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**“INDUSTRIAL LOCATION.
A MULTIPLE CRITERIA APPROACH”**

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ABSTRACT

The aims of this paper are two-fold: to explain the nature and importance of factors that currently determine industrial firms' location strategy, and to determine the power of attraction exercised by various industrial estates and zones preferentially located within a geographical area on firms wishing to locate there. Firstly, this enables us to determine the extent to which the restructuring of the productive system has influenced traditional location trends in the last decade, along with the behavioural guidelines of different industrial areas. Secondly, it enables us to contrast the efficiency and validity of the prevailing incentivisation and town and country planning policies and tools.

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I) INTRODUCTION

In recent decades, the economic environment in which firms operate has undergone a considerable transformation, resulting in significant variations in its productive structure. These changes have occurred at such an accelerated rate that the models of strategic response to the competitive challenges of the immediate past are not a valid precedent for guiding future business.

Phenomena such as the persistent *rising trend of energy inputs*, a consequence of successive oil crises, have provoked a change in firms' strategic response model from one based on sources of plentiful and low-cost energy, to another based on limited and high-cost energy sources.

Or such as the *surprising technological advance* that has resulted, on the one hand, in the so-called "biogenetic revolution", based on research into the human genome with the promise of ground-breaking medical applications and, on the other, the professed "digital revolution", which enables the manufacture of intelligent robots and the application of new information technologies through the creation of intelligence chips.

Or the *process of productive restructuring*, which has been taking place in the most developed countries, resulting in the industrial sector losing importance in favour of the services sector.

Or the *privatization and progressive liberalization processes of regulated sectors*, which have pushed developed countries towards embarking upon substantial privatization programmes for public companies, so that they may benefit from the advantages of competition.

And, essentially, phenomena such as the current *globalization trend*, which is bringing about significant change in firms' production and spatial areas and in generating a new economic scenario that, in turn, is giving rise to a modification in firms' models of strategic response to competitive challenges, with the appearance of new factors and behavioural guidelines for industry when faced with decision-making concerning investment and location.

II) THEORETICAL BASIS OF DISCRETE MODELS OF MULTIPLE CRITERIA ANALYSIS.-

This paper begins with a thorough chronological review of the main theories and methodological approaches devised for industrial location. This has enabled us to show how new location models, based on the principle of satisfaction, are generally more convincing than classic mono-criteria methods, since they are based on the contingent idea of these decisions and facilitate the incorporation of different multiple factors, not only quantitative but also subjective and qualitative, for which multiple criteria analysis methodology provides highly rigorous solutions.

Studies undertaken in this regard, including contributions made by Auriolés and Pajuelo, 1988, and Cotorruelo and Vázquez, 1997, are generally based on a series of surveys where companies are requested to arrange the location factors considered in order of importance, with the performance of an ensuing merely descriptive analysis. Our research, however, has a much broader scope. Without excluding the descriptive review prior to the survey results, in an attempt to reveal the nature and importance of the factors that currently determine location strategy within the industrial organization of the Canary Islands, we also aim to formulate a discrete

model of multiple criteria analysis that will enable us to measure the degree of attraction for manufacturing firms exercised by the various industrial estates and areas within the archipelago.

In stating the theoretical fundamentals of multiple criteria programming, distinctions are made between continuous and discrete cases: by dealing with the necessary data homogenization process from alternative viewpoints, and by reviewing the different weighting methods of the factors intervening in this process. This culminates in the explanation of a good number of multidiscrete models, which include the six versions of the Electre method currently in existence, with versions I and III being the most suitable for attempting to model current locational processes and for reaching the objectives described above.

III) THE DATABASE AND ITS STRUCTURE

The main source of information for the database used in this research was the Register of Industrial Establishments of the Autonomous Community of the Canaries, which comprises a total of 5,331 industrial firms that were either created or transferred and/or extended their facilities between 1990-2000 (3,056 in the province of Las Palmas de Gran Canaria and 2,275 in Santa Cruz de Tenerife). This data was completed by using the details of a survey carried out on a representative sample within this group.

Data structuring was performed by considering the double criteria of differentiating between the different types of industry, according to the National Classification of Economic Activities 1993, and size, based on the number of employees.

The location criteria considered have been grouped into 7 homogenous categories of factors:

Transport Costs (F_1), referring to both resource supply and commercial distribution.

Cost of Premises (F_2), assessed by directly consulting firms in the sample about an estimated price per square metre of building, and by subsequently adding the data obtained from consulting real estate chiefs and managers of the various industrial estates, as well as from the Industrial Land Database of the Government of the Canaries.

Qualitative Factors (F_3), such as the level of competition and availability of infrastructure and productive resources appropriate to new technologies (skilled labour force, energy, supplies, etc), as well as additional services, such as finance and insurance, technical assistance and maintenance, security, management and recycling industrial waste, environmental impact and integration with the environment, etc.

Agglomeration Economies (F_4), understood to be *the advantages obtained by a production unit from locating to an area of high industrial density.*

Fiscal Pressure (F_5), determined by the tax regulations applied with greater or lesser intensity by the various Local Authorities to industries located within their borough, according to industry type and the category of the public area in question.

Location Incentives (F_6), monetary subsidies and land assignment at a below-market price, more permissive environmental legislation, and fewer bureaucratic hitches for location.

Subjective Values (F_7), such as awareness of company environment, local origins or proximity to the entrepreneur's home.

A total of 39 industrial areas (20 belonging to the province of S/C de Tenerife and 19 to Las Palmas) were assessed, by following each of these locational criteria or factors.

Table 1
Normalized assessment matrix.-

	F₁	F₂	F₃	F₄	F₅	F₆
Z₁	35,90	34,29	10,00	93,26	94,37	100,00
Z₂	11,54	28,57	13,33	92,23	68,31	50,00
Z₃	3,85	31,43	5,00	100,00	57,04	50,00
Z₄	6,41	14,29	13,33	64,25	57,04	50,00
Z₅	1,28	37,14	1,67	97,93	57,04	50,00
Z₆	10,26	11,43	23,33	82,90	10,56	50,00
Z₇	41,03	85,71	10,00	45,60	26,06	50,00
Z₈	84,62	42,86	43,33	44,56	13,38	50,00
Z₉	80,77	8,57	6,67	36,27	30,99	50,00
Z₁₀	64,10	37,14	16,67	20,73	66,20	100,00
Z₁₁	100,00	25,71	23,33	41,45	21,13	50,00
Z₁₂	7,69	8,57	33,33	9,33	47,18	0,00
Z₁₃	32,05	28,57	18,33	1,04	31,69	25,00
Z₁₄	48,72	28,57	10,00	2,07	15,49	25,00
Z₁₅	74,36	5,71	25,00	0,00	0,00	25,00
Z₁₆	98,72	14,29	48,33	0,00	30,99	25,00
Z₁₇	32,05	25,71	11,67	1,04	71,83	25,00
Z₁₈	25,64	11,43	100,00	11,40	23,24	25,00
Z₁₉	19,23	2,86	95,00	1,04	16,20	25,00
Z₂₀	17,95	0,00	53,33	62,18	2,82	25,00
Z₂₁	32,05	37,14	6,67	29,02	18,31	100,00
Z₂₂	6,41	42,86	0,00	58,03	20,42	50,00
Z₂₃	12,82	54,29	0,00	98,45	20,42	50,00
Z₂₄	15,38	31,43	3,33	34,20	20,42	50,00
Z₂₅	0,00	100,00	0,00	82,90	20,42	50,00
Z₂₆	12,82	35,71	0,00	18,65	20,42	50,00
Z₂₇	25,64	24,29	10,00	98,45	100,00	50,00
Z₂₈	32,05	22,86	1,67	51,81	100,00	50,00
Z₂₉	29,49	24,29	6,67	88,08	100,00	50,00
Z₃₀	30,77	14,29	13,33	70,47	100,00	50,00
Z₃₁	29,49	20,00	0,00	69,43	100,00	50,00
Z₃₂	0,00	34,29	0,00	66,32	33,10	0,00
Z₃₃	23,08	25,71	26,67	10,36	28,17	25,00
Z₃₄	24,36	8,57	20,00	0,00	25,35	0,00
Z₃₅	42,31	14,29	53,33	5,18	15,49	25,00
Z₃₆	19,23	17,14	35,00	9,33	19,72	25,00
Z₃₇	69,23	5,71	38,33	6,22	30,28	25,00
Z₃₈	23,08	28,57	81,67	9,33	21,83	25,00
Z₃₉	5,13	31,43	45,00	23,83	73,94	25,00

For this purpose, we have distinguished between areas classified as industrial estates or preferential areas for industrial location, and others that have traditionally welcomed a large number of manufacturing firms, despite not being catalogued as land for industrial use.

The results are shown in the assessment matrix (table nº 1), and, for the purposes of the ELECTRE methodology, it was necessary to normalize them, in order to rate the units of measurement and sizing.

IV) RESULTS ANALYSIS AND CONCLUSIONS

When analysing the results obtained, we have focussed on three aspects which are fundamental to this type of decision.

Firstly, this process is analysed from a descriptive viewpoint, using the results obtained in the survey. This enables us to characterize basic conduct where these decisions are concerned, their scope and strategic impact, in addition to the economic rationality implicit in them.

Secondly, a study is performed on the hierarchy of the location factors considered, which facilitates an assessment of their significance or importance in relation to the different segments in the sample.

And thirdly, a multiple criteria analysis of the power of attraction of the industrial areas considered is undertaken, as well as a diagnosis of the factors or elements that most affected the final classification.

Finally, a review is made of the main conclusions extracted from the analysis performed, while attempting to explain the most significant implications for policies of

industrial development in the Canary Islands that may derive from the results obtained.

As for the conduct of industrial location within the environment analysed, we can say that it adapts to several somewhat complex behavioural patterns, which are changeable in nature or variable in time, given that the locational factors that make up these models do not go unchanged either. On the contrary, as a result of the movements of economic globalization, firms are forced to pursue new markets, seeking alliances that enable them to mitigate intensified competitor pressure and to permanently review the location of their facilities if they want to maintain or increase their competitive position.

In other words, industrial location is not a static problem that merely affects the initial search for a plant site. It influences all the processes subsequent to relocation, expansion or decentralization with the establishment of subsidiary plants, either at the initial or at a different site.

Moreover, the evolution of economic and technological systems means that the weighting assigned by each industrial typology to the location factors examined for the first establishment will vary in time.

For the purposes of hierarchical factor analysis, location factors have been structured into three different categories according to their decisional potential:

- *Decisive (or determining) factors*: the most decisive factors for company location, expressed by the number of times a factor obtains a first or second place in the classification of the seven factors per industry polled.
- *Influencing (or incidental) factors*: to a certain extent able to influence the decision of location and expressed in terms of frequency, or number of times that a factor appears in third, fourth and fifth place.

- *Factors with little influence (or irrelevant)*: when classified as last or next to last, expressed by the number of times a factor figures last or next to last.

Based on this classification, an analysis has been made of the importance of location factors in accordance with two criteria: the *type of industrial activity* of each of the firms polled, and the *size* of these firms, according to the number of employees.

Thus, based on these premises, and bearing in mind the results obtained, we can consider factors 1 and 3 as *decisive*, since, generally speaking, all the firms consider transport costs (F_1) or qualitative factors (F_3) to be the first and/or second most important.

Likewise, we observe how location incentives (F_6) and subjective values (F_7) are relegated to the final positions of ranking in most typologies, which leads us to consider them as *low influential factors*.

As for the intermediate positions in the ranking, we might consider Cost of Premises (F_2), Agglomeration Economies (F_4) and Fiscal Pressure (F_5), as *influential*.

The Transport Cost (F_2) factor continues to bear ample weight on the decision for site location, despite a large time lapse since Weber considered it. Indeed, generally speaking, this factor, along with proximity to current and future markets and availability of resources and supply (F_3), carries most weight when deciding on a specific area, irrespective of size and type of activity.

Moreover, the lack of importance attributed by industrial entrepreneurs to Location Incentives (F_6) leads us to conclude that, if political powers aim to restructure industrial geography and achieve some influence on entrepreneurs' decision-making concerning site choice, it would be advisable to point these political actions in another direction, such as fiscal pressure from local authorities as

mentioned in factor 5. This factor is highly assessed by entrepreneurs, since it generally falls in third or fourth place in order of importance, and in some specific cases, reaches an even higher position in the ranking.

Other possible lines of action could include, on the one hand, an improvement in infrastructure and supply in industrial areas, since this is a component of the Qualitative Factors (F_3) much appreciated by the entrepreneurs interviewed. On the other hand, despite not figuring in the first positions in the ranking, Cost of Premises (F_3) does appear in the last places and, in certain specific cases, is found in a primary position. Hence, this could be another line of action and, by reducing the cost of land and building per square metre, might influence these decisions.

As for the analysis of the power of attraction of each of the industrial areas considered, we can report that, while in mainland Spain 60% of the new industrial centres with over 10 employees (between 1987-1992) are located in average-size cities and rural areas, the picture is somewhat different in the Canaries. Although the preferentially located industrial areas and estates established in the metropolitan areas of the main islands (Tenerife and Gran Canaria) still hold first place in location preferences (53.3% of all companies polled), these are reduced in favour of industrial areas and estates situated away from the capital city and average-size urban districts in prominently rural or tourism areas (preferred by 46.1% of all the industries consulted).

These results show us that the twelve zones included in the metropolitan boroughs of both provinces (Z_2, Z_3, Z_4, Z_5, Z_6 y Z_{12} for Tenerife and $Z_{22}, Z_{23}, Z_{24}, Z_{25}, Z_{26}$ y Z_{32} for Las Palmas de Gran Canaria) currently maintain their power of attraction, sharing the nucleus of version I of the model (for a level of total concordance and null

discordance) with another eleven zones situated in smaller centres of population in rural and tourism surroundings.

The results obtained from applying the Electre III model to the industrial areas of the two island capitals show that Z_3 and Z_6 (metropolitan area of Santa Cruz de Tenerife), respectively, have the most power of attraction, followed in third, fourth and fifth place in the average classification, by Z_{25} , Z_{22} , and Z_{32} , correlatively, which in turn are integrated into the metropolitan area of Las Palmas. The remaining areas situated away from the provincial capitals appear in seventh place and beyond, in the final classification. This simply confirms the results obtained in the first version of the model undertaken.

To sum up, a final mention of some of the main conclusions reached:

- First of all, we can deduce that, though the classic location factors, such as *Cost of transport*, supply and commercial distribution, or *Agglomeration Economies* influence decisions concerning industrial location, they nevertheless lose importance in favour of other factors based on the modern location theory, such as qualitative or intangible aspects of a strategic nature.
- Regulation and incentives, such as subsidies (for innovation, creation of employment, quality, exports, etc), land assignation, the existence of more permissive environmental legislation, the level of local authority bureaucratization and so on, are factors to be taken into account though to a lesser extent than the former.
- The subjective factors and personal preferences of the entrepreneur, such as the local origins of the firm, relations with suppliers and banks and knowledge of the environment influence decisions about location, although they become more relevant as the size of the productive unit decreases.

- Though the metropolitan belts of the island capitals *continue maintaining the most power of attraction* regarding location preferences for the Canary Island industrial sector, *this ability to attract gradually diminishes in favour of average population centres in rural and tourism surroundings*. This fully coincides with the process observed in principal studies undertaken on a national scale, though *with a slight delay in this region*.

This has altered the classic territorial model and has favoured a progressive flourishing of new multiple hierarchical territorial models, which remove locational predominance from capital city belts and metropolitan centres to the benefit of average-size towns, with smaller populations in a rural and tourism environment.

In this general context of productive restructuring of developed economies, the corporate organisation of the archipelago of the Canaries is affected by the simultaneous action of two different models for industrialization: the former "*concentration models*", which have distinguished the entire industrialization process of the last century and currently prevail; and the appearance of new emerging ways of industrial organization, deriving from so-called "*diffuse models of flexible specialisation*", which favour the creation of new industrial location zones in non-metropolitan areas.

V - BIBLIOGRAPHY

Auriolos, J. y A. Pajuelo (1988), “Factores determinantes de la localización industrial en España”. *Papeles de Economía Española* nº 35, pp. 188-207.

Barba-Romero, S. y J. C. Pomerol (1997). “Decisiones Multicriterio. Fundamentos Teóricos y Utilización Práctica”. Servicio de Publicaciones Universidad de Alcalá. Madrid.

Bustos, M.L. (1993) “Las teorías de Localización Industrial: una breve aproximación”. *Estudios Regionales* nº 35, pp. 51-76.

Consejería de Industria y Comercio del Gobierno de Canarias (1996), “Plan de Desarrollo Industrial de Canarias 1996-2000”. *Canarias Industria, Tecnología y Comercio*, año I, nº 1, pp. 17-24

Costa Campí, M. T. (1997), “Factores de la localización empresarial”. *Grandes Cuestiones de la Economía* nº 15. Fundación Argentaria.

Cotorruelo, R. y Vázquez, A. (1997), “Nuevas pautas de localización de las empresas industriales y de servicios a las empresas en España”; en A. Vázquez Barquero; G. Garofoli y J. P. Gilly. “Gran Empresa y Desarrollo Económico”. Síntesis-Fundación Duques de Soria. Madrid, pp. 171-214.

Galán Zazo, J. I. y otros (1988), “Factores determinantes de las decisiones de localización en España”. *Economía Industrial* nº 320, pp. 151-164.

Maystre, L. Y., J. Pictet y J. Simos (1994), “Méthodes multicritères ELECTRE. Description, conseils et cas d’application à la gestion environnementale”. Presses polytechniques et universitaires romandes. Lausanne, Suiza.

Precedo, A. y M. Villarino (1992) “La localización industrial”. Editorial Síntesis, Madrid.

Ravelo, T., M. C. Moreno, R. J. Díaz y J. T. Pastor (1997), “Definición de un modelo de atracción para la determinación de la localización industrial en la Isla de Tenerife”. *VII Congreso Nacional de ACEDE*. Ponencias y Comunicaciones, vol. II, pp. 83-103.

Ravelo, T. y M. C. Moreno, (2001), “Las decisiones de localización industrial en Canarias: un análisis descriptivo”. Comunicación presentada en el *III Seminario de Economía Canaria*. Universidad de La Laguna.

Ríos, S. M.J. Ríos-Insúa y S. Ríos-Insúa, (1989), “Procesos de Decisión Multicriterio”. Eudema.

Romero, C. (1993), “Teoría de la decisión multicriterio: Conceptos, técnicas y aplicaciones”. Alianza Universidad Textos. Madrid.

Roy, B. (1968), “Classement et choix en présence de points de vue multiples, la méthode ELECTRE”, *R.I.R.O.*, vol 2, nº 8, pp.57-75.

Roy, B. (1985), “Méthodologie Multicritère d’Aide à la Décision”. Economica. París.

Roy, B. y Ph.Vincke (1981) “Multicriteria Analysis : survey and new directions” *European Journal Operational Research* 8, pp. 207-218.

Schärlig, A. (1990), “Décider sur plusieurs critères. Panorama de l’aide à la décision multicritère”. Collection Diriger l’entreprise 1, Presses polytechniques et universitaires romandes. Lausanne, Suiza.

Scheifler, M.A. (1993), “Nuevas tendencias en la teoría y práctica de la localización”. *Economía Industrial*, enero-febrero, pp. 163-170.

Smith, D. (1971), “Industrial Location”. John Willey and Sons, Inc.

Townroe, P.M. (1972), “Some behavioural considerations in the industrial location decision”. *Regional Studies*, número 6, pp. 261-272.

Yoon, K. (1980). “Systems Selection by Múltiple Attribute Decisión Making”. UMI.