (1994), Weinhold and Rauch (1997), through the specialization and diversity indexes^{vi}. In this case, the differences in the sectoral specialization patterns, and in the sectoral diversity in the region, may have a meaningful impact in the variation of the technological gap between regions. In fact, the presence of local external economies will increase the rate of technical progress of region's sector, increasing the technological gap among regions. Moreover, this effect will be greater if externalities are more important in the developed region. On the contrary, the interregional externalities which allows technology flow among regions, will equalize the sectoral technological progress in both regions. Thus, including this ideas in equation (7) and operating:

$$\begin{aligned} \frac{\dot{PTF}_{jBt}}{PTF_{jBt}} - \frac{\dot{PTF}_{jAt}}{PTF_{jAt}} = & \lambda_{jAB} - \theta \ln \left(\frac{PTF_{jB(t-1)}}{PTF_{jA(t-1)}} \right) - \phi \theta \ln \left(\frac{Z_{jBt}}{Z_{jAt}} \right) + \\ & + \theta \left[\pi \ln \left(\frac{P_{Bt}}{P_{At}} \right) - c \ln IC_{jBA} + \varepsilon \ln IE_{jBt} + \delta \ln ID_{jBt} - \psi \dot{Z}_{jBt} \right] + u_{jABt} \end{aligned} \quad (8)$$

Equation (8) indicates that technological catch-up between two regions, A and B, is greater, or the difference in technical progress among them is smaller, when sectoral technological gap in the previous period is greater. In the same way, $(\Delta \ln n_{jBt} - \Delta \ln n_{jAt})$ is smaller when the sectoral capital accumulation in the less developed region is greater, and when the trade flows is greater. On the contrary, local externalities will increase the differences of sectoral technological progress. The term λ_{jAB} includes the individual differences that will depend on initial conditions of the technology in each sector and region, and the relative individual's steady state.

5. General results.

For this empirical exercise we have a pool of data for each sector: agriculture, energy, industry, construction, private services and collective services, and for each one of 17 Spanish regions from 1980 to 1994, therefore we consider a 102 individuals sample. The equation (9) estimation is done through the panel data approach. This econometric method allows us to consider the so-called differences in the individual effects.

The available data condition both the sample period as well as the characterization of the region either as leaders or as followers. Firstly, data information about wages restricts the initial sample observation to 1980. Second, the region characterization as leader or follower is specially related to the information on interregional trade. Since there is not information for this variable desegregated by sectors and regions for the current sample, we use regional importation from the rest of the world, by activity branches. Thus this fact implies that the leader region, the one from which the Spanish regions buy goods and from which they receive technological knowledge, is away from the Spanish frontiers. Under this hypothesis, short run leader's trend would be approximated by the national average.

Due to our short run approach, it is possible to find regions with a greater or smaller technological progress than the national average. This is due to the influence of the economic cycle, as well as by the diffusion of the technology from the rest of the world. So, as it has been previously explained, the individuals are each of the six sectors in each of the seventeen Spanish regions: $i=jB$, being leader the corresponding sectoral national average: $N=jA$. Furthermore, since final goods' prices are not available by sectors, regional consumption prices index have been used: CPI of each region, P_R , and the national CPI, P_{NN} .

Table 1 reports the equation (8) estimation results. We have estimated four different specifications in which we have progressively incorporated variables that approximate the externalities effects, both the one derived from the knowledge diffusion within region and between regions.

We can observe in Table 1 a technological catch-up process, since the parameter corresponding to the technological gap in the previous period has the expected negative sign. Nevertheless, and according to De la Fuente (1996a), this parameter's value in estimation (1) can be understood as the sum of many divergent and equalizing forces that affect the technological progress.

Once externalities are considered explicitly in (2), (3) and (4) estimations, it can be observed that the speed of sectoral technological progress convergence increases from their relative positions in the previous period. According to our theoretical hypothesis, intrarregional externalities deviated from the knowledge diffusion within the region and approximated by the specialization and diversity indexes, increases technological progress differences between the region's sector and the national average.

TABLE 1. Technological catch-up and knowledge diffusion.
Dependent variable: $\frac{\dot{TFP}_{it}}{TFP_{it}} - \frac{\dot{TFP}_{Nt}}{TFP_{Nt}}$. Estimation with fixed effects

	(1)	(2)	(3)	(4)
c	-	-	-	-
$\ln \frac{TFP_{i(t-1)}}{TFP_{N(t-1)}}$	-0,42** (-17,35)	-0,72** (-30,99)	-0,72** (-30,89)	-0,73** (-31,57)
$\ln \frac{z_{it}}{z_{Nt}}$	-0,29** (-6,93)	-0,48** (-13,45)	-0,48** (-13,35)	-0,48** (-13,62)
$\ln \frac{P_{Rt}}{P_{NNt}}$	0,13** (0,56)	0,68** (3,30)	0,73** (3,46)	0,55** (2,64)
\dot{z}_{it}	-0,001 (-1,49)	-0,001 (-1,67)	-0,001 (-1,68)	-0,001 (-1,10)
$\ln IE_{it}$		0,73** (24,28)	0,73** (24,32)	0,72** (24,19)
$\ln ID_{it}$		0,21** (7,92)	0,21** (7,90)	0,22** (8,44)
$\ln IC(\text{total})_{Rt}$			0,01 (1,33)	
$\ln IC(A)_{Rt}$				-0,03** (-5,26)
$\ln IC(E)_{Rt}$				-0,80** (-3,46)
$\ln IC(K)_{Rt}$				-0,01 (-1,41)
$\ln IC(Q)_{Rt}$				0,02* (2,37)
$\ln IC(C)_{Rt}$				0,03** (2,65)
	$\bar{R}^2 = 0,17$	$\bar{R}^2 = 0,44$	$\bar{R}^2 = 0,44$	$\bar{R}^2 = 0,46$
Hausman test: Random vs fixed effects	$\chi^2(4)=211,2^{**}$	$\chi^2(4)=730,8^{**}$	$\chi^2(4)=725,6^{**}$	$\chi^2(4)=749,7^{**}$

Note: * meaningful to the 5%, ** meaningful to the 1%.

Interregional knowledge diffusion will be meaningful sector by sector, because of the absence of significance of region's total imports. In this sense, estimation (4) allows us to differentiate the equalizing effect of relative imports in agriculture; energy and equipment goods increase. Nevertheless, an increase in intermediate and consumption goods imports will increase the technological progress differences. The results we have obtained are coherent if we consider the kind of goods that are imported. The less developed region will mostly import goods that allow

them to increase technology in their productive system, like energy and machinery (equipment goods). Thus, they start from a lower technological level than the national average, so these imports and the technology that they incorporate, allows this regions to increase their sectoral technological progress rate. However, the chemical and construction material imports (intermediate goods) and manufactures (consumption goods) are mostly bought when the region has a mature productive system. Thence, these imports do not reduce the regional technological gap.

The panel data approach makes it possible to recover the individual effects. Concretely, we have recovered the regional individual effects based on the estimation (4). We have used its time average as the endogenous variable and the regional dummies as the explicative one. OLS estimation parameters can be understood as the relative steady state of the technology in each region. The first column in Table 2 considers the rest of the world as the leader region. The second column in Table 2 considers the national average.

TABLE 2. Relative steady State of the Spanish regions.

	<u>Leader Región: Rest of world</u>	<u>Leader Región: National Average</u>
Extremadura	0,201	-0,170
Navarra	0,217	-0,154
Murcia	0,221	-0,150
Rioja	0,242	-0,129
Castilla-La Mancha	0,261	-0,110
Baleares	0,272	-0,099
Cantabria	0,275	-0,096
Canarias	0,287	-0,084
Aragón	0,303	-0,068
Asturias	0,360	-0,011
Castilla-León	0,393	0,023
Galicia	0,437	0,066
País Vasco	0,449	0,078
Comunidad Valenciana	0,449	0,078
Andalucía	0,514	0,143
Cataluña	0,683	0,313
Madrid	0,742	0,372

The results that are reported in Table 2 confirm the different steady states for each of the Spanish regions. Furthermore, they permit to analyze which regions are technologically more advanced and which ones are not.

If we consider the first column of results, a nearby value to zero indicates a region with a relative technology level highly inferior, while, a value near to one indicates a relative level of technology near to that of the reference region, being Madrid and Cataluña the most advanced regions. If the relative level of each region is compared to the national average, it can be seen that there are regions more and less advanced than the national average. So, according to the preceding ideas, the first ones would export ideas and technology, and they would not imitate existing technologies since they would be the innovative regions. The second ones would be follower regions. They would imitate the technology developed by the first group of regions. Then, in the group of less developed regions, imports would have an equalizing effect over the technology.

To test this idea, that is one of the key issues of our paper, we have divided the individuals sample in two groups. The first one includes all those sectors in different regions whose technological level is superior to the corresponding national average in the previous period. The second group includes all those individuals technologically less developed than the corresponding national average.

Results are reported in Table 3. In the first column we can see that less developed regions, with an inferior technological level in $t-1$, the agricultural, energetic and machinery imports have a positive impact on their technical progress rate. In that group, such imports reduce the technological progress inequalities between the region and the nation. Furthermore, and according to the theoretical ideas, the speed of catch-up is slightly superior for these regions than for the most developed ones. However, for the most developed group of individuals with a higher technology than the corresponding national average, imports do not have a meaningful impact on the technological progress inequalities, except for the agricultural imports.

Thus, Table 3 results allow us to conclude that once the less developed regions incorporate the copied technology, their technological progress rate will tend to homogenize. The more technology is imitated the slower technological progress rate is got so that each region will reach their long run technology. Up to this period, technology will increase in a constant rate. Thus, the technological distance between the regions will hold fixed, and this would be the reason that explained the possibility of long run differences between regions.

TABLE 3. Technological "catch-up" by regional groups. Regions more advanced vs. Regions less advanced than the national average.

	$PTF_{i(t-1)} < PTF_{N(t-1)}$	$PTF_{i(t-1)} > PTF_{N(t-1)}$
$\ln \frac{PTF_{i(t-1)}}{PTF_{N(t-1)}}$	-0,79** (-26,99)	-0,76* (-22,16)
$\ln \frac{z_{it}}{z_{Nt}}$	-0,36** (-8,44)	-0,58** (-10,99)
$\ln \frac{P_{Rt}}{P_{NNt}}$	0,68** (3,20)	0,92** (2,47)
\dot{z}_{it}	-0,001 (-1,60)	-0,001 (-0,96)
$\ln IEi_t$	0,71** (20,48)	0,78** (16,91)
$\ln ID_{it}$	0,01 (0,29)	0,42** (9,30)
$\ln IC(A)_{Rt}$	-0,01** (-2,03)	-0,05** (-4,87)
$\ln IC(E)_{Rt}$	-0,01** (-6,37)	0,01 (1,27)
$\ln IC(K)_{Rt}$	-0,03** (-3,31)	-0,00 (-0,30)
$\ln IC(Q)_{Rt}$	0,01 (1,10)	0,01 (1,13)
$\ln IC(C)_{Rt}$	0,02 (1,47)	0,02 (0,70)
	$\bar{R}^2 = 0,58$	$\bar{R}^2 = 0,45$
Hausman test:		
Random vs fixed effects	$\chi^2(4)=387,39^{**}$	$\chi^2(4)=378,81^{**}$

Note: * meaningful to the 5%, ** meaningful to the 1%.

6. Conclusions.

This paper offers, an empirical test about the role that technological knowledge diffusion performs in the unequal sectoral productivity growth in the Spanish regions. The theoretical hypothesis that underlies in this analysis is based on the idea that sectoral technological knowledge diffusion among regions through final goods trade is one of the mechanisms that encourages the technological catch-up process among those regions which are related by trade flows.

The empirical analysis of this hypothesis needs, as previous analysis, the sectoral technology measurement. To compute this variable it has been used a wide concept of total factor productivity in each sector and region. Thus, this technological variable, obtained as the factor

returns in each sector and region, includes the technological externalities derived from the knowledge diffusion.

The main results come from the sample segregation in two groups, one technologically advanced and the other with a less developed technology. It is possible to conclude, according to the theoretical ideas, that knowledge diffusion among regions through trade flows increases the technological catch-up process, especially for less developed regions.

We have approximated interregional knowledge diffusion by sectoral goods imports over consumption in each region, and we have studied its effects on productivity growth differentials in each sector and region in relative terms to the corresponding national average. These imports have a positive and meaningful effect that homogenizes technological progress, especially in the less advanced group.

According to these results, the economic policy is an important instrument to achieve regional equality objectives. Furthermore, they imply that it would be necessary to revise the objectives and performance measures, towards a most local and active perspective. It would be possible to differentiate those measures with national objectives, such as those based on the sector development objectives, also those measures intended to reduce the regional disparities. In this latter case, it would be more effective to identify local dynamic sectors, those sectors which grow faster in a determined region, and secondly, to instrument policy rules to promote those sectors. In this case, the positive effects of the technological externalities derived from the interregional knowledge diffusion would play a determinant role.

Notes

ⁱ There exists multitude of projects devoted to the TFP growth analysis, concretely they are based on analyzing its sources, as well as the causes of its slower rate. Those aspects are not analyzed directly in this paper since our main objective is to test the existence of sectoral technological catch-up among regions.

ⁱⁱ Yet in this case, the TFP computation would be biased if the factors share would not be cost minimizing

ⁱⁱⁱ Variables are measured in 1986 constant prices. Output variable is gross value added (GAV). Labor variable is the number of occupied workers. Sectors: agriculture, energy, industry, construction, private services transports and communications, and collective services. The study is performed for the 17 Spanish regions. Data sources ESC (European system account) for Spain. Stock of capital data: Daban et al. (1997).

^{iv} The follower region will imitate first the easiest varieties. Along the imitation process, cheaper imitation varieties are copied at each point in time, and the most expensive ones are left. At the end, there are only expensive varieties to imitate. Thus the imitation cost is higher than the initial one. Moreover, because of this fact the imitation rate is slower than the beginning one.

^v It is supposed that region A innovates. The region A's innovation rate will hold fixed in time.

^{vi} IE_{jR} = specialization index. Where Y = gross added value (GAD), R = region, N = nation, j = sector.

$$IE(Y)_{jR} = \left[\frac{Y_{jR}}{Y_R} \right] / \left[\frac{Y_{jN}}{Y_N} \right]$$

ID_{jR} = diversity index. Where L = labor, R = region, N = nation, j, k = sectors. $ID(L)_{jR} = \sum_{k \neq j} (L_{kR}/L_R)^2 \dots$

7. References

- AGHION P., HOWITT P. (1992): "A Model of Growth Through Creative destruction". *Econometrica*, 60(2), pp 323-351.
- BARRO R., SALA-I-MARTIN X. (1991): "Convergence Across States and Regions". *Brookings Papers on Economic Activity*, 1, pp107-182.
- BARRO R., SALA-I-MARTIN X. (1992): "Convergence". *Journal of Political Economy*, 100, pp 223-251.
- BARRO R., SALA-I-MARTIN X. (1995): "Technological Diffusion, Convergence and Growth". *NBER. Working Paper*, n° 5151 (June).
- CABRER B, SERRANO G. (1999): "Interregional Trade, Knowledge Diffusion and Regional Convergence". *Western Regional Science Association. 39th Annual Meeting*. Mimeo.
- COE D., HELPMAN E. (1995): "International R&D Spillovers". *European Economic Review*, 39, pp 859-887.
- DABAN T., DÍAZ A., ESCRIBÁ F.J., MURGUI M.J. (1997): "La Base de Datos BD.MORES". Ministerio de Economía y Hacienda. DGAAP. Mimeo.
- DAGUM C., FONTELA E. (1997): "Partage de Gains de Productivité et Distribution Fonctionnelle du Revenu". Mimeo. *Association Internationale des Economistes de Langue Française*. Congrès de Porto, 28-31 Mai.
- DE LA FUENTE A. (1995): "Inversión, Catch-up Tecnológico y Convergencia Real". *Papeles de Economía Española*, 63, pp 18-34.
- DE LA FUENTE A. (1996): "On the Sources of Convergence: A Close Look at the Spanish Regions". *CEPR Discussion Papers*, n° 1543.
- DIXIT A., STIGLITZ J. (1977): "Monopolistic Competition and Optimum Product Diversity". *American Economic Review*, 67, pp 297-308.
- GLAESER E., KALLAL H., SCHEINKMAN J., SHLEIFER A. (1992): "Growth in Cities". *Journal of Political Economy*, 100, pp 1126-1152.
- GROSSMAN G., HELPMAN E. (1994): "Endogenous Innovation in the Theory of Growth". *Journal of Economic Perspectives*, 8, pp 23-44.
- HENDERSON V. (1994): "Externalities and Industrial Development". *NBER. Working Paper* 4730.
- HISPALINK (1993): *Banco de Datos Multirregional. Hispalink*. Proyecto Hispalink. Mimeo.

- ROMER P.M. (1987): "Growth Based on Increasing Returns Due to Specialization". *American Economic Review*, 77(2), pp 56-62.
- ROMER P.M. (1990): "Endogenous Technological Change". *Journal of Political Economy*, 98, 5 (october). Parte II, pp S71-S102.
- ROMER P.M. (1994): "The Origins of Endogenous Growth". *Journal of Economic Perspectives*, 8(1), pp 2-22.
- SOLOW R.M. (1994): "Croissance Economique: Problemes et Perspectives". Colloque du Bicentenaire du Conservatoire National des Arts et Metiers. Paris.
- WEINHOLD D., RAUCH J. (1997): "Openness, Specialization and Productivity Growth in Less Developed Countries". NBER .Working Paper 6131.