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Industrial characteristics, production milieu and regional innovation: A comparison of Israel and German industrial plants

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European Regional Science Association
38th European Congress
Vienna, Austria
28 August - 1 September 1998

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**Firm Characteristics, Location and Regional Innovation:
A Comparison Between Israeli and German Industrial Firms**

ABSTRACT

In recent years, we have been witnessing a growing number of researchers whose objective is to gain a better understanding of the variation in the rate of spatial innovation of different industrial plants. Several studies have investigated the similarity and dissimilarity of spatial innovation between countries. This study reports the results of a large study carried out jointly by a team of researchers from Germany and Israel. In Germany, the study focused on the State of Baden Württemberg, and in Israel on the Northern District. Altogether in both countries, more than 400 industrial plants, belonging to the fastest-growing industrial branches (Electronics, Metals and Plastics) were included in the study.

The use of simple statistical models, augmented by multi-variable Logit Models, enabled us to point out the similarity and dissimilarity in spatial innovation patterns between the two countries. The results further support the hypothesis that expenditure on R&D is a good surrogate for the probability of the firm to innovate, regardless of the industrial branch to which the plant belongs.

In general, we can conclude that there exists a strong similarity in the frequency of industrial innovation in both countries; i.e., the rate of innovation in their hi-tech industries is significantly higher than in their traditional industries. On the other hand, the pattern of spatial variations in the rate of innovation in Israel is much more pronounced and visible compared to Germany.

Key words: sSpatial innovations, fastest growing-industries, industrial innovation in Germany, industrial innovation in Israel.

1. Introduction

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In recent years there has been an increase in the number of empirical studies attesting to inter-regional variations in the rate of innovation, both within and between countries. International comparisons of the regional behavior of industrial plants, and the innovation processes characterizing them, are becoming increasingly important following world economic globalization and the transformation of the world into 'one small village' (Alderman and Fisher, 1992; Suarez-Villa and Fisher, 1995; Suarez-Villa and P-H Han, 1990, 1991; Suarez-Villa and Katlsson, 1996; Suarez-Villa and Rame, 1996; Nelson, 1993; Kleinknecht, 1996; Roper et.al, 1996). The international comparison is particularly interesting in this study since it compares the rate of innovation in a country with an established industrial innovation with a country that only recently gain the innovation game, particularly in the hi-tech industries.

This paper is the result of a study carried out jointly by an Israeli team from the S. Neaman Institute for Advanced Research in Science and Technology, at the Technion, and a German team from the Fraunhofer Institute for Systems and Innovation Research in Karlsruhe, Germany. The research is supported financially by the German-Israel Fund (GIF) for the sciences. The paper presents the results of a comparative analysis of empirical data gathered from both Israel and Germany. It enables examination of the inter and intra-regional variations of innovation occurring in these countries, as well as the differences and similarities in the factors influencing the creation of innovation, from the inter-regional and international perspectives. The analysis was based on data collected recently during field surveys conducted simultaneously by the research teams in both countries. In this paper we focus on product innovation as distinct from process innovation*.

2. The National and Regional Aspects of Innovation

The contribution of innovation to regional development is extensively reported in the literature which discuss economic growth and development, pointing out the significant role played by innovation in fostering regional economic growth (Suarez-Villa, 1993; Freeman et al. 1982; Nelson and Winter, 1982; Feldman and Kutay, 1997; Davelaar and Nijkamp, 1997; Schmookler, 1966; Rosenberg, 1972).

Development of a region as an incubator for innovations is generally accompanied by the appearance of new economic activity, market expansion, and new technological applications. Such regions become a preferred destination for highly skilled labor, by

* For more on that aspect, see Frenkel, 1997

attracting them to migrate from other areas. These conditions promote development and in-migration of major corporate head-offices which subsequently impact the region's educational infrastructure and auxiliary services (Suarez-Villa, 1993). Innovation provides an infrastructure for the development of new firms by increasing market share, improving the competitive edge and inducing economic growth. The assumption therefore follows that regions characterized by a high rate of innovation will enjoy greater economic growth by comparison with other areas. (Grossman and Helpman, 1990, 1991, 1994; Krugman, 1979, 1991, 1995; Stokey, 1995). There is now strong evidence of the positive effect of innovation on the performance of individual business (Geroski and Machim, 1992; Kleinknecht, 1996).

The burgeoning interest in the regional perspective of innovative activity is based on the recognition of the close link between economic efficiency, competition and innovation (Romer 1990, 1994; Bertuglia et al., 1995; Nijkamp and Poot, 1997; Bertuglia et al. 1997). This recognition led to a new regional policy designed to promote adopting and creating new technologies in existing plants, while at the same time encouraging the establishment of new hi-tech firms (Feldman, 1994).

Studies focusing on the analysis of the path followed by new firms along the time-space dimensions conclude that this path generally commences in the metropolitan areas, which serve as urban incubation sites for the emergence of innovative firms (Davelaar and Nijkamp, 1988; Hoover and Vernon, 1959). Empirical studies tended to support the assumption that companies located in large metropolitan areas have a significant advantage (Thwaites, 1982; Camagni, 1984; Fischer, 1989). The conditions offered by this concentration of economic activities, which contain head-offices of large hi-tech companies, R&D facilities, information centers, etc., favor the generation of innovations. By contrast, peripheral regions are often characterized by a lower innovation capability (Fischer, 1989; Sweeney, 1987; Frenkel, 1997).

Concomitantly, there were reports of studies arriving at precisely the opposite conclusions. For example, a study carried out in Holland presented surprising results with respect to the regional innovation potential of small and new firms (Davelaar, 1991). These results indicated the poor innovation potential of firms located in the Amsterdam and Rotterdam metropolitan regions.

The study demonstrated that, in comparison to the central regions, Holland's more peripheral areas were found to be more promising from the perspective of attracting innovative firms. These findings, which are particularly valid for the Amsterdam metropolitan area, were accepted with a degree of reservation, since the study sample included only small industrial firms. It may thus be assumed that, as indicated in most

other studies, metropolitan areas are better suited for large industrial plants and business services (Davelaar and Nijkamp, 1989, 1992).

A regional analysis of the innovation activities in the USA focused on the variations between different states (Feldman, 1994). The research results highlighted the link between regional technological infrastructure, and the rate of innovation characteristic of the region. The study identified four variables that indicate the existence of a high rate of regional innovation: basic research carried out in universities, industrial R&D, concentration of firms, and concentration of business services. The positive impact of university research activities on the scope of innovation in a region is also supported by results obtained in other studies (Jaffe, 1989; Mansfield, 1991). A concentration of firms also attests to innovation activity in a region, by indicating that the technological progress gained during manufacturing processes, leads to an increase in innovation outputs. This conclusion supports the hypothesis that 'learning by doing' constitutes a significant input for the innovation process.

As has been shown by numerous studies, R&D activities are considered to be the most influential factor in a firm's ability to develop innovation (Roper, 1996; Frenkel, 1997; Thwaites et al., 1981; Dosi, 1988; Roseberg, 1985; Nelson, 1986). Various studies have indicated that R&D efforts tend to be concentrated in the larger urban areas (Malecki, 1979). However, a study conducted in the south-east of U.K. showed large concentration of R&D employment in small, rather than large, urban areas (Howells, 1984).

An international comparison of the regional distribution of R&D activity in the USA - the San Francisco Bay area, including the Silicon Valley, and the U.K - Eastern England and Scotland, showed a significant concentration of this activity in the San Francisco Bay area, compared with relatively limited activity in Scotland (Oakey, 1984). However, from the outcome of the study, it was apparent that Scotland did not demonstrate the characteristics of a development area. The study concluded that the peripheral region also contains small independent firms that develop and generate innovation.

In Holland, in-house R&D efforts, as well as outsourced R&D services, were found to play a significant role in the generation of both product and process innovation (Davelaar, 1991). The importance of R&D in generating product innovation is also linked to location. R&D plays a more important role in creating innovation in the central, rather than the peripheral regions. The intermediate regions function as if positioned between the central and peripheral regions. These results demonstrate the leading role of the metropolitan region in this context. However, in the later stages, with regional diffusion of innovation, the emphasis turns to the improvements in manufacturing production, i.e. process innovation. Similar findings were also obtained in another empirical study recently conducted in Israel (Shefer and Frenkel, 1998).

The empirical results obtained from the various studies indicate that innovation activity is not limited solely to metropolitan or central regions. It is apparent that different regions play unique and separate roles in the innovation processes. This is apparent in the spatial diffusion of new products and production processes. Therefore, the ability of the various regions to function in the long term is dependent on the interrelationships existing between them, while complementing rather than competing with each other. On the one hand, metropolitan areas provide the medium required to launch new industrial activities requiring more advanced technological systems. On the other hand, in the subsequent stage these technologies are transferred to other regions outside the metropolitan area. Due to the high cost of land, metropolitan areas are the preferred location for industries featuring recently developed technologies, which can yield a high added value. By contrast, regions, which are outside the influence of metropolitan areas, are generally unable to provide conditions necessary for the early life cycle stages of technologies and firms (Malecki and Nijkamp, 1988). It should however be noted that a policy based on a uniform distribution of industries in space, is liable to hinder and disrupt spatial specialization and thus efficiency. The objectives of such a policy may even counteract the potential of some areas to grow in the long term. Furthermore, such a policy is even liable to contradict existing location preferences, thus adversely affecting regional economic growth (Frenkel, 1997).

3. The Framework of the Study

3.1 Inter-Regional Comparison

The data collected in Germany and Israel on the structure of regional innovation was concerned with industrial firms, in a selected number of fast growing industrial branches (for more details on the methodology of fast-growing industry see: Shefer et al., 1998). These included the following three major branches of industry: electronics (including optics and precise instruments), plastics and metal products.

Identification of the fast growing industries was based on the analysis of the rate of growth in output, employment and export in each of the industrial branches. Industrial rates of growth serve as an indicator for defining the regional economic-employment potential. The assumption is that firms belonging to the fast growing industrial branches have a significant growth potential, and their impact on the region's economy will therefore be greater than that of firms belonging to the declining industrial branches. Industries demonstrating significant export potential - in which the export component comprises a significant proportion of the branch's output - are more likely to grow compared to industries which rely mainly on local markets (Shefer et al., 1998).

The data was collected via field surveys conducted simultaneously in both countries, from a carefully selected sample of firms. In order to conduct the survey, questionnaires were constructed for gathering the data on the firm's level. Data concerning innovation activity, as well as information concerning firm's characteristics such as: ownership type, size, age, R&D activities, etc., was included in the questionnaires

In Israel, personal interviews were held with senior managers in each of the firms included in the sample. In total, 211 industrial firms, from the three selected industrial branches, were personally interviewed. This sample comprised approximately 72% of the firms in the surveyed region, associated with these three industrial branches. In Germany, questionnaires were mailed to approximately 2,800 plants located in the research region - the federal state of Baden Württemberg. 482 plants returned the questionnaires with the requested information, of which 220 came from the three fast growing industrial branches that had been selected.

The fundamental research question is linked to the spatial rate of innovations by the industrial firms in the various sub-regions. For this reason, regions of different types were selected to be included in the study. The two research regions chosen, in the two countries, each encompass three types of sub-regions: metropolitan area, intermediate zone and peripheral zone.

In Israel the Northern part of the country was selected for the analysis. The Northern region is one of the most fascinating regions in Israel in terms of the composition of its residents (Jews and non-Jews, veteran settlers as well as new immigrants), its settlements (type and pattern), and its landscape. In 1995, some 1.4M people, constituting about 26% of the population of Israel, resided in the region, which extends 5,000 sq. km., or 23% of the total land area of the state.

The northern region of Israel was divided into three sub-regions: 1) Haifa Metropolitan Area (central zone). 2) central Galilee (intermediate zone) the areas that surround the Core zones, on the fringe of the metropolitan area, and are within acceptable commuting distance. Although this zone was considered until not too long ago, peripheral, the recent tide of population expansion in the Core zone 'spilled over' into the surrounding areas, bringing about a change in their rate of growth and regional functionality. The northern intermediate region contain the central and west Galilee. 3) Eastern Galilee (peripheral zone) an area that removed from the metropolitan influence, and is not within acceptable commuting distance. It exhibits most of the classical characteristics of a Peripheral zone, including fewer employment opportunities, as well as fewer social and commercial services. This area consists the Golan Heights, Eastern Galilee and all along the Jordan Valley, from Metula and Kiryat Shamona in the north to B'iet Sh'ean in the south-east (see Map 1a).

In Germany the investigated areas are part of the federal state of Baden-Württemberg. Baden-Württemberg is one of the industrial regions in Germany. It is characterized by a broad, medium-sized industrial structure and by large internationally operating companies like Daimler-Benz, Porsche and Bosch. Major branches are machinery, electrical and electronic equipment, transport equipment, and metal products. The "Mittelstand" of Baden-Württemberg is seen as the important economical success-factor of this federal state, also named as "model region" (Cooke et al. 1993). Baden-Württemberg consists of 12 planning regions whereas three of them were selected for the analysis (see Map 1b). In 1995 the three planning regions investigated contained 2.4M people, constituting about 23% of the population of Baden-Württemberg. These planning regions represent the 3 types of sub-regions analyzed in the study: 1) Karlsruhe metropolitan area - "Mittlerer Oberrhein" (central area), 2) Südlicher Oberrhein - Freiburg area (intermediate zone), and 3) Schwarzwald-Baar-Heuberg („peripheral area“).

Table 1 depicts comparative on the research region in the two countries. The data shows that the population in the research area in Germany is 1.7 times larger than that in Israel. However, the relative share of the population in each of the three types of sub-regions is similar in both countries. By contrast, the overall distribution of the employed population differs significantly in the two countries. The data indicates that the Haifa metropolitan area in Israel provides a larger percentage of employment opportunities than does the region of Karlsruhe, its German counterpart. In Israel, the percentage of employees drops sharply and significantly when moving out of the metropolitan area towards the intermediate zone, and from there on to the peripheral area; by comparison, Germany has a more equitable distribution of employment among the sub-areas. In Israel, a more equitable distribution of employment can be seen in the manufacturing industries (see Table 1). This is due to the fact that in recent years the intermediate zone in Israel has been undergoing a transformation, attracting new industrial plants. This trend is reflected in the high proportion of young firms, which have been set up in this sub-region. This phenomenon is linked to the availability of land for the development and expansion of firms, the development of needed infrastructures road and communications systems, and the relative proximity to a large pool of highly skilled labor residing on the outskirts of the

Map 1: Major Arial Division

1a: Northern Region in Israel

1b: State of Baden-Württemberg

metropolitan area. In Germany the distribution of manufacturing employment in the three sub-regions is similar to the distribution in Israel, with the exception of the peripheral zone of Baden Württemberg, wherein a larger percentage of manufacturing employees can be found by comparison with its counterpart in Israel. This imitates that the peripheral zone in Germany is not a pure peripheral area as is the case in Israel. In Israel, the peripheral area is hermetically sealed to the neighboring countries, whereas the peripheral area of Baden Württemberg is located next to one of Western Europe's major traffic junctions, near Basle, in proximity to the open common border between Germany, Switzerland and France.

Table 1: Distribution of Population and Employment Between Sub-Regions in Israel and Germany 1995*

% of Manufacturing Employees	% of Employees ¹	Population size		Country	Type of Zone
		%	number		
46.3	62.3	40.0	575.3	Israel	Metropolitan Area
39.1	42.1	39.8	952.6	Germany	
40.5	26.8	43.7	628.4	Israel	Intermediate Zone
34.9	38.4	40.3	963.8	Germany	
13.3	10.9	16.3	235	Israel	Peripheral Zone
26.0	19.5	19.9	474.4	Germany	
100.0	100.0	100.0	1,438.7	Israel	Total
100.0	100.0	100.0	2,390.8	Germany	

Sources: for Israel - Statistical Abstract of Israel 1995, for Germany - BfLR 1996; Statistics Landesamt Baden-Wuerttemberg 1995.

1. The Israeli data is an estimation based on analysis from the C.B.S manpower survey of urban settlements with more than 10,000 residents (it consists of more than 70% of the whole employees in the area).

Table 2 depicts the distribution of industrial firms in the two samples, according to sub-region and industrial branch. The data indicates that, in addition to the variations in the overall distribution of the industrial firms in Germany and Israel, there are also differences in the sectoral distribution of the industries located in the study areas. The electronics industries predominate the sample in Israel's Haifa metropolitan area (54.4%). In Germany, on the other hand the metal industry dominates the Karlsruhe metropolitan area (40.7%). In both countries the electronics industry dominates the intermediate zones (41.5% in Israel and 56.7% in Germany). Israel's peripheral zone is distinguished by the predominance of the plastics industry (57.1%); this phenomenon is linked to the concentration of kibbutzim in the peripheral area and to the high prevalence of plastics

firms in the kibbutz industry. The industry in the peripheral region of Germany's Baden Württemberg State has a polarized branch structure. The plastics industry is significantly limited in this region (only 7.5%) being dominated primarily by the metal industry (50.0%) which is closely followed by the electronics industry (42.5%). It can be assumed that the spatial variations in the regional distribution of these industrial plants in the two countries are likely to impact the rate of regional innovation of each sub-region by type.

Table 2: Distribution of Firms by Industrial Branch, Country and Location (in %)

Industry Type	Countries		Regions					
	Israel	Germany	Metropolitan		Intermediate		Periphery	
			Israel	Germany	Israel	Germany	Israel	Germany
Electronics	40.8	44.5	54.4	35.2	41.5	56.7	25.4	42.5
Plastics	37.9	12.7	22.7	24.1	35.4	11.7	57.1	7.5
Metals	21.3	42.7	22.7	40.7	23.2	31.7	17.5	50.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
N	211	220	66	54	82	60	63	106

4. Innovation Pattern

Many studies distinguish between product innovation and process innovation. As time passes, it becomes increasingly difficult and expensive to innovate and substantially improve new products and services. When this time is reached, innovation efforts are directed more towards improving production techniques, i.e., process innovation (Dosi, 1984; Davelaar, 1991). A low regional economic capacity, while constituting a constraint on the innovation of new products, still allows for the diffusion of production processes (Alderman, 1990). Firms adopt process innovation by purchasing it in the marketplace, similar to the purchase of other production inputs. By contrast, product innovation is protected, both structurally and conceptually, since it is a vehicle of gaining superiority of the firm over its competitors.

In this study we defined innovative firms as those firms that have created innovation during the past three years. Included in this definition are activities leading to the development of new products, the adoption of products, which are new to the market, and the substantial improvement of existing products (development of the next generation of products). These activities emanate from in-house investments in R&D, or the purchase of know-how through outsourced R&D services. Firms that dealt exclusively with developing or adopting innovative processes, or with adopting new products not requiring R&D investment, were not classified as innovative firms.

The regional variation of the innovation pattern in Germany and Israel is reflected in the frequency of innovation among the firms located in each of the defined sub-regions. Analysis of the two samples demonstrated the different locational patterns of firms with respect to innovation, considering their industrial branches. The results suggest that it

would be appropriate to examine the impact of the industrial branch on the rate of regional innovation, while categorizing firms into two basic industrial groups on the basis of technological character. The first group represents the hi-tech industries, and it includes the electronics industry, electro-optics, optics, and precision instruments. The second group represents the more traditional industries, and it includes the plastics and metal products industrial branches.

The reasons for this division is also connected to the fact that the number of plants affiliated to the metal products industry in the Israeli sample, and the number of plants affiliated to the plastics industry in the German sample, are relatively small. The similarity in behavior among the traditional industrial branches (plastics and metal products) on the one hand, and the difference between these industries and the hi-tech industries on the other hand, both lend justification to this grouping. Furthermore, numerous variations have been found in the innovative properties characterizing these two industrial groups. This divergence is reflected in the high expenditure on R&D made by the high-tech industries compared with those made by the traditional industries. Table 3 depicts the results of the statistical analyses concerning several selected variables measuring the extent of R&D activities in the firms. The results show that a significant difference exists among the different industrial branches. When a similar analyses has conducted but only between the plastics and metal products – no statistical difference was observed. It is for this reason that we decided to stratify the industries into two major groups – the hi-tech, which includes the electronic industry, and the traditional group which includes the plastics and metals industrial branches.

Innovation development is a prerequisite activity for hi-tech firms. These firms must therefore invest in R&D, including basic research, and are obliged to engage highly skilled labor in order to handle the complex technological problems. By contrast, for the firms in the traditional industries innovation are not as essential, and are chiefly linked to process innovation, aimed at improving and/or adopting new products.

The distribution of innovative firms, when categorized into the two aforementioned industrial groups, demonstrates a strong similarity between the two countries, both in the prevalence of innovation in the sampled firms, and in their regional behavior (see Tables 4 and 5, below). There is a significantly high rate of innovation in the hi-tech industries of both Israel and Germany (77.2% and 74.4% respectively).

**Table 3: Labor and R&D inputs, ANOVA between Industrial Groups
(in bracket number of observations)**

Industrial Groups	% Highly Skilled Labor	% R&D Workers	% R&D Expenditure	R&D Expenditure (M\$)
Electronic	25.9 (183)	17.7 (175)	14.2 (170)	2.46 (161)
Plastic	6.9 (104)	3.4 (98)	2.0 (94)	0.14 (88)
Metal	4.8 (138)	3.1 (128)	3.0 (124)	0.25 (107)
F Value	25.61	48.96	28.18	7.31
P	0.0000	0.0000	0.0000	0.0011

By contrast, firms representing The distribution of innovative firms, when categorized into the two industrial groups, demonstrates a strong similarity between the two countries, both in the prevalence of innovation in the sampled firms, and in their regional behavior (see Tables 4 and 5, below). There is a significantly high rate of innovation in the hi-tech industries of both Israel and Germany (77.2% and 74.4% respectively). By contrast, firms representing the traditional industries show a much lower rate of innovation, in Israel and, to an even greater extent, in Germany (49.6% and 36.5% respectively). This difference between the two countries is statistically significant at the 0.05 level. The inter-area comparison of hi-tech firms showed no significant differences between the rates of innovation in the two countries. However, the inter-area comparison of innovation by the traditional firms showed a significant difference between the rates of innovation in the two countries. The rates of innovation of firms affiliated to the traditional industries, located in the metropolitan and intermediate sub-regions, are very similar to each other in both countries. By contrast, Israeli firms located in the peripheral area show much higher rate of innovation (almost double the rate) comparable to firms located in the peripheral area in Germany.

Table 4: Distribution of Hi-tech Firms by Innovation and Location in Israel and Germany (%)

German regions			Israeli regions			Countries		Innovation
Periphery	Intermediate	Metropolitan	Periphery	Intermediate	Metropolitan	Germany	Israel	
70.5	77.4	94.1	56.3	67.6	88.9	77.2	74.4	Innovative firms
29.5	22.6	5.9	43.8	32.4	11.1	22.8	25.6	Non-Innovative Firms
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	Total
44	31	17	16	34	36	92	86	N
3.899			7.553			0.1842		χ^2
0.140			0.023			0.671		P

Table 5: Distribution of Traditional Industrial Firms by Innovation and Location in Israel and Germany (%)

German regions	Israeli regions	Countries	Innovation
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Periphery	Intermediate	Metropolitan	Periphery	Intermediate	Metropolitan	Germany	Israel	
31.6	50.0	35.3	61.7	45.8	36.7	36.5	49.6	Innovative firms
68.4	50.0	64.7	38.3	54.2	63.3	63.5	50.4	Non-Innovative Firms
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	Total
57	24	34	47	48	30	115	125	N
2.503			5.033			4.172		χ^2
0.286			0.079			0.039		P

An examination of the inter-area variations in each of the countries, as presented in Tables 4 and 5, points to the existence of a trend in regional behavior, with regard to innovation, in the two industrial groups - particularly in Israel, and less so in Germany. In Israel, there is a significant decrease in the rate of innovation in hi-tech firms as one progresses from the metropolitan area to the intermediate zone, and from there, to the periphery. These inter-areas differences are statistically significant. A similar decline in the rate of innovation when progressing from the metropolitan area to the periphery has also been observed in Germany; however, the inter-area variations are smaller in Germany (especially between the intermediate and peripheral areas) and not statistically significant. The reverse regional trend has been observed in Israel's traditional industries, where the rate of innovation increases with the movement from the metropolitan area towards the intermediate zone, and from there, to the periphery. These regional differences are of moderate statistical significance. In Germany, the rate of innovation characterizing traditional industries is higher in the intermediate zone when compared with the metropolitan and the peripheral areas; however these differences are not statistically significant.

The impact of the firms' organizational structures on their propensity to innovate is greater in Germany than in Israel. In both countries, the rate of innovation for multi-plant companies is higher than those of single-plant firms (see Table 6). Similar results were obtained also in study carried out in the UK (Geroski and Machin, 1992; Roper and Love, 1997). In Germany, this variation in the rate of innovation is statistically significant, but not so in Israel.

The importance of R&D as a major factor in inducing innovation has been shown in many studies, including this study. The results presented in Table 7 demonstrate the statistically significant relationship existing between the rate of innovation and the firm's R&D activities, as expressed in the number of R&D employees and the expenditure on R&D.

Table 6: Distribution of Firms by Innovation and Ownership Type, in Israel and Germany (%)

German	Israel	Innovation
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95.7	89.7	88.0	5.1	94.3	94.9	64.9	3.3	Innovative firms
4.3	10.3	12.0	94.9	5.7	5.6	35.1	96.7	Non-Innovative Firms
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	Total
46	39	25	59	35	54	37	61	N
122.6				124.7				χ^2
0.000				0.000				P

5. Multivariate Analysis

5.1 The models used

The results obtained with the Logit model pointed out the differences existing between the two countries. The Logit model is a binary choice model which assumes that a firm must choose between two alternatives: either to engage in innovation or not. This choice is influenced by the firm's internal attributes such as: branch affiliation, expenditure on R&D, ownership type, size and age of the firm as well as its location and production milieu (Shefer and Frenkel, 1998).

The variables in the model that explain the probability of a firm engaging in innovation are categorized into three types:

a. Basic variables:

Location variable – divided into three sub-regions – metropolitan area, intermediate zone and peripheral area.

Branch affiliation– categorized into two types of industrial groups – hi-tech industries and traditional industries.

b. Firms Attributes:

Firm R&D activity – the assumption is that product innovation is, to a large extent, dependent on the existence of R&D activities. The indices used to measure the scope of this activity are related to the firm's annual expenditure on R&D and to the number of employees engaged in R&D.

Organizational structure – the firms in the samples were divided into two principal groups: multi-plant group, and single-plant group.

Firm age – It is hypothesized that newer firms are more innovative compared with older firms. The age of a firm is a continuous variable, i.e. number of years.

Firm size – Plant size is measured according to the number of employees. The sample of firms was divided into three groups: small firms up to 20 employees; medium-sized firms, with 20-99 employees; and large firms, employing more than 100 workers.

c. Production milieu:

The impact of production milieu on the rate of innovation is examined by means of agglomeration indices in the various sub-regions. Since the geographical sizes of the sub-regions are not identical, the absolute size of the population does not constitute an index of the relative concentration of economic activities. We therefore decided to use population density as a surrogate measure of concentration, thereby canceling-out the differences which exist in the geographical size of each sub-region.

We assumed that the agglomeration effect follows an exponential function, therefore the agglomeration index was calculated by squaring the population density variable in each of the sub-regions (Shefer, 1987, also used this method; see also Moomaw, 1983).

The Logit model was applied separately to the two defined industrial groups - the hi-tech industries and the traditional industries. The model was applied while constructing dual-nation models incorporating the sample data of the two countries. These models enabled examination of the impact of each of the above-mentioned variables on the probability of developing innovation. In order to statistically test the differences between Germany and Israel, we introduced a dummy variable. A value of 1 was assigned for the firms in the German sample, and a value of 0 was assigned for the plants in the Israeli sample.

Six of the models used are presented in Table No. 9. Three divisions were used in the analyses of the models. First we classified the models into two exclusive groups: 'a', 'b' and 'c' present the results obtained when applying the data of the firms belonging to hi-tech industries, whereas models 'd', 'e' and 'f' present the results obtained when applying the data of the firms belonging to the traditional industries. Secondly, we have used two alternative measures of R&D activities, based on the hypothesis which stated that a significant positive relationship exists between expenditures on R&D and the rate of innovation. In order to examine this hypothesis, we used separate R&D indices, while the rest of the independent variables in the model remained unchanged. Models 'a' and 'd' include the overall expenditure on R&D, measured as the percentage of the firm's annual turnover. This index incorporated both in-firm expenditures and the expenditures on outsourced R&D services. Models 'b' and 'e' include only expenditures on in-house R&D, measured by means of the percentage of the firm's employees engaged in R&D. It was thus possible to carry out a more sensitive analysis similar to the ones conducted in previous studies (Thwaites, 1982; Oakey, 1984; Davellaar, 1991). Thirdly we have

Table 9: LOGIT Model Results for the Dual-nation Model Analysis (t-value in parentheses)

Independent Variable	High-tech Industries			Traditional Industries		
	Model a	Model b	Model c	Model d	Model e	Model f
Constant	-5.565 (-2.66)*	-4.575 (-3.22)*	-5.932 (-2.68)*	-3.115 (-4.87)*	-4.019 (-5.59)*	-4.087 (-5.25)*
R&D expenditures***	1.225	0.394	1.228	0.161	0.226	0.229

	(4.44)*	(4.62)*	(4.48)*	(3.32)*	(4.74)*	(4.79)*
Germany (yes) (1)	3.288 (2.18)*	1.665 (1.79)**	3.878 (2.04)*	_____	_____	_____
Location in Israeli metro- politan area (yes) (1)	2.641 (2.03)*	1.450 (1.60)**	_____	-1.120 (-2.06)*	-1.647 (-2.70)*	_____
Location in German inter- mediate zone (yes) (1)	_____	_____	_____	0.731 (1.41)	0.913 (1.72)**	0.886 (1.66)**
Size of Firms (large=3, medium =2, small = 1)	0.958 (1.27)	1.272 (2.35)*	0.993 (1.27)	1.050 (3.50)*	1.338 (4187)*	1.364 (4.20)*
Age of German Firms (number of Years)	-0.408E-01 (-1.39)	-0.256E-01 (-1.70)**	-0.434E-01 (-1.41)	_____	_____	_____
Age of Israeli plants (number of years)	_____	_____	_____	0.461E-01 (2.90)*	0.494E-01 (3.01)*	0.558E-01 (3.02)*
Israeli multi-plants (yes) (1)	-0.769 (-0.56)	-0.771 (-0.86)	-0.893 (-0.66)	0.279 (0.23)	0.526 (0.44)	0.646 (0.53)
German multi-plants (yes) (1)	1.646 (1.02)	2.085 (1.65)**	1.670 (1.05)	0.198 (0.34)	0.300 (0.48)	0.218 (0.34)
Index of Isrtaeli Agglomeration	_____	_____	0.321E-05 (2.00)*	_____	_____	-0.205E-05 (-2.82)*
Index of German Agglomeration	_____	_____	-0.379E-05 (-0.33)	_____	_____	0.982E-06 (0.31)
N	167	172	167	203	207	207
Initial Likelihood	-115.75	-119.22	-115.75	-139.17	-143.48	-143.48
Final Likelihood	-23.23	-40.54	-23.27	-115.74	-108.48	-107.94
p ²	0.80	0.66	0.80	0.18	0.24	0.25
\bar{p}^2	0.75	0.57	0.75	0.17	0.24	0.24

* Significant at $p < 0.05$

** Significant at $p < 0.10$

*** In model a, c and d = % R&D expenditures from total revenue; in model b, e and f = % R&D employees.

(1) Dummy Variable, reference group in parentheses

introduced into the two remaining models 'c' and 'f', a new variable which measures the extent of the production milieu. This variable is the agglomeration index (surrogate of the production milieu) which replaces the locational dummy variable included in the previous models. Since a high correlation exists between the locational dummy variables, and the agglomeration index, to avoid multicollinearity and for efficient and reliable estimations, we have decided to include in these two models only the agglomeration index and to exclude the locational dummy variables.

The results obtained are presented in Table 9. The t-values presented in the table indicate the level of statistical significance of each of the coefficient estimated, as well as the direction and scope of the variable's effect. The overall strength of the model is also presented in the table by means of the final likelihood obtained, and the model's overall level of explanation (p^2) given by the independent variables included in the model.

5.2. Empirical results

5.2.1 The Hi-Tech Industries

As anticipated, the results in the three models ('a', 'b' and 'c') indicate the dominant and positive effect of the R&D variable on the probability of generating innovation. In the comprehensive R&D model (a), in addition to the strong and positive effect of this variable (in both countries), the country dummy variable, was also found to be statistically significant. This means that all things being equal, the probability of generating innovation in a hi-tech firm in Germany is slightly higher than in Israel. The location variable constitutes an additional difference between the two countries. In Israel, a firm located in the metropolitan area has a greater probability of generating innovation; no such locational effect was observed in Germany.

Based on the results obtained from the application of the second model (b), we conclude that in both countries the percentage of persons engaged in R&D positively impact the probability of generating innovation. However, significant differences between the countries were found for the other variables. Here too an Israeli hi-tech firm located in a metropolitan area has a statistically significant effect on the probability of generating innovation, although the level of significance is lower here compared to the one obtained in the previous model. In this model, the impact of the size of the firm (scale effect) on the probability of generating innovation was found to be similar in both countries. The increase in the probability that large firms will develop innovation may be due to the fact that they are more likely to procure sources of capital for financing R&D expenditure and their ability to take risks, more than the small firms.

By contrast, a difference was found between the two countries in the effect of plant age. In Germany, the effect of the firm's age was found to be negative and statistically significant. In other words, younger firms in Germany have a greater probability of developing innovation. No such effect was detected in Israel. This finding may be explained by the fact that a very large proportion of Israel's hi-tech firms are young firms established in the late 1970s and the early 1980s, unlike Germany, where the age distribution of the firms is much wider. An additional effect, similar to the one obtained in the second model is linked

to the organizational structure of the plants. In this case as well, the effect of this variable is statistically significant in Germany, but not so in Israel. In Germany, plants belonging to multi-plant companies are more likely to develop innovation than single-plant firms. The likelihood obtained in the two models discussed above is good, and the level of explanation obtained in both is very high, particularly in the more complete model 'a'.

The results obtained from the application of model 'c' show a statistically significant and strong positive effect in Israel, which the agglomeration variable has on the probability of generating innovation. It was found that only one other variable, namely, R&D expenditure, makes such a significantly positive contribution towards the development of innovation. The result obtained reinforces even further the conclusion that in Germany, unlike Israel, location has almost no impact on the probability of generating innovation. This result may be partly explained by the smaller variation in the agglomeration indices calculated for each of the sub-regions in Germany, compared with the variations obtained in Israel. This is particularly so when we compare between the agglomeration indices calculated for the intermediate zone of Freiburg and the peripheral area of Baden Württemberg. However, the agglomeration index calculated for the metropolitan area of Karlsruhe is double the indices calculated for the two other areas. Yet, despite this fact, this variable in Germany has not been found to influence the probability of generating innovation in hi-tech firms.

5.2.2. The Traditional Industries

The results obtained from applying models 'd', 'e' and 'f' using the data from firms affiliated with the traditional industries, show that there are a number of variables which affect the probability of generating innovation - particularly in Israel, and less so in Germany. The overall level of explanations obtained in these models is less than the one obtained in the hi-tech industries.

Here too the expenditure on R&D variable has a significant and dominant impact on the probability of generating innovation. This impact is positive, and is highly significant statistically. This is true for both overall expenditure on R&D and the percentage of employees engaged in R&D. A further similarity between the two countries is found in the impact of firm size on the probability of generating innovation. A similar result was obtained for the model using the data from the hi-tech plants.

Differences were found between the two countries with regard to the firm's location. In Israel, it was found that being located in the metropolitan area generally lowered the probability of generating innovation in the traditional industries (the opposite was found for hi-tech industries). It is possible that this statistically significant result, is connected with the fact that most traditional firms owned by kibbutzim (which are located mostly in

peripheral area) have a greater tendency to innovate, compared with firms in this sector that are not owned by the kibbutz sector (see Frenkel, 1997). In Germany, firms located in the intermediate zone increase their probability to innovate, albeit at a low level, and then only when expenditure on R&D is in-house.

A further difference between the two countries is in the impact of the firm age on the rate of innovation. It was found that in the traditional industries in Israel (not in Germany), the age effect is positive, and of statistical significance; in other words, the older is the firm, the higher is the rate of innovation. The fact that most of the old innovative firms in this group of industries owned by the kibbutzim may serve as an additional explanatory factor. Most of these traditional firms were set up in the seventies, when many kibbutzim began to undergo some structural change. Industrial jobs were created in order to replace the surplus of workers in agriculture. From the mid-eighties, with the economic crisis suffered by the kibbutzim, fewer and fewer new firms were set up in this sector. On the other hand, in both countries, no impact on the probability of generating innovation was found as a result of the firm's organizational structure.

The results of model 'f' reinforce the conclusions regarding the location impact on the rate of innovation of the firms belonging to the traditional industries. The agglomeration index in Israel shows the negative impact of the metropolitan area. This negative effect is statistically significant. This finding is due specifically to the unique situation in the Israel's northern periphery. In Germany, also, the rate of innovation of the firms in traditional industry was not found to be influenced by the agglomeration index (a result similar to that found in the case of firms belonging to the hi-tech industries). The positive effect of the intermediate zone of Freiburg on the firms' probability of generating innovation is not related to agglomeration index in this area, which is similar to the one calculated for the peripheral area of Baden Württemberg.

6. Conclusion

This paper presents the results of a study, which compared innovative activity behavior of industrial firms on a regional and national level in both Germany and Israel. The analysis utilizes data gathered in the framework of a field survey conducted in both countries, covering more than 400 firms from both the hi-tech and the traditional industries. Unlike many other studies, which did not use a shared database, we were presented with the

opportunity to conduct a comparative study, and to better examine the similarities and dissimilarities between innovative behavior in different locations in the two countries.

Examination of the attributes of the firms included in the study, demonstrate a significant difference between the countries in the distribution of firms by industrial branches and location. The share of the hi-tech industries in the intermediate and peripheral areas in Germany is significantly greater than that of the central metropolitan area. In Israel, on the other hand, the share of hi-tech firms in the Haifa metropolitan area and in the intermediate zone is much greater than in the peripheral area.

The results obtained from the study clearly attest to the contribution made by R&D activity to the generation of innovation in the two industrial group categories. In this connection, a similarity was found between Germany and Israel. The study findings demonstrate the positive impact of the size of the firm on its rate of innovation. This result was found to be valid for both countries and for the two groups of industry examined. Age was found to have a negative effect on the rate of innovation in the German hi-tech industry. Long-established hi-tech industries in Germany have a lesser tendency to generate innovation. This conclusion may be linked to the life cycle stage of the older firms, which engage mainly in mass production, and only to a limited degree with the development of new products. In Israel, on the other hand, it was found that the age of the firm has a positive effect on the rate of innovation in the traditional industries. This result is connected with both the structure of the metal and plastics industries and the age of firms, which were established in the seventies, mostly owned by the kibbutzim.

The effect of industrial branches on the rate of innovation is varies in accordance with location. In general, no significant differences between the innovative ability of the two countries were detected. In both countries, innovation is more prevalent among the hi-tech firms than among the traditional firms. The results of the Logit model, with respect to the rate of innovation frequency in the different sub-regions point to the prevalence of an inter-area variation in innovative activities, especially in Israel. The hi-tech firms located in the Haifa Metropolitan area in Israel, with its high agglomeration index, enjoy a particularly high rate of innovation. This significant outcome is apparently linked to the production milieu, in which well-developed infrastructure, as well as economic activities supporting innovation exist. This infrastructure is reflected in the existence of academic institutions and research centers, a concentration of business services, and a large pool of skilled labor, all of which help induce the generation of innovation. Hi-tech firms located in the metropolitan area engaged more in R&D, and less with production activities. The latter activities are left to the subsidiary plants located in the intermediate zone of the central Galilee. The traditional industries in Israel demonstrate a „reverse“ spatial innovation pattern. In these industries the rate of innovation increases with the move to the

peripheral area, in spite of the fact that the index of agglomeration in this area is relatively low. This outcome is the result of both the unique characteristics of the Israeli periphery, where many kibbutzim are located, and the nature of the traditional industries, which have less need for a production milieu as reflected in the high value agglomeration index.

In Germany, no significant locational impact on the rate of innovation of hi-tech firms was observed. The inter-regional variation in the rate of innovation in the state of Baden Württemberg in Germany is not statistically significant. It is possible that the positive effect of the intermediate zone of Freiburg on the rate of innovation in the traditional industries is rooted in historical causes and, as in Israel, is not affected by the agglomeration index. As noted above, the strong and marked impact of the metropolitan area in Israel on the rate of innovation in hi-tech firms, compared with the decrease in this rate when moving out towards the periphery, does not exist in Baden Württemberg. The reason may be associated with the differing nature of the peripheral areas in the two countries. In Israel, the northern peripheral area is hermetically sealed to the neighboring countries, whereas the peripheral area of Baden Württemberg is located next to one of Western Europe's major traffic junctions, near Basle, in proximity to the open common border between Germany, Switzerland and France. This is most definitely not a sealed peripheral area, and can apparently benefit from the advantage offered by its location. Therefore, the peripheral area in Germany which is not similar in character to Israel's peripheral area, could enjoy a higher rate of technological innovation.

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