# Technology and industrialization at the take-off of the Spanish economy: New evidence based on patents

Antonio Hidalgo [a,*], José Molero [b], Gerardo Penas [c]

[a] Dept. Business Administration, Universidad Politécnica de Madrid, c/José Gutiérrez Abascal, 2, 28006 Madrid, Spain
[b] Dept. Applied Economy II, Universidad Complutense de Madrid, Madrid, Spain
[c] Technical Adviser, Spanish Patent and Trademark Office, Madrid, Spain

ARTICLE INFO

Keywords:
Technology
Industrialization
Patents
Structural change
Spain
Developing countries
Foreign technology input

ABSTRACT

The aim of the paper is to contribute to a better knowledge of the existing relationship between the incorporation of technology and the industrial take-off, based on the case study of the sectoral dynamism of the Spanish industry during its period of highest development. The main hypothesis is that only an appropriate combination of the introduction of foreign technology and the creation of domestic technology guarantees the acquisition of the technological knowledge required for developing and less developed countries to reach a level closer to that of more developed countries. An evolutionary perspective has been applied considering that industrial growth depends on three types of variables: innovation or technology creation, dissemination potential and absorption capacity potential. The results confirm that the introduction of imported technology has been significant, both for unincorporated knowledge, shown in the growth of patents in the period 1960–1966, and that introduced through the importation of production technology by companies in the process of modernization.

## 1. Introduction

Economists have devoted a lot of attention to the international movement of standard factors of production, such as capital and labor, and to what these movements imply for growth. The spread of technology among countries gets far less attention even though decompositions of the sources of growth show that technological innovation is a major contributor. A reason for this gap is the difficulty of observing either the creation or diffusion of inventions. While we can observe inputs into the inventive process, such as R&D expenditure or R&D scientists and engineers, we have no direct measure of the output.

Patents indicate research output, and where patent protection is sought reflects where inventors expect their ideas to be used. In order to isolate patterns of invention and technology diffusion from patent data we distinguish among various influences on the decision to patent. The level of patenting of one country in another depends on the following factors: the source's research effort, the destination's market size, how rigorously the destination country protects intellectual property, the cost of patenting in the destination country, and the likelihood that invention from the source can be adopted into the destination's technologies.

Several authors from different theoretical backgrounds have acknowledged the role of technology in economic development. Some of the most significant studies have been the neoclassic growth models [1,2], the historic studies [3,4], the endogenous growth models [5–7], and the evolutionary studies [8–11].

Empirical evidence based on conventional growth models is hardly conclusive. If we compare the countries with the highest growth rates in the world with the rest, they seem to show stronger technological efforts, evidenced in the resources allocated to R&D. However, when analyzing the group of countries with a higher growth rate, it is not clear that those with the strongest growth are also those allocating more resources to R&D. In fact, comparatively less developed and smaller countries have shown the highest growth rates in the last decades without actually making any significant R&D effort [12].

On the other hand, the endogenous growth models imply positive relations between R&D intensity, the rate of patenting and the growth rate of output per worker. These models predict a constant level of R&D expenditure or number of scientist and engineers during periods of steady growth. Moreover, the evidence points out to technological spillovers from aggregate research intensity to industry-level innovation success.

To clarify these issues, some authors have adopted a broader perspective of technical progress. The school of evolutionary economy has developed some appreciative theories of a less formal nature for the study of growth as a qualitative change and the

* Corresponding author. Tel.: +34 913363210.
E-mail addresses: ahidalgo@etsii.upm.es (A. Hidalgo), jmolero@icei.ucm.es (J. Molero), gerardo.penas@oepm.es (G. Penas).

essential role of technology. Technology is regarded in a broader perspective, not merely as the production of domestic knowledge, as other forms of adapting and disseminating technologies developed by external agents are included. In this sense, a critical factor determining a country's relative productivity level is its ability to adopt technology, whether the technology was developed abroad or at home. The country's level of education is significant in explaining this ability [9–11].

From the perspective of developing and less developed countries, these studies have highlighted the essential role of technology [3,13,14]. In these countries, the lack of resources for the creation of technology leads to an intensive use of foreign technologies as a way of promoting growth and coming closer to more developed economies [15,16]. In this respect, there has been a clear change in the specialized literature from more traditional thesis on technology transfer as a development factor, going from the traditional debate on the convenience of creating rather than buying technology, to confirming that only an appropriate combination of these two actions can guarantee the acquisition of the technological knowledge required [17–21].

This is why the theory of innovation has been fundamental. This theory has shown the double function of R&D [22]: the conventionally acknowledged function of creating new technologies and its role in providing elements for knowledge building and therefore creating the capacity of absorbing technology developed in other contexts.

The case of the Spanish economy is particularly important for these issues as its recent industrial growth – in the 1960s Spain still received development aid – allowed the change from a very closed-up and national economy to a highly competitive economy on the international market. This expansion took place throughout several decades, reaching its high point in the 1960s. In this period, after a radical change towards economic liberalization and benefiting from an extremely favorable international environment, the Spanish industry experienced its period of maximum growth, ranking among the more dynamic economies worldwide [23].

The aim of this paper is to contribute to a better knowledge of the existing relationship between the incorporation of technology and the industrial take-off, based on the case study of the Spanish economy during its period of highest industrial development. For the first time, it is possible to use a detailed indicator of the technological activity in Spain during this period, as the most used indicator up-to-date relating to R&D is only available in its aggregate form for two years: 1964 (of an experimental nature) and 1967. So the original contribution of this paper is twofold. The first contribution is a description of the role of registered patents in Spain in such a crucial period of industrialization, providing new and more detailed knowledge on the technological activity undertaken during those years. The second contribution is an econometric analysis that tries to measure its importance in relation to the sectoral growth in the Spanish industry.

The remainder of this paper is organized as follows: Section 2 describes some stylised facts of the Spanish industrialisation in the 1960s. Section 3 summarises, according to the academic literature, a set of factors or determinants that influence the considerations of patents as technological indicators. Section 4 describes the characterization of the technological activity in Spain and the evolutionary model that explains its economic growth. The final section consists of a summary of the conclusions and suggestions related to technological policy.

## 2. A brief reference to the opening-up and structural change of the Spanish industry

After a long period of nationalist and protectionist involution that began in the last decades of the 19th Century and was further enhanced in the years following the Spanish Civil War (1936–1939), the Spanish economic policy began to open up during the 1950s, consolidating and showing its most important results in the 1960s: a decade characterized by a very high growth rate and extremely significant structural changes.

The introduction of technology became an essential factor for the high growth rates in industrial production, reaching similar o higher growth rates than during most of the 1950s. As we will argue below, the capacity needed for the domestic production of technology was clearly insufficient and foreign sources were incorporated, both in an "embodied" way, through equipment and direct investments, or in a "disembodied" way through technology transfer agreements or patents.

The framework of economic opening-up and liberalization described above also appeared in the more limited context of industrial policy. The general reference of the policy was to maintain the previous model mainly based on the domestic market, but with an increasing interest in foreign markets as the previous experience of autarchy had led to a dead end. All this was slightly out of step with the general liberalizing measures of the 1950s and within an increasing opening-up philosophy.

Changes in industry could be seen quickly and the growth rate of the Industrial Gross Product in constant values experienced between 1960 and 1966 the most dynamic period in the 20th Century[1] [24]. This strong dynamism resulted in the industrial sector gaining in importance in the national production, going from 19.6% in 1958 to 28.4% in 1974. In this way, the contribution of the industrial sector to the economic growth in the period of 1958–1974 can be estimated in 33.7%, the most important growth in the longer period from 1954 to 1998 [25].

Apart from other factors, the one we would like to highlight in this summarized vision is technology. The Spanish economy, in its process of strong growth and industrialization, required much more and much better technological resources. However, the capacity of producing domestically such resources was very limited and, therefore, turning to foreign technology became an extremely important factor. As a result of such a scarce internal activity, the strong demand of technology due to the growth and diversification of the industry was to be covered to a great extent by imported technologies. In fact, as already indicated [26], a great part of the companies involved in the few national programs available were also important buyers of foreign technology, indicating that the domestic effort played a clear complementary role to guarantee the incorporation of imported technology [27].

The purchase of foreign technology is reflected in a strong increase of the payments registered in the balance of payments and in the imbalance in terms of incomes. Indeed, the payments went from 19.3 million dollars in 1958 to 199.6 millions in 1972, and the deficit in income during this same period went from 17.5 million dollars to 179 million dollars. In addition, we must point out that the ratio between R&D spending and payments for imported technology were very low (0.25) while in developed countries it is usually higher than 1, ranging from 1.3 in Italy to 200 in the United States [28].

## 3. Methodological considerations on patents as indicators

Since the interest of economic analysis on the study of the problems associated to technological change, there is a search for appropriate indicators that may help to explain technological activities and their relationship to economic efficiency in a coherent way. For some time, the focus has been on analyzing research

[1] The year-on-year growth rate in real terms was 13.6% in 1961, 10% in 1962, 11.5% in 1963, 13.3% in 1964, 9.4% in 1965 and 9.6% in 1966.

and development activities (R&D). However, the most recent research has shown a need to broaden the scope of the analysis to the so-called innovation process and technological capacities within organizations.

This change of focus, going from studies based exclusively on research activities towards the inclusion of innovation activities, has consolidated due to the fact that the elements influencing the process of technological development, studied from the point of view of knowledge accumulation and learning, covers a much broader range of variables [29–31]. Moreover, from the mid-1980s innovation has begun to be considered as an independent and interactive process [32] following its own logic and to which in-house research activities contribute greatly but not exclusively. In fact, the publication of the Oslo Manual [33–35] has helped clarify the interpretation of the measurements of technological innovation activities, giving rise to the development of the recent Community Innovation Surveys (CIS) supported by the European Commission.

From this perspective, patents constitute relevant indicators on the output of an organization and provide specific information on the whole of the technological innovation process. From the first research undertaken based on the use of patents as indicators of technological activity [36], the use of the information contained in these indicators has changed greatly, to the extent that it is practically impossible to find now studies on innovation processes or technological capacity of any organization (corporation, university, research center) in which patents are not used as associated variables [37,38].

There are recent studies that try to analyze the qualitative information content on the patent documents to increment the knowledge about innovative activities. Specific information can be obtained related to technology watching, novelty, industrial applications, etc [39,40].

However, the use of patents as an innovation indicator is linked implicitly to a series of conceptual and availability difficulties that must be taken into account [41,42].

Firstly, only a certain amount of innovations are patented, due to different reasons such as the existence of other mechanism to protect findings (industrial confidentiality), the fact that the prospects for financial profit could not justify the patent costs, the ease for competitors to invent based on already registered patents and with low costs or the existence of advanced innovations in some technical fields which are not adequately provided for in patent legislation [43].

Secondly, some innovations cannot be patented because they are expressly excluded in the legislation or because they do not meet some of the requirements (novelty, level of invention and industrial application).

Thirdly, in determined sectors the product life-cycle is very short and there is no interest in patenting.

Fourthly, the specific impact of institutional aspects such as the difference in patent legislation and different procedural practices for granting patents of the competent organisms in each country and the administrative changes that take place affect the analysis of longer periods of time.

Fifthly, different classifications are used in documents and patent databases and in the classification of economic activities. Although specific actions have been taken to address this problem by designing correspondence tables, it has not been totally solved yet.

## 4. Empirical study

Indeed, the impression that the selection of the 7-year period (1960–1966) has more due with the availability of a newly released data from the Spanish Patent and Trademark Office, the reality shows that this time frame represents the take-off across the board of the economy examined. Moreover, a comparison with the already existing patent records for post-1966 years is not relevant for the study due to the generation of structural changes, as important modifications of the legal framework, which introduced relevant distortions.

### *4.1. Characterization of the technological activity*

Table 1 shows the quota of patents granted in Spain attributable to research of a domestic (46.2%) and foreign (53.8%) origin. In general, there was a moderate increase in the growth of patents of foreign origin, which rose from 47.0% in 1960 to 64.4% in 1966. There are different reasons for this phenomenon: on the one hand, the increased internationalization of the technological activity carried out by multinational companies, mainly from United States, Germany, France and Switzerland, who wished to protect their products on the Spanish market [44] and on the other, the search by these companies for a greater capacity to gain access to locally based technological know-how. This prevailing tendency is based on that where only a limited investment is needed to manufacture the product, greater focus was given to covering the major market countries (as was the case of Spain) rather than the manufacturing countries, since it would be easy for competitors to shift manufacture in order to avoid a patent [45].

The analysis related to the origin of the patents granted shows that 89.8% of foreign patents come from seven countries, indicating a strong concentration of the external technological influence (Table 2). This influence was concentrated in the United States (21.5%), Germany (18.1%), France (17.3%), Switzerland (10.3%), United Kingdom (9.6%), Italy (7.6%) and Holland (5.2%). This fact provides evidence of a significant increase in the foreign technological development of the companies from these countries from the sixties onwards, contrasting with the more centralized approach to research strategies taken by other countries such as Japan and Sweden, whose quotas of patents granted in Spain were of just 0.6% and 1.8%, respectively [46]. On the other hand, not surprisingly, companies from small European countries such as Holland and Switzerland show a high level of foreign technological activity, and this has remained at a steady rate of 50% up to the present day [47].

The International Patent Classification (IPC) allowed us to identify the technological areas that have had the strongest impact on the industrial development of Spain in 1960–1966. The transfer of these patents to sectors of economic activity, using the correspondence table in Annex 1, shows a strong concentration in the most traditional sectors, the so-called mature industries, such as foodstuff, textile, furniture and accessories, footwear, metallic products and diverse manufacturing industries. However, there was a strong domestic development of other sectors with a stronger technological content such as the production of chemical products, mechan-

**Table 1**
Granting of patents by year.

| | Spain | (%) | Foreign | (%) | Total |
|---|---|---|---|---|---|
| 1960 | 5 018 | 53.0 | 4 457 | 47.0 | 9 475 |
| 1961 | 4 501 | 53.6 | 3 892 | 46.4 | 8 393 |
| 1962 | 4 834 | 50.5 | 4 741 | 49.5 | 9 575 |
| 1963 | 5 158 | 46.4 | 5 968 | 53.6 | 11 126 |
| 1964 | 4 459 | 44.3 | 5 616 | 55.7 | 10 075 |
| 1965 | 4 371 | 40.8 | 6 348 | 59.2 | 10 719 |
| 1966 | 3 044 | 35.6 | 5 507 | 64.4 | 8 551 |
| Total | 31 385 | 46.2 | 36 529 | 53.8 | 67 914 |

*Source*: Elaboration of authors on SPTO data.

**Table 2**
Granting of foreign patents by country of origin.

| Country | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | Total | (%) |
|---|---|---|---|---|---|---|---|---|---|
| South Africa | 4 | 6 | 4 | 10 | 9 | 13 | 6 | 52 | 0.14 |
| Germany | 973 | 690 | 769 | 1 084 | 1 069 | 1 116 | 912 | 6 615 | 18.10 |
| Argentina | 12 | 16 | 19 | 15 | 10 | 10 | 7 | 89 | 0.24 |
| Australia | 11 | 4 | 7 | 7 | 9 | 12 | 9 | 59 | 0.16 |
| Austria | 48 | 26 | 28 | 56 | 54 | 44 | 39 | 295 | 0.81 |
| Belgium | 84 | 80 | 94 | 125 | 103 | 128 | 78 | 692 | 1.90 |
| Canada | 16 | 25 | 35 | 42 | 38 | 33 | 27 | 216 | 0.59 |
| Denmark | 31 | 34 | 28 | 32 | 50 | 44 | 37 | 256 | 0.70 |
| United States | 808 | 649 | 929 | 1 276 | 1 255 | 1 464 | 1 486 | 7 867 | 21.54 |
| France | 728 | 703 | 877 | 1 028 | 956 | 1 127 | 917 | 6 336 | 17.34 |
| Great Britain | 441 | 386 | 505 | 512 | 580 | 594 | 496 | 3 514 | 9.62 |
| Holland | 239 | 195 | 286 | 347 | 267 | 336 | 239 | 1 909 | 5.23 |
| Italy | 355 | 330 | 365 | 531 | 368 | 448 | 391 | 2 788 | 7.63 |
| Japan | 18 | 7 | 34 | 33 | 41 | 49 | 49 | 231 | 0.63 |
| Liechtenstein | 14 | 34 | 29 | 31 | 31 | 25 | 28 | 192 | 0.53 |
| Luxemburg | 16 | 11 | 7 | 8 | 4 | 9 | 9 | 64 | 0.18 |
| Norway | 24 | 13 | 12 | 23 | 18 | 17 | 16 | 123 | 0.34 |
| Portugal | 7 | 10 | 7 | 7 | 18 | 14 | 13 | 76 | 0.21 |
| Sweden | 69 | 69 | 66 | 108 | 92 | 148 | 103 | 655 | 1.80 |
| Switzerland | 475 | 528 | 550 | 587 | 524 | 552 | 559 | 3 775 | 10.33 |
| Other countries | 63 | 67 | 81 | 81 | 87 | 110 | 236 | 725 | 1.98 |
| Total | 4 457 | 3 892 | 4 741 | 5 968 | 5 616 | 6 348 | 5 511 | 36 529 | 100.00 |

*Source*: Elaboration of authors on SPTO data.

ical and electric machines, shipping material and electricity, gas and steam (Table 3).

The patents from the United States greatly complemented the technology developed domestically by Spanish companies, for example in the foodstuff, textile and metallic products. However, they were mainly focused on the development of two basic sectors: the chemical and the mechanical machinery sectors. The chemical sector (chemical products and rubber products) is the most relevant with a total of 2 554 patents distributed in the technological areas of inorganic chemistry (C01), glass (C03), organic chemistry (C07), organic macromolecular compounds (C08), and dyes, paints, polishes, natural resins and adhesives (C09).

On the other hand, the European countries that provided the greatest amount of technology to the Spanish industry have focused their patents in areas related to different industrial techniques supporting the industrial development in the more traditional industrial sectors. We must also highlight the European technological momentum to other sectors such as the production of mechanical machinery in the area of combustion engines (F02) and engineering elements or units (F16), with 2 117 patents; and the sector of shipping material with 1 582 patents. However, the European contribution with the highest degree of technological content in Spain concentrated on the development of the chemistry sector with 3 202 patents, strongly oriented towards organic chemistry (C07 and C08) with 1 415 patents, complemented the technology transferred by the United States; and fundamentally on the generation of electricity through nuclear power (G21) whose development in Spain was mainly due to transfer of tech-

**Table 3**
Distribution of patents, according to origin, in the different economic sectors (1960–1966).

| Sector | SPA | USA | GER | FRA | GBR | ITA |
|---|---|---|---|---|---|---|
| Coal extraction | 10 | 6 | 4 | 3 | 1 | – |
| Extraction of metallic minerals | 10 | 7 | 2 | 1 | 2 | 1 |
| Crude oil and natural gas | 20 | 13 | 8 | 7 | 4 | – |
| Stone, clay and sand extraction | 20 | 14 | 7 | 8 | – | – |
| Non-classified, non-metallic mineral extraction and quarry exploitation | 74 | 13 | 12 | 14 | 7 | 7 |
| Food product manufacturing industries, excluding beverage industries | 2 376 | 385 | 130 | 249 | 99 | 83 |
| Beverage industries | 75 | 56 | 9 | 18 | 16 | 10 |
| Tobacco industries | 35 | 47 | 5 | 4 | 8 | 3 |
| Textile industries | 2 210 | 318 | 140 | 248 | 206 | 149 |
| Manufacture of footwear, clothing and other articles made using textile products | 862 | 61 | 16 | 41 | 18 | 31 |
| Wood and cork industries, excluding furniture manufacturing | 274 | 23 | 22 | 19 | 11 | 17 |
| Furniture and accessory manufacturing, and auxiliary industries | 1962 | 114 | 58 | 173 | 69 | 77 |
| Paper and paper product manufacturing | 189 | 63 | 12 | 25 | 23 | 7 |
| Printing, editorials and related product industries | 642 | 113 | 29 | 58 | 25 | 7 |
| Leather and leather product industries, excluding footwear | 35 | 9 | 4 | 2 | 2 | 4 |
| Rubber product manufacturing | 783 | 712 | 129 | 192 | 262 | 318 |
| Chemical substance and product manufacturing | 2 275 | 1 842 | 359 | 970 | 547 | 425 |
| Oil-derived and coal-derived product manufacturing | 98 | 101 | 13 | 31 | 32 | 10 |
| Production of non-metallic mineral products, excluding oil and coal-derived products | 611 | 267 | 45 | 192 | 108 | 50 |
| Basic metal industries | 194 | 184 | 41 | 161 | 76 | 15 |
| Production of metallic products, excluding machinery, shipping equipment, and furniture | 1 864 | 394 | 150 | 279 | 182 | 86 |
| Machinery construction, excluding electric machinery | 4 567 | 763 | 296 | 1080 | 565 | 176 |
| Construction of electric machinery, appliance, accessories and elements | 1 454 | 200 | 84 | 226 | 72 | 60 |
| Construction of shipping materials | 3 455 | 554 | 245 | 723 | 402 | 212 |
| Diverse manufacturing industries | 2 543 | 175 | 111 | 310 | 136 | 96 |
| Electricity, gas and steam | 2 412 | 735 | 116 | 679 | 290 | 76 |

*Source:* Elaboration of authors on SPTO data.

nology from France and Great Britain through a total of 164 patents.

These data shows that most of the technological development has taken place in those sectors where foreign patents have contributed to complement the technology developed domestically. We can therefore say that the existence of a basis of technological knowledge in a sector becomes a necessary condition for the efficient assimilation of a technology from the outside, regardless of its origin. This would explain, for example, the later development in Spain (in the 1980s) of technologies associated to the electricity, gas and steam sectors, whose origin can be found in the incorporation of technology coming from another source than the one developed by national companies in the period studied.

### *4.2. Sectoral industrial growth and the introduction of technological knowledge*

In order to go further in the understanding of the role of technology in the industrial development, an evolutionary perspective has been applied to relate sectoral growth and the availability of technological knowledge. In particular, it addresses the need to follow through with certain studies manifesting the differences in countries' growth rates, mainly due to the distinct form in which technological knowledge has been incorporated. In this paper a similar consideration is made but it will be applied to the explanation of differences in the sectoral development of Spanish industry.

According to Fagerberg and Verspagen [48], a hypothesis can be made that there is a close relationship between economic development -in this case, industrial growth- and technological development, so that a country's growth rate- here industrial sectors growth rates- is positively influenced by the growth rate of technology levels. In addition, the existence of a significant technological gap can affect an increase in growth rate through imitation or catching up. Similarly, the rate of use of the previous possibilities depends on the ability to mobilize resources for social transformation in addition to economic and institutional structures. Keeping these considerations in mind, it can be said that industrial sectors growth depends on three types of variables: firstly, innovation or technology creation (through indicators such as R&D expenditures or patents); secondly, dissemination potential as a possible source of convergence (approximated by productivity or per capita GDP); and thirdly, complementary factors in exploiting absorption capacity potential (estimated by investment and other structural and institutional data) [10].

The general model proposed is type $Y = A_1 Q^{\alpha} C^{\beta}$, with $Q$ as technological knowledge and $C$ as the capacity for knowledge absorption. The knowledge variable is expressed with the equation $Q = A_2 D^{\chi} N^{\delta}$, where $D$ is foreign knowledge incorporated in production and $N$ is internally created knowledge.

The need for this research to be adaptable to an environment of industrial sectors within an economy and the availability of data guide the application of somewhat distinct variables, while maintaining the theoretical foundation represented by elements of technological knowledge incorporation. Variable selection and development is determined by the need to coincide with the new patent data supporting the study. Thus, a set of variables are added to the patents, with respect to theoretical criteria, making it possible to develop them on the same level with sector-by-sector details and applied to the same-time frame as the reference variable. Specifically, the following variables are used[2]:

The variable to explain is sectors growth in Spanish industry. It is estimated from *Sector Added Value [VA]*, for the period between 1960 and 1966, measured at a constant pesetas value for the year 1960.

With respect to independent variables, patents are introduced as an indicator for technological activity in firms. Patents are distributed into two categories: *Resident Patents [PE]* and *Non-Resident Patents [PX]*, with the former as a good indicator of foreign patents, as it is used by the OECD. This distinction is fundamental due to the empirical interest in understanding foreign technology's importance in the Spanish industrial boom. The underlying hypothesis is that the technology demand that created the industrial growth assumes a positive relationship between patents and industry growth. Nevertheless, the distinct technological significance shown by Spanish patents with respect to foreign ones introduces the possibility of expecting significant differences between them.

Following the previously mentioned guidelines laid down by the works of Fagerberg, work productivity can be considered as the way to reach technology diffusion potential. In this manner, *Productivity per unit labor cost [PV]* has been incorporated, measured in the pesetas value of 1960. Among the specific contents reflected by productivity, at the end of this study the importance of human capital improvement should be stressed along with the knowledge incorporation thus represented. A positive and significant indication is therefore expected from this variable.

Incorporation of foreign technology happens in various ways, just as it happened in other countries that have reduced the gap with leading economies. This makes it convenient to introduce variables that estimate the importance of incorporated technology in both foreign investments and productive imports. The extreme difficulty in accessing disaggregated investment data has reduced the possibility for accessing data on sectoral imports. To resolve this, one must take into account that imports utilized by sectoral firms as production components are of interest in this study, as they are the mechanism for incorporating new technology. In this fashion, imports used as production processes inputs, or *Production Imports [MP]*, have been estimated through adjusting global statistics on sector imports using a production imports coefficient assessed by the input–output tables for 1962 and 1966, the only data available for the study's period. In order to avoid possible biases caused by variations of a year, the arithmetic average of the values for the two years is used. A positive relationship between production imports and growth in industrial added value is expected.

Although the process for technology incorporation was generalized, there is no doubt that its intensity was different in distinct sectors. Unfortunately, the data available does not allow for incorporating of Dummy variables for each sector, so the number of observations is insufficient for guaranteeing degrees of freedom. Therefore, a general character Dummy variable was chosen [TM], consisting in grouping sectors into two categories according to their demand of embodied technology incorporated in productive imports: sector with a demand over and below average. The first are supposed to depend more on foreign technology while the second are more self-sufficient. Based on this, the expected outcome is that the sectors that were less dependent on foreign-produced technology, i.e. those with the most technological self-sufficiency, benefited more efficiently from foreign technology.

The model proposed is a regression model whose generic expression is

[2] It is important to point out that we have not been able to calculate in such detail other variables that would have been of interest such as the productive investment of each sector per year and foreign direct investments received.

**Table 4**
Synthesis of general model and by large industrial sectors.

| | General model | Mature sectors | Modern sectors |
|---|---|---|---|
| Adjusted $R^2$ | 0.957 | 0.979 | 0.969 |
| Estimation standard error | 0.19104 | 0.14519 | 0.15522 |
| D W | 2.07 | 2.505 | 1.884 |
| F (significant) | 289.238 (0.000) | 267.105 (0.000) | 184.984 |
| Constant | 6.998 (0.000) | 12.307 (0.000) | 6.450 (0.000) |
| LNPV–Beta | 0.625 (0.000) | 0.092 (0.452) | 0.569 (0.000) |
| LNMP–Beta | 0.103 (0.046) | 0.372 (0.000) | 0.280 (0.782) |
| TM–Beta | −0.149 (0.000) | −0.255 (0.000) | −2.756 (0.011) |
| LNPE–Beta | −0.356 (0.000) | 0.254 (0.131) | −0.466 (0.000) |
| LNPX–Beta | 0.549 (0.000) | 0.210 (0.220) | 0.656 (0.000) |

In brackets the level of significance.

$$\mathrm{LNVA}_{it} = c + \beta_1 \mathrm{LNPV}_{it} + \beta_2 \mathrm{LNMP}_{it} + \beta_3 \mathrm{TM}_{it} + \beta_4 \mathrm{LNPE}_{it} + \beta_5 \mathrm{LNPX}_{it} + \varepsilon_{it}$$

With the variables defined as[3]

- VA change in added value in the 1960 value for pesetas (lagging Ln)
- PV change in productivity per labor unit cost in 1960 pesetas (Ln)
- MP change in production imports (Ln)
- TM tendency of production imports (Dummy)
- PE patents granted to residents – Spanish patents (Ln)
- PX patents granted to non-residents – foreign patents (Ln)

Subscripts *i* and *t* refer to the economic sectors and time, respectively. The result is integrated with information on 11 groups of industrial activity, categorized according to the National Classification of Economic Activities of 1952 (CNAE-1952).

The theoretical supposition applied as underlying the modern theory of technical change is that the make or buy technology dilemma is false because both tasks are necessary in countries with relatively lower development; in fact, in the previous section several indicators pointed to the trend that Spanish firms with the most imported technology were the same firms developing technological efforts, indicating the creation of a complimentary relationship instead of substitution. Based on this, the expected outcome is that the sectors that were less dependent on foreign-produced technology, i.e. those with the most technological self-sufficiency, benefited more efficiently from foreign technology.

The model estimates the total results for industry, presented in the second column of Table 4. The set of parameters and statistics supports its validity.

As a function of the estimate, the progression of Spanish industrial production from 1960–1966 would be given by the following equation:

$$\Delta \mathrm{LNVB} = 6.99 + 0.625\Delta \mathrm{LNPV} + 0.549\mathrm{LNPX} - 0.149\mathrm{TM} - 0.356\mathrm{LNPE} + 0.103\mathrm{LNMP} + \varepsilon$$

These results can be interpreted as relatively coherent with the initially proposed theories. Beginning with the direct incorporation of technology, foreign patents show a positive influence and an elasticity which fits perfectly with the general knowledge available on the Spanish industrialization process: the dependence on foreign technology is clear, now that sector detail has made the data collected by the study's authors available.

Secondly, foreign technology incorporated in production imports also shows a positive influence on industrial growth. Although elasticity is lower, this shows the modernization of production structures, which are strongly dependent on importing foreign intermediate products, and the significant role it has played in the Spanish economy's industrial boom.

Thirdly, the results of the Dummy variable (TM) are also relatively coherent with the proposals. The relationship indicated that other variables' effects increase by 14.9% in sectors with lower dependence on foreign production imports. This is a clear sign that the existence of the countries' own capacities (absorption capacity) allow for more efficient use of technological knowledge incorporated by other sources.

The variable with the most difficult results to interpret is that of Spanish patents [PE]. A negative value indicates that when Spanish patent production was lower, growth rates were higher within industrial sectors. There are two possible interpretations of this outcome. The first is a lower technological content expressed in Spanish patents, according to the results in Section 4.1, and the second is the significant number of these patents that were not registered by firms, but rather by individuals and applied to inventions that were difficult to use for industrial purposes. One could argue that a higher abundance of this patent type does not necessarily mean higher availability of technology, but rather on some occasions, knowledge (or technology) on a lower level than that of foreign technology. Consider that these two problems are not present in foreign patents, where practically all patents are registered by firms and the average innovative level is clearly superior.

Last but not least, it is remarkable the role of productivity. This variable is significant, with a positive sign and its elasticity has the highest value; therefore, the dissemination potential plays a very important role in diffusing technologies among the Spanish industrial production system and resulted in higher industrial growth.

Taking a more profound look at sector aspects, the indicators available allow for replicating model estimates for two subsets of sectors: *type 2* sectors can thereby be selected, corresponding to traditional, mature industries, with less complex production process, and *type 3* sectors are grouped along more modern and with more complex systems of production lines. The results, together in columns 3 and 4 of Table 4, show different behaviors in both cases. In the mature sectors, technology incorporation through productive imports best explains the dynamic behavior and modernization of the sectors in this group. On the other hand, in most modern sectors that source is not significant, while the incorpora-

[3] The previous analysis detected a failure in certain regression analysis assumptions. The existence of non-linear relationships among dependent variables and some explanatory were found, such as indications of non-normality. On the other hand, signs of self-correlation appear to be positive and two of the independent variables show indications of collinearity. To resolve these problems the variables were adjusted. First, the dependent variable (added value) was transformed through a first-order delay and calculated in logarithms. Second, all numerically explained variables are expressed in logarithms. This considerably improves the performance of assumptions: giving better normality, linearity and homogeneity of variance and substantial improvement with the self-correlation problem. Collinearity was also improved for tolerance level. The complete calculations are available to any interested party.

tion of knowledge through patents is. It must be emphasized that in both cases, the Dummy that affects technology absorption capacity is also significant and greater than for the general model, especially in more traditional sectors.

## 5. Conclusions and recommendations

Technology, contemplated with a broader perspective than internal generation of knowledge, constitutes a basic component fueling economic development in a country. The scarcity of resources dedicated to technology generation by developing countries implies they must take intense measures towards importing foreign technology, either incorporated in equipment or disembodied through patents and other mechanisms. This article has aimed at making a robust approach to the evolutionary economy, advocating a country's growth as a process of qualitative change where technology takes on an essential role. The main hypothesis is the need these countries have to find a balance in the combination of foreign technology transfer with a capacity to develop elements of internal learning, acting as a facilitator in the absorption process for technology developed in other contexts.

The econometric analysis performed has allowed for a much more precise understanding of technology's role in the Spanish industrial boom during the 1960s, and particularly the importance of incorporated foreign technology has had in the distinct behaviors of industrial sectors in reference to relative growth. Three main conclusions can be derived from this research:

Firstly, the significant impact of technology in the Spanish industrial boom and throughout the modernization process, characterized by higher growth in more modern and technologically complex sectors such as the chemical, mechanical machinery and metals sectors, in relation to lower growth in more traditional and mature sectors such as food products, textiles, footwear and furniture. In this sense, it appears that the transformation made moving from models designed to explain the differences in growth between countries to a newer version that explain differences among economic sectors is acceptable.

Secondly, imported technology has been fundamental in the process described above. This incorporation has been significant in reference to technology received through unincorporated knowledge, expressed in an increase in patents, as well as the technology incorporated through production imports received by Spanish firms during their modernization processes (it was not possible to analyze the more classic method of incorporating foreign technology – direct investment – because the disaggregated data necessary for this analysis was not available on a sectoral level).

Thirdly, the importance of the availability of national firms' own technological capacity was confirmed, which guarantees an efficient absorption of foreign technology. This can be proven by the relative results of two different variables: work productivity, in expressing the potential of technological knowledge dissemination, and a lower dependence on production imports in sectors that experienced the largest growth within the period studied. This has been the case in the technological impulse within the chemical sector (and in the different branches, such as organic chemistry, macromolecular compounds, inorganic chemistry, dyes, paints, resins and adhesives), shipping materials, machinery construction (the technological branch for combustion motors in particular), electricity, as well as gas and steam (with the generation of electric energy through nuclear power).

A set of general implications can be derived from these conclusions for technological policy. Firstly, it reaffirms the importance of technology as a driving factor in structural change and, therefore, the interest in increasing resources allocated to generating technological capacities in developing countries, especially those which are close to or in consolidation phases at certain levels of industrial development.

Secondly, the characteristics of the technology itself and the innovation process shows that it is not possible or recommended to let this effort fall within one of two basic areas: internal technology generation and importation from foreign countries. On the other hand, the empirical evidence confirms the necessity of combining the two. Absorption capacity is converted into a decisive element, indicating that countries should make every effort to increase this capacity with two basic changes: through designing actions for improving and intensifying the educational system, including continuing training; and on the other hand, through perfecting domestic production mechanisms, particularly in training professionals of small and medium-sized firms who, in many cases, work as suppliers or subcontractors for transnational companies.

Thirdly, the changes in technology generated on an international scale make it essential to readjust the self-sufficient activity models. More diverse modes of generating technological knowledge are becoming widespread, affecting international activities from the global use of locally-created technology to the establishment of R&D centers in countries other than where firms were originally founded. This facilitates the creation of strategic technological alliances which, among other objectives, allow for the sharing of knowledge and technology with partner firms, in addition to opening new markets and accessing beneficial financing formulas. It can therefore be deduced that technological policy activity in developing countries should also be open to international collaboration, not only in the most common sense, within the country's public sector, but also in collaboration between national and foreign firms.

The final conclusion addresses the desirability of implementing mechanisms focused on design and support technology transfer strategies and their relation to the processes of technology sale and market presentation. Among these mechanisms, commercial agreements can be included, as well as technology leasing agreements, production licenses, development of licenses and patents. From a technological perspective, the impulse of these innovative measures implies a clear alternative for developing countries for internationalization of industrial activity and opening-up to new markets.

## Annex 1

Definition of industrial branches according to the Spanish National Classification of Economic Activities (CNAE-1952) and the correspondence with the IPC.

| CNAE 1952 | Industrial branch | International patent classification (IPC) |
|---|---|---|
| 11 | Coal extraction | E21D |
| 12 | Extraction of metallic minerals | E21D |
| 13 | Crude oil and natural gas | E21B |
| 14 | Stone, clay and sand extraction | E21C |
| 19 | Non-classified, non-metallic mineral extraction and quarry exploitation | E21C, F42 |
| 20 | Food product manufacturing industries, excluding beverage industries | A01, A21, A22, A23, C13 |
| 21 | Beverage industries | C12 |
| 22 | Tobacco industries | A24 |

(*continued on next page*)

Annex 1 (*continued*)

| CNAE 1952 | Industrial branch | International patent classification (IPC) |
|---|---|---|
| 23 | Textile industries | D01, D02, D03, D04, D05, D06 |
| 24 | Manufacture of footwear, clothing and other articles made using textile products | A41, A42, A43 |
| 25 | Wood and cork industries, excluding furniture manufacturing | B27 |
| 26 | Furniture and accessory manufacturing, and auxiliary industries | A47, E06 |
| 27 | Paper and paper product manufacturing | B31, D21 |
| 28 | Printing, editorials and related product industries | B41, B42, B43, B44 |
| 29 | Leather and leather product industries, excluding footwear | C14 |
| 30 | Rubber product manufacturing | B29, C08 |
| 31 | Chemical substance and product manufacturing | A61, B01, B02, B03, B04, B05, B06, B07, B08, B09, C01, C02, C05, C06, C07, C09, C11 |
| 32 | Oil-derived and coal-derived product manufacturing | C10 |
| 33 | Production of non-metallic mineral products, excluding oil and coal-derived products | B28, C03, C04, C30 |
| 34 | Basic metal industries | C21, C22, C23, C25 |
| 35 | Production of metallic products, excluding machinery, shipping equipment, and furniture (metal blinds fall into category 26) | B21, B22, B24, B25, B26, B32, E05, F41 |
| 36 | Machinery construction, excluding electric machinery | B23, B30, F01, F02, F03, F04, F15, F16, F23, F25, G01, G02, G03 |
| 37 | Construction of electric machinery, appliance, accessories and elements | B81, B82, F21, F24, F26, F27, F28, G04, G05, G06, G07, G08, G11, G12 |
| 38 | Construction of shipping materials | B60, B61, B62, B63, B64, B65, B66, E21F |
| 39 | Diverse manufacturing industries | A44, A45, A46, B67, B68, G09, G10, E01, E02, E03, E04 |
| 51 | Electricity, gas and steam | F17, F22, G21, H01, H02, H03, H04, H05 |

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**Antonio Hidalgo** is Professor of Technology Strategy, Director of the Research Group of Innovation, IPR and Technology Policy, and Director of the Master in Economics and Innovation Management at the Universidad Politécnica de Madrid, Spain. He received an MBA and a PhD in Industrial Engineering from the Universidad Politécnica de Madrid. He acts as an expert to the European Commission as technology consultant in different European projects. His works have appeared in R&D Management, Production, Planning and Control Journal, Journal of Intelligent Manufacturing, Journal of Technology Transfer, International Journal of Product Development, and International Journal of Enterpreneurship and Innovation Management.

**José Molero** is Doctor in Economics and Professor of Applied Economics at the Faculty of Economics at the Universidad Complutense de Madrid, Spain. He is Director of the Virtual Incubator of the Madrid Regional Government and was Vice-Rector of Postgraduate Studies and Director of the Complutense Institute for International Studies. He has acted as consultant of national and international organizations as the European Commission, the EUREKA Programme, the Spanish Ministry of Industry and the Madrid Regional Government. His works have appeared in Research Policy, International Journal of Entrepreneurship and Innovation Management, and Journal of Interdisciplinary Economics.

**Gerardo Penas** is Quality Advisor at the Spanish Patent and Trademark Office. Previously, he was Head of the Technological Information Unit and Patent Examiner at the same office. He is Industrial Engineer from the Universidad Politécnica de Madrid. He participates in several important Working Groups and Committees related to patents and quality.