TITLE: The Evaluation of the National Agrifood Technology Programme: the Articulation of the Spanish Agrifood Innovation System.

Authors: Ignacio Fernández de Lucio, Fernando Jiménez, Elena Castro and Antonio Gutiérrez.

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Key words: Evaluation, articulation, National Agrifood Innovation Systems, R&D public policies.

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1. Introduction

The evaluation of public policies supporting R&D and innovation activities is a common process, fully incorporated in the socio-economic activity of several developed nations. In the USA, for instance, it became fashionable during the 1960's [1]. The main aim was to provide policy makers with results that could be used as a basis for judgement in readdressing policies toward specified goals. This approach produced a large volume of literature, currently considered the core bibliography in the evaluation of public programmes and policies [2,3]. Regarding technology policy evaluation there was some delay, though we can now find a considerable amount of bibliography and research focused on this topic [4,5,6,7]. This work shows different methodologies applied to programmes and policies supporting R&D and technological innovation activities in developed countries.

It has taken longer for Spanish society to realise the need for the evaluation of public activity in general and, more specifically, that which concerns science and technology policy. The announcement of the "Science Law" in 1986 [8] and the subsequent implementation of the National R&D Plans provide the key dates of the process of institutionalisation of the support for such activities. This process encompasses evaluation activity, previously reflected in sporadic reports, which lacked a commonly accepted methodology or some regularity in order to be considered reliable. Following the implementation of the National R&D Plans there was an incipient trend towards evaluation during the 1990's which will undoubtedly offer results of interest for both public policy makers and practitioners connected with these topics [9,10,11].

So far, most evaluations of the National R&D Plans have focused on the results relating to the resources (both financial and human) involved in their particular programmes, as well as the outputs produced with those

resources such as publications, patents or trained personnel [12,13,14,15]. However, none of them show results regarding the relationships that have been fostered using those resources, which constitute one of the objectives pursued by the R&D Plans. Furthermore, from a structural point of view, those relationships are considered crucial for building, articulating and consolidating a real Innovation System. Little work has been done in relation to this topic. Only Acosta and Modrego [11] address the point by offering an integrated approach to economic and structural aspects, but fall short of explaining the reasons for co-operation between Public Research Institutions (PRI) and firms.

In the specific case of the food industry research carried out in Spain, the evaluation of such activity started with the publication of a booklet [16] in 1984 by the Spanish Council of Scientific Research (CSIC). It is a description and quantification of the R&D activity carried out by the Institutes of the CSIC during 1978-1994 related to the topic of food technology and the consequences for the Food and Beverages Industry. Subsequently, a real evaluation of the National Agrifood Technology Programme (NATP) financed from the R&D Plans has not been addressed and just a few studies have been published pointing out the role of agrifood technology in Spain as a real Sectoral Innovation System [17,18].

This paper [19] is an attempt to fill this gap and contribute to the awareness of evaluation of R&D public policies in Spain. It offers results on the evaluation of the NATP, which has been part of the National R&D Plans since 1988. More specifically, an alternative evaluation methodology, integrating economic information from databases into qualitative information, is introduced. This methodology describes the articulation capacity of the System and the role of the infrastructures supporting the creation of networks among the actors of the Spanish Agrifood Innovation System. In addition, we analyse the role of the management structure in the development of the NATP.

In the next section, the theoretical framework used for this evaluation is discussed, as well as the description of the methodologies proposed within this framework. We point out their characteristics and expected results related to the articulation of an Innovation System. Afterwards, we show some results of the analysis of data on the Programme's output. Secondly, a first approach to the network analysis among the actors involved in this Programme is presented. Thirdly, we briefly describe the role of the management structure of the NATP. Finally, some conclusions are drawn.

2. The Structuralist approach to the Innovation System and its Application to Innovation Policy Evaluation

The *Innovation System* concept is by now widely established among economists and politicians, and it is possible to sustain the application of several methodologies under the auspices of this idea. Regarding the evaluation of public policies, the underlying IS approach has provided us with several models and methodologies to bring the results of a programme evaluation closer to the institutional network, social actors

and relationships as main components of the Innovation System [20,21,22]. This concept arises as a response to the need to study the type and role of infrastructures in the economy [23] and, more specifically, innovation processes [24]. The Structuralist approach allows us to make explicit both technology and institutions and studies their relation to the generation of technological change. Under this approach, technological change is considered endogenous from the point of view of its response to economic incentives [23,25]. Moreover, the application of the “structure” concept to the evaluation of a public policy supporting R&D and innovation is of interest because it allows us to find out to what extent such a policy is the right tool for fostering the articulation of the Innovation System. Lipsey and Carlaw’s scheme [24] emphasises the concept of the “facilitating structure” as the embodiment of existing technological and organisational knowledge. Such a structure is influenced and altered by technological factors as well as by the structure managing public policies. This approach is consistent with the idea of evaluating an R&D Programme fostered and managed by the Administration. Under this scheme, a technology policy is defined as the search for certain objectives, which have been expressed in a specific programme, as well as the specification of the means to achieve those objectives. The implementation of such policy will influence the facilitating structure, which will also receive the influence of the factors supplied to the system in the form of human and physical capital as well as the actual technology. This interaction process will generate measurable economic results, which are finally evaluated. That is to say, the level of success reached with the technology policy and, in general, the degree of development achieved is determined, among other things, by the compatibility and interaction between the technology, the facilitating structure and the policy structure.

These relationships are precisely the key to the analysis and methodology used by different scholars and practitioners who study in depth the structural aspects and, more specifically, the articulation aspects when analysing and evaluating the implementation of a particular programme supporting R&D activities. Thus, *network analysis*, on its economics side, offers a measure of the types of relationships found among the actors or institutions of the System. Within this framework, there are several methodologies with a more or less macroeconomic results. The *network analysis* used for the evaluation of specific programmes provides us with a measure of the relationships created between the research units (research institutions, R&D units of firms, researchers, etc.) taking part in the programme. Such a methodology is applied by Lahlou in the evaluation of the European Commission’s Science and Stimulation Programmes [26]. From a structuralist viewpoint, this is a quantitative methodology in which the units of analysis are observed *before* and *after* the collaboration in the programme evaluated. The network characterisation is carried out through an indicator (mean value) of the relationship between pairs of the observed units, which give shape to the network studied. Such an indicator is calculated according to the measure of these core variables in the quantification of the relationships. The possibilities of applying this methodology to the Spanish case seem to be rather distant for several reasons. First, the Spanish Innovation System (SIS) is quite young: it would seem inappropriate to apply to it and to measure the network concept, which requires the durable relationships that shape and characterise the Innovation System in developed countries, where there is a long tradition of R&D and innovation activities. Second, the links among the various elements of the SIS are very tenuous [27], which obstructs the application of the network concept at this stage. Finally, there is very little participation by Spanish agrifood firms in R&D

activities [28,29]. This reduces any possibility of analysing and evaluating the public programmes supporting such activities with this methodology, since the participation of firms is considered to be a key element.

A less quantitative methodology, but also used to analyse relationships and structural effects, is Callon's techno-economic network analysis [30,31,32]. Under this methodology it is possible to go deeper into the participation of the different actors and institutions of the Innovation System, which influence and are influenced by each other's actions. This methodology pursues the observation *within* and *between* units, and provides us with a characterisation of the interactions among units taking part and co-operating in R&D and innovation activities. Its application provides us with results at a mesoeconomic level, which are useful for structurally characterising economic sectors and Sectoral Systems of Innovation. Hence, it seems a suitable methodology for application to the SIS.

In short, these analyses assume that the relationships existing between the System's actors are more relevant than the individual attributes of those actors [33], an important factor to be taken into consideration when evaluating their importance. What all these analyses have in common is a system approach clearly addressed toward the production of innovations.

Taking up the idea pursued by the structuralist approach, the evaluation will also require stating another basic characteristic of the innovation process: the *absorptive capacity*. This concept, when applied to a firm or a nation's production system, can be understood and defined as its capacity to "recognize the value of new information, assimilate it, and apply it to commercial ends", see Cohen and Levinthal [34]. The concept can be applied to evaluate the role of firms participating in R&D and innovation activities which are financed with public funds.

The absorptive capacity concept can be related to the network analysis concept in such a way that the larger the firms' absorptive capacity, the greater the integration among the System's actors [35,36]. This relationship produces some consequences which might be considered when applying the network analysis.

3. Methodology and Data

The methodology used in the evaluation of the NATP is threefold. Firstly, a statistical descriptive analysis of the outputs is performed. The aim is to roughly quantify and qualify these outputs in order to establish the initial characterisation of the research target and the possibility of monitoring articulation in the Innovation System. We apply uni- and bi-variant statistical methods to the main output variables. Such outputs are the results of the *R&D Projects* [37] financed by the NATP.

Secondly, in order to evaluate the articulation fostered by the NATP in the Spanish Agrifood Innovation System (SAIS), a methodology based on Callon's techno-economic networks has been designed. To do this, we monitored the actors' participation in *R&D Projects*, and their further participation in co-operation with firms

through other types of projects such as *PETRI Actions* [38] and *Concerted Projects* [39] or even bilateral contracts [40]. The aim of this methodology is to monitor and trace the trajectory of these actors in a way that makes it possible to characterise and analyse whether they configure a network within the SAIS, or just interact sporadically, in which case it is impossible to speak about the articulation of the System.

Thirdly, the NATP management has been analysed using a structured qualitative interview addressed to the Programme managers in an attempt to find out the role of the *policy structure*: whether such structure has been used, among other things, to facilitate relationships among participants in the System.

The information on R&D Projects was obtained from the final reports submitted to the General Secretariat of the National R&D Plan (which comes under the Interministerial Commission of Science and Technology, CICYT) by the Head of the Research Group (HRG). From these reports we obtain quantitative data on the diffusion of research results (articles published in national and international reviews, monographs, congresses), personnel training (measured by the number of doctoral thesis submitted), some economic results (measured by the personnel incorporated into firms or number of patent applications and patents granted). Furthermore, these reports provide us with some qualitative information on the research results obtained: whether they are mainly theoretical, theoretical-practical, practical or ready for application. It has been possible to obtain information on 343 cases, or 78% of a total of 441 projects financed during the period analysed [41]. Likewise, we gathered information on 56 *PETRI Actions*, as well as *Concerted Projects* and bilateral contracts. In this case, the information refers to the contracts between firms and the research groups of the Polytechnic University of Valencia (UPV) as a representative PRI in Food Technology research.

The units of analysis are the HRG, representative of the R&D groups of universities and other PRIs, and the firms. The connection between these two units of analysis is their participation in the NATP.

The time frame used to perform the analysis runs from 1988 to 1995, which coincides with the First and Second National R&D Plans. Additionally, this period has been extended to 1998 to analyse the information on the Polytechnic University of Valencia, as the representative case of the participation of a university in the NATP.

4. Results of the Evaluation of the National Agrifood Technology Programme

4.1. Measurement of Outputs

The information on the main outputs produced by the research groups with their participation in the *R&D Projects* of the NATP is shown in Table 1 [42]. The initial analysis of the frequencies of these variables reveals that they do not follow normal distributions [43]. Hence, the mean and modal values of the different variables seem more reliable and representative as statistics.

Table 1. Outputs of R&D Projects between 1988 and 1994*.

	Total Number	Mean Value	Modal Value	Frequency of Modal Value (%)
Personnel Trained	1,079	3.1	2	20.4
Non PhD grant holders	189	0.5	0	71.1
PhD grant holders	56	0.2	0	87.8
PhD Theses Submitted	534	1.6	1	29.1
National Articles	410	1.2	0	62.7
International Articles	1,953	5.7	0	21.9
Disclosure National Art.	288	0.8	0	72.0
Disclosure International Art.	21	0.1	0	96.5
Review National Art.	126	0.4	0	80.5
Review International Art.	77	0.2	0	84.5
National Monographs	229	0.7	0	72.9
International Monographs	265	0.8	0	66.2
National Conferences	591	1.7	0	52.8
International Conferences	517	1.5	0	52.2
Patent Applications	54	0.6	0	87.8
Patents Granted	6	0.0	0	98.5
Spanish Pat. Applications	50	0.1	0	86.9
Internat. Pat. Applications	11	0.0	0	97.4

Source: Own elaboration. Data extracted from the final reports on R&D Projects (CICYT).

* These data correspond to 343 final reports on R&D Projects.

An initial observation of the values shows *zero* as the most frequent value for most of the variables, including those with a mean value higher than zero. The frequency distribution of the modal value is high not only in variables with economic significance, such as “patents”, but also for those variables measuring scientific outputs such as “conference assistance”, or “national articles”. The only variables with lower frequencies are “international articles” “theses submitted” and “personnel trained”, these two being the only ones with non-zero values.

These results show the high dispersion in the outputs of R&D Projects; the mean value can therefore be misleading. Thus, the diffusion of research results can be considered of importance since, on average, each project produces 6 international and 2 national articles. However, as has been stressed before, the most frequent value is zero. To better emphasise the heterogeneity of the research groups, the next graph depicts percentages of international publications and patents in relation to percentages of projects: 20% of the most productive projects generate around 55% of international publications. This result almost holds good for patents, the same projects being those with the highest rate of patent applications. This heterogeneity can be found in all outputs: the most productive 20% of projects generate, on average, 40% of outputs, and the least productive 20% generate hardly any output (just 3.5% on average).

Furthermore, the variable “international articles” fits an equation that resembles Lotka’s Law [44] on the distribution of scientific productivity. Other significant results are those referring to personnel training: each project generates 1.6 PhD theses and trains 3 people (these variables are the only ones with a modal value other than zero). However, the transfer of these personnel to the industry has been very low: only 1/3 of the non-PhD grant holders and 10% of PhD grant holders have been recruited by companies [45]. Clearly, it is not possible to blame the NATP for this low transfer of personnel, rather the industrial framework in which it develops. These indicators reflect, on the one hand, the low interrelation between the scientific community and the production system and, on the other, the low tendency of firms in the Food and Beverages Industry to hire research personnel. Summarising, the gap between personnel trained and personnel transferred to firms is an indicator that reflects the fact that the economic results of the NATP are not comparable to its scientific or training results and makes it evident that the objectives pursued by researchers -scientific publications and personnel training, which are closely related to each other- should be those used to evaluate their activity.

From the analysis of the types of results obtained by R&D Projects, HRG mostly think that they are mainly of a theoretical-practical character (81% of projects, Table 2). Only 2% consider the results to be of a theoretical character. However, more than half consider that, although the results are of a theoretical character, they are ready to be applied. This is supported by the fact that a patent has been granted. Finally, 35% of the cases are ready to be applied.

Table 2. Degree of Applicability of R&D Project results.

Type of Results	Nº of Projects	Ready for Application	Patent Applications	Patents Granted
Theoretical	7	4	3	--
Theoretical-Practical	276	80	45	5

Practical	20	17	4	--
Ready for Application	1	1	2	1
Not Determined	39	--	--	--
TOTAL	343	102	54	6

Source: CICYT and own elaboration from the information in 343 final reports on R&D Projects.

The differences in opinions on the types of results reflects the fact that, although there is some optimism among researchers, the necessary relationship between them and the firms that are able to apply those results does not exist. Both actors of the SAIS belong to different environments that seem to interact accidentally. To turn these sporadic contacts into regular ones requires a deep change in the actors' behaviour which, additionally, requires a much more professional management of the NATP and, above all, more financial and human resources.

4.2. Evaluation of the Articulation

The starting point for the analysis of the articulation is the participation of research groups and firms in PETRI Actions. Firstly, we have considered the Actions' *records* to check if there is any previous background of research carried out by the group and, secondly, we have checked whether this research has had any *continuity* with the collaboration of the firm in further research through Concerted Projects or bilateral contracts. We have monitored this possibility in the case of the Polytechnic University of Valencia. The *records* show that the number of financed PETRI Actions in the period is 56. This figure represents just 12.7% of the total of 441 R&D Projects. Only 31 (57%) of those Actions were carried out by HRG taking part in other R&D Projects of the NATP, 9 were carried out by HRG taking part in other programmes of the National R&D Plan, and 16 (almost 25%) by HRG who did not take part in other research activities financed by the National R&D Plan. Since the number of HRG in the NATP was 229, the percentage of HRG taking part in PETRI Actions was a poor 13.5%.

The declared degree of satisfaction by firms and PRIs is high. In the case of the PRIs, 82% of research groups have considered the Action positive and only 8% have considered it negative. Afterwards, it will be shown whether this initial high degree of satisfaction has its reflection in a subsequent continuity of the relationship between the PRI and the firm. With respect to the 25 firms that submitted their report, only 20 indicated the degree of satisfaction: 85% of the answers indicated that the satisfaction was high, 10% of answers were in the middle of the scale and only in one case was the degree of satisfaction low. This lower interest of firms is a consequence of the low interaction with the research group, as shown in Acosta and Modrego [11].

With respect to the *continuity* of the Actions, 71.8% of the PRIs and 80% of the firms declare the intention of maintaining the relationship established, and the most usual form in which this continuity is envisaged is a research contract (48.7% of cases for the PRIs and 48% for the firms) followed by a Concerted Project (12.8% of cases for the PRIs and 16% for the firms). Although initial optimism is shown regarding the continuity of the relationship, in a high percentage of cases (46% for the PRIs and 48% for the firms) it is indicated that the

transfer of results will not be possible in the short run. In this respect, we have not detected, after the PETRI Action, any research group having or maintaining the relationship with the firm through any Concerted Project. Hence, the continuity of the relationships through alternative tools of the National R&D Plan is very rare.

Focusing on this lack of continuity, the types of results have been analysed in relation to the following characteristics: technological level, protection awarded and economic value. The results are mostly the transfer of non-original scientific knowledge of interest to the firm, although they are not protected in any specific form. In 43% of cases it is considered unnecessary to protect the results for several reasons: the firm is not interested in protecting them, there exists a confidentiality agreement between the PRI and the firm, or the firm has considered it necessary to carry out more tests. Only in 18% of cases, has a patent been applied for. The remaining cases did not answer the question. The amount involved in the transfer of results did not exceed US\$ 10,000 in any case. From this analysis it is possible to conclude that the technological level of the results obtained with the PETRI Action is medium-low.

The case of the Polytechnic University of Valencia will be used to undertake an in-depth analysis of the articulation fostered by the NATP. To do so, information on the bilateral contracts relating to food technology signed by researchers and firms has been obtained. The aim is to find any trace of network generation supported by the bilateral contracts since, as it was previously said, researchers and firms tend to maintain an initial relationship through this type of agreement. Table 3 contains the information on both the activities financed by the NATP and the bilateral contracts carried out by the Food Technology Department of this university in the course of 11 years [46]. This department has carried out 21 actions of the NATP, including 15 R&D Projects. In addition, the university has signed 29 bilateral contracts fully financed by the firms, representing the relationships fostered.

Research carried out by the Food Technology Department at the Polytechnic University of Valencia*.

Professor	Spanish Competitive Research (National Programme of Agrifood Technology)													Total NATP	Contracted Research										Total Contracted Research	Main Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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* There are 35 professors and 5 scholars at the Food Technology Department. Those here included are the ones who undertake any competitive and contracted activity related to Food Technology.

Source: Own elaboration from the data provided by the CICYT and the TTC at the UPV.

There is not a high degree of professional interaction in this department. There are two groups around two lecturers (P6 and P7, Table 3) to whom two other lecturers (P4 and P10) have been associated. The other lecturers in the department do not come into contact either with these two groups or with each other.

Concerning articulation with the socio-economic environment, it is observed that those lecturers who do not come into contact with any of the others, generate sporadic and non-significant relationships. The analysis will focus on the two consolidated groups around the two above-mentioned lecturers [47] who represent and absorb 90% of activities carried out under the NATP and 75% of contracts. In one of these cases, a strong relationship can be observed with the Agrifood Industry Research Association (AINIA), which is a nationwide Technology Institute. The other group shows a strong interrelationship with a disperse socio-economic environment during the first years of the time frame. This changed when the Technology Transfer Centre (TTC) [48] of the Polytechnic University of Valencia was established to support and help lecturers with their relationships with firms. This support has meant the development of two PETRI Actions and one contract related to a specific topic between this group and one firm since 1996.

First, this fact reflects that it is necessary to obtain information on the bilateral contracts in addition to that on the activity financed by the NATP; second: the analysis has to focus on the research groups with a wide R&D activity (research groups generate knowledge, not technologies); and third: the university research groups have the possibility and the inherent tendency to establish relationships with the socio-economic environment, even if they still need special managerial support to undertake them systematically and to turn them into a system to boost their research activity. Otherwise, lecturers tend to react sporadically to the firms' calls. It is necessary to keep in mind that lecturers have a strong pressure of competing activities used to evaluate them: teaching and research.

4.3. The Role of the Managerial Structure

This paper encompasses the evaluation of the first two National R&D Plans. This is the first time that a Spanish administration has devoted significant amounts of money to the support of research activity in a systematic fashion [49]. Hence, the responsible management body (the General Secretariat of the National R&D Plan) tried to distribute the funds to those research groups with higher research capacity, according to an impartial and independent evaluation of the projects submitted. The evaluation consisted of two phases: first, applying peer evaluation methods to the scientific quality of the proposals submitted to the National Evaluation and Planning Agency, and second in the Committee of Experts, evaluating the suitability of proposals regarding Spanish agrifood context. The aim was the generation of a scientific community in each area.

Technical management of the Plans was given to the Secretariat of the National R&D Plan, which had only a small staff, temporarily transferred from the PRIs [50]. Therefore, the NATP was managed part time by just one prestigious researcher [51] in this area with a small administrative staff. Under these circumstances, regardless of the manager's capacity, the management of the Programme was passive, just trying to distribute the money assigned to this area fairly among the different proposals submitted by the research groups.

Different people, also with very few administrative staff, managed the PETRI Actions for all the programmes of the National R&D Plan in a different department of the General Secretariat. Hence these Actions, mainly arising from research groups, were managed in a passive way without any co-ordination with other programmes. Finally, the Centre for Technological and Industrial Development (CDTI), belonging to a different Ministry, managed the Concerted Projects. These projects emerged as a response to the demand of industry for scientific support from research groups. Summarising, the lack of co-ordination in the management of the three types of instruments has disabled the possibility of facilitating relationships among the System's actors.

Under these circumstances, this weak managerial structure can hardly improve and increase the scientific community in the food technology field and contribute to the consolidation of a number of research groups. However, the management carried out so far, has not applied different managerial methods to the heterogeneous scientific community, nor has sufficiently influenced in the relationship of research groups with other System's actors, boosting their scientific capacity to co-ordinately look for solutions to technological problems. In short, this managerial structure has offered very little stimulus to strengthening relationships among actors and has not fostered the articulation of the SAIS.

The experience acquired through these two National R&D Plans has to be helpful in changing the guidelines for the next plan as well as its management. Other objectives for new Plans must include one that addresses the growth of the number of research groups considering their internal and external articulation within the SAIS. With respect to management, the starting point for obtaining greater transfer of research results is the realisation of the difficulties and the complexity of relationships, which undoubtedly implies an active promotion of the relationships between the scientific community and industry. This implies better endowment and administration of human resources to offer better support to research groups and carry out the necessary tasks of co-ordination and promotion of articulation.

5. Conclusions

The indicators of scientific production and training have been very helpful in characterising the heterogeneity of the scientific community in the area of food technology. There is a presence of consolidated groups, which coexist with other emerging groups, some with a more or less scientific or technological orientation. Their degree of maturity largely depends on the centre where they carry out the activity and on their records. The use of mean values for outputs in evaluating scientific communities in the process of formation, as is usual, can lead to error. Thus, it seems necessary to use other statistical values according to each distribution.

The NATP has supported different research initiatives while allowing the growth of a small scientific community, very sensitive to scientific promotion criteria and showing very little articulation, not only with other actors of the Innovation System, but also and more worryingly, among the members of the community, both at national and regional level or even inside the research centre itself. Furthermore, the analysis of outputs

and proposals submitted show that a significant proportion of the research groups in this area cannot consolidate: a few groups (around 20%) generate 40% of outputs.

The indicators used to measure the economic effects of the Programme have smaller values than those of the scientific or training indicators, relationships having been found between the two types of indicators. All the tools analysed were designed and implemented to increase the economic effects of the NATP. The analysis of such tools demonstrates that they have not been as fruitful as expected, despite the initial satisfaction manifested by the researchers who have participated. On the other hand, the Programme shows an important gap between the applicability of the results according to the researchers and their actual application. This cannot be attributed only to an excess of researchers' optimism, but also to the fact that the NATP is aimed at an industrial sector mainly integrated by SMEs and multinational enterprises, and these types of firms undertake hardly any technological development activities in Spain.

In addition, it is not possible to measure articulation by merely monitoring the NATP tools; it is also necessary to use information on bilateral contracts, which is more difficult to obtain. Our experience at the Polytechnic University of Valencia, incorporating the analysis of contracts, has shown that around 10% to 20% of research groups sporadically collaborate with firms while the creation of a network and its further consolidation need to count on technical support and specialised management since, as has been said before, their interests are mainly scientific and firms in the food and beverages sector do not pay attention to technological aspects.

The NATP possesses suitable tools to reach its objectives but needs to undertake a profound change in its conception and management. This new conception must integrate articulation as part of its philosophy, and management must be professional and have greater human and financial resources. Only in this way, is it possible to focus on homogeneous groups of researchers, develop a more active management encouraging the efforts to co-ordinate research groups and create networks with the participation of different actors of the SAIS. This new style of management will need to co-ordinate effectively with other national or regional R&D programmes involving the participation of the Agrifood Innovation System and, particularly the production sector. In addition, there has to be real management support from the PRIs where researchers carry out their activity in order to bring continuity to the relationships already established with other actors of the SAIS. Firms also need to count on the support of Technology Institutes and other liaison structures closer to the firms in order to ease their access to innovations.

6. References and Notes

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37 R&D Projects are one of the tools used by the NATP to foster applied R&D projects among research groups of Public Research Institutions.

38 PETRI Actions (Stimulus Programme for Research Results Transfer) are another NATP tool used to partly subsidise projects of research groups in co-operation with firms. The aim is to foster the transfer of research results from those groups to the firms.

39 Concerted Projects are the third NATP tool analysed and are used to partly subsidise firms' large scale projects which are carried out in co-operation with Public Research Institutions.

40 The NATP structure and that of the National R&D Plans forces us to monitor these tools in such a way that it implicitly recalls the linear innovation model.

41 More detailed information on these results can be obtained in Fernández de Lucio,I., Jiménez,F., Azagra,J., Castro,E., and Gutiérrez,A. (1999) 'Una Primera Aproximación de la Contribución del Programa Nacional de Tecnología de Alimentos a la Articulación del Sistema Alimentario Español.' Conference Proceedings of ALTEC'99. Valencia, Spain.

42 The Spanish Administration has devoted a total amount of US\$ 400 million to subsidising the NATP, which represents 5.1% of the total budget of the two National R&D Plans in this period.

43 The analysis of distributions applied to these variables reveals that some of them follow a binomial distribution, some others a Chi square distribution and others have no clear distribution adjustment.

44 We have estimated the parameters of the functional form $f(x) = \frac{C}{x^b}$, the values being $C = 0.3574$ and $b = 1.4569$.

Lotka's Law is defined for values of parameters $C = 0.608$ and $b = 2$ for this functional form. Alfred Lotka analysed authors' productivity in the chemical area. Further information can be obtained in Lotka,A. (1926) 'The Frequency Distribution of Scientific Productivity.' Journal of the Washington Academy of Science, Vol.16, No.12, pp.317-323.

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46 The period of time considered for the analysis of this university is longer due to the long run effects of most of these activities.

47 In order to measure the constant and convergent articulation with the socio-economic environment, the existence of two or more contracts with a firm within the time frame has been considered.

48 The Technology Transfer Centre (TTC) at the Polytechnic University of Valencia is a liaison unit aimed at fostering relationships between this university's scientific community and others actors of the SIS.

49 Up to this point, university research groups have had very scarce public funds to carry out any research activity.

50 This transfer of personnel to the administration was already established in the Science Law (art. 7.2.c).

51 There have been three different managers of the NATP during the two National R&D Plans.