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Public Policy, Locational Choice and the Innovation Capability of High-tech Firms: A Comparison Between Israel and Ireland

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Abstract

Marked differences exist in the industrial and regional policy regimes in Israel and Ireland. This paper reviews these differences and investigates their influence on the development of the high-tech sector in each country. Using survey data from Irish and Israeli firms we examine the influence of public policy on the characteristics, location and innovation capability of high-tech firms.

Important differences are observed between the characteristics and market orientation of high-tech firms in the two countries. These are consistent with the overall orientation of the two countries' industrial policy regimes. Reflecting these differences, the innovation activities of Israeli firms are found be much more locationally sensitive than that of Irish companies. Regional policy incentives, involving the dispersal of high-tech activity to more peripheral areas in Ireland are therefore likely to have had little negative effect on firms' innovation activities. In Israel, however, inducing highly R&D intensive firms to locate away from the main metropolitan areas may be counter-productive without balancing developments in higher education etc.

Key words: Innovation, High-tech Firm, Location, R&D, Plant's characteristics

Public Policy, Locational Choice and the Innovation Capability of High-tech Firms: A Comparison Between Israel and Ireland

1 Introduction

The development of high-tech industry in Israel and Ireland, and in particular the development of the electronics sector, represents a success story on an international scale (Roper and Frenkel, 2000). This is evident in impressive sales growth, an established position in world export markets and the fact that in both countries the high-tech sector now plays a dominant role in manufacturing employment and exports[1]. The impressive achievements of the hi-tech sectors in Ireland and Israel are partly the result of national policy programmes. In Ireland, growth in the high-tech sector is largely due to a policy of encouraging inward investment, particularly from the US; while in Israel the development of indigenous high-tech industry has been seen as a strategic priority. As a result, the Irish high-tech sector is today dominated by externally-owned, large-scale production facilities while the Israeli sector is characterised by relatively small plants combining significant R&D facilities with small to medium-scale production activities (Roper and Frenkel, 2000).

One aspect of the development of the high-tech sector, which has received considerable attention in recent years, is its effect on regional development (Shefer and Frenkel, 1998; Felsenstein, 1996; Suarez-Villa, 1993; Feldman and Kutay, 1997; Davelaar and Nijkamp, 1997). High-tech inward investment, for example, may lead to technological innovation which, in turn, may contribute to the economic development of a region[2]. The issue of where in a country high-tech inward investment or development takes place is therefore crucial to understanding the effectiveness of public policy intended to support the development of high-tech industry in the country in general, and in specific regions in particular.

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[1] The population of Israel numbered 6.0 m. in 1998, and that of the Republic of Ireland reached 3.7m., with an additional 1.6m people in Northern Ireland. The data is from the Statistical Abstract of Israel No. 55, 1999, and the Central Bureau of Statistics and Trade (1999) CSO of Ireland, respectively. Between 1991 and 1998, for example, high-tech production in Ireland and Israel grew at an annual average rate of 8.4% and 15.5% respectively, compared to an EU15 average of only 3.6% pa. The high-tech sector now provides 17.5% of manufacturing jobs in Israel and 27.7% in Ireland, and accounts for 37% of total industrial exports from each country (Roper and Frenkel, 2000).

[2] For example, Grossman and Helpman, 1990a, 1990b, 1991a, 1991b, 1994; Krugman, 1979, 1991, 1995; Stokey, 1995; Romer, 1990, 1994; Bertuglia et. al., 1995, 1997; Nijkamp and Poot, 1997.

Over the last three decades both Ireland and Israel have implemented regional policies designed to influence firms' location decisions in favour of less developed areas. In Ireland, this policy of 'dispersal' was directed primarily at encouraging inward investment to locate in the West and South-West of the country and away from the main Dublin conurbation (e.g. O'Farrell, 1980). In Israel, policy was designed to move investment, both by inward investors and locally-owned businesses, away from the central Tel Aviv-Jerusalem axis towards the less developed Northern (e.g. the Galilee) and Southern (e.g. the Negev) regions (e.g. Shefer and Bar-El, 1993). Other aspects of each countries policy portfolio have also been important in shaping the types of investment and inward investment undertaken. For example, higher levels of R&D support in Israel may have encouraged investment in more R&D intensive sectors than in Ireland.

Differences in the industrial and regional policy regimes and operating environment for high-tech firms in Israel and Ireland suggest two key questions. First, how have these differences in policy affected the characteristics of high-tech industry in each country? Secondly, how has the regional dimension of policy influenced firms' competitiveness and long-term viability? In particular, how has the location (or re-location) of firms' to more peripheral areas influenced their innovative capability?

The remainder of the paper is organised as follows. Section 2 provides the context for the study including a brief overview of the historical development of the high-tech sector in each country. Section 3 then outlines differences in the Israeli and Irish industrial policy regimes focussing on policy measures with a specific regional dimension. Section 4 then compares the characteristics of high-tech firms in Israel and Ireland based on data collected from samples of high-tech plants. Section 5 then extends the analysis to investigate the impact of location on plants' innovation capability adding to the growing literature on inter-state and inter-regional variations in the extent and determinants of innovation activity[1]. Section 6 concludes with a review of the implications for public policy.

[1] See, for example, Alderman and Fischer, 1992; Suarez-Villa and Fischer, 1995; Suarez-Villa and Han, 1990, 1991; Suarez-Villa and Karlsson, 1996; Suarez-Villa and Rama, 1996; Nelson, 1993; Kleinknecht, 1996; Roper et. al., 1996; Frenkel et. al., 1998).

2 The Emergence of The High-Tech Sectors

One possible origin of the very different development paths of the high-tech sectors in Israel and Ireland are the differences in science policy and tradition which characterise the two countries. While Israel is distinguished by a tradition of scientific research, which began long before the establishment of the State, in 1948, the emphasis in Ireland was mainly on academic research which did not contribute directly to industrial or commercial applications (Roper and Frenkel, 2000).

The development of the high-tech sector in Israel was given a particular boost after the Six-Day War in 1967 and the ensuing French embargo on the export of military equipment to Israel. (Until then France was the main source for supplying military technology and equipment to Israel.) The embargo caused Israel's strategic policy to shift towards massive domestic development of a sophisticated military industry. This change also had considerable influence on the civilian sector, and encouraged the development of the electronics industry in the seventies. At the same time, the government of Israel adopted a strategic policy aimed at developing a scientific and technological infrastructure that would promote civilian industrial development. This was also an era of industrial structural change with a shift in emphasis from traditional industries towards export-based industries. Measures such as providing investment incentives were used (beginning with the Law Encouraging Capital Investment in 1959), intentionally favouring the high-tech sector. The government of Israel even supported the establishment of science parks near academic institutions, such as the Weizman science park established in 1967 (Felsenstein, 1994), and started providing R&D grants to individual firms (Teubal, 1993).

In Ireland as well, the 1970s witnessed a change in industrial policy, manifested in a sharp move towards the development of hi-tech industries, especially electronics and chemistry. This shift contributed to the development of a dual economy in Ireland: on the one hand, a sector with advanced technology, owned by foreign investors and based on R&D undertaken in other places abroad, and on the other hand, a traditional, industrial sector employing unsophisticated, locally-owned technology (NESC, 1982).

In Israel, in the seventies, the focus was on the continued development of advanced industry and military technology, although these developments were undertaken in the context of increased openness to exports and foreign markets. In 1975, the first trade agreement with the Common Market countries was signed, following by agreements on

scientific co-operation with the United States (BIRD) and with Germany (GIF). The government even tried to attract investments in peripheral areas. However, despite the generous grants policy, success in this direction was rather meagre (Shefer and Bar-El, 1993). A swift structural change occurred in the local, high-tech sector as the civilian sector expanded along with the military one. Thus, for example, between 1968-1983 hi-tech industries increased their proportion of the total industrial production from 6% to 24% and their share of exports from 5% to 28% (Teubal, 1993).

The first half of the eighties brought with it a severe economic crisis in Israel, evidenced in rampant inflation, which threatened the rapid growth that had characterised the high-tech sector. The relative stability that the economy attained in the second half of the eighties resulted in a growth in foreign direct investment (FDI) (Roper and Frenkel, 2000). The policy of incentives provided on the basis of fixed capital grants and R&D support also continued during this period. Capital grants for new plants and equipment dropped from 40% of the investment expenditure in the 1960s, to 20%-25% in the 1990s. R&D grants were institutionalised in 1984 with the Law Encouraging Industrial R&D, and provide fixed support of 50% of the expense of an approved R&D programme. The end of the Cold War and geo-political changes in the Middle East resulted in a considerable reduction in military industries in Israel and the relocation of many employees with high levels of professional skill to the civilian labour market. This factor significantly influenced the growth in hi-tech initiatives in Israel. From 1994, an impressive increase in the extent of FDI in Israel was noted, and the electronics industry continued to be led by companies which located their headquarters in Israel.

In Ireland too, as in Israel, the early eighties brought severe economic conditions intensified by the world oil crisis. Economic growth was halted, and income per capita declined with the growth in population. These factors revealed Ireland's basic weakness, rooted in the unstable structure of her local industry. This resulted in the awareness of the need to develop her scientific and technological potential, and thereby to contribute to the competitive ability of local firms. Unfortunately, as the economic crisis persisted, government pressure on the Treasury to cut back R&D budgets for the sake of solving immediate social problems increased (Yearly, 1995).

The external influence of the European Community in 1982 resulted in a significant change in the industrial incentives offered by the Irish government. The government was forced to make structural changes to their package of incentives to reduce any export bias. Instead, reduced corporation tax rates of 10% were extended to all manufacturing

firms regardless of their market orientation. The package of selective incentives for capital investments was also expanded to include all firms (Ruane and Gorg, 1997). Furthermore, a policy of technological development was introduced, employing financial aid from the European Union *via* both its funds and outline plans. The share of the foreign-owned industrial firms in Ireland grew along with the continued decline in the number of those employed in local firms. O'Sullivan (1995) reports that between the years 1973-1994, the proportion of those employed in foreign companies in Ireland grew by 29%, while at the same time, the proportion of those employed by local companies declined by 21.3%. Directing local investment to rural areas in Ireland had considerable influence on reducing unemployment. Greater ambiguity exists in this issue regarding the influence of foreign investments. Research has shown that foreign companies have little influence on the development of lagging areas compared to local firms (McAleese and McDonald, 1978; O'Farrell and O'Loughlin, 1980, 1981).

3 Industrial and Regional Policy Regimes[1]

In both Israel and Ireland, the government aids and supports the development of local industry and FDI[2]. A wide range of government support is available in both countries including grants to support R&D and capital investment, tax breaks and rebates, support for business start-ups, export incentives, technology transfer initiatives and measures to promote international co-operation in R&D. Some of these measures are regionally differentiated with higher grant rates, for example, offered in the more peripheral areas of Israel.

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[1] In this section we focus solely on changes in the policy regime in the Republic of Ireland. Industrial policy in Northern Ireland has been different and is discussed extensively elsewhere see, for example, Birnie and Hitchens, 1999). Throughout the rest of the paper the term Ireland is used to refer to the whole island of Ireland including both Northern Ireland and the Republic of Ireland. See Roper and Hewitt-Dundas (1998) for a discussion of differences in innovation behaviour between Northern Ireland and the Republic of Ireland.

[2] Indeed, Ireland and Israel are often direct competitors for internationally mobile investment. A recent example occurred when Intel was considering either Ireland or Israel as a location for a new two billion dollar plant. Intel had previously invested one and a half billion dollars in a new plant in Kiryat Gat, Israel with 600 million dollars of grant support. Intel also has large manufacturing operations in Ireland. According to the Intel management, due to the slow response from the Israeli government as to the support that the Israeli government was willing to grant the new plant, Intel decided to locate its new manufacturing plant close to Dublin, Ireland. More recently, however, Intel announced that in the next three years it plans to expand and double its R&D centre in Jerusalem to employ 350 engineers. This expansion plan will require an expenditure of over 40 million dollars for the next 2 years.

The structure of capital grant provision in the two countries illustrates both the regional dimension and also highlights another key difference between the countries' support regimes, i.e. that grant rates are automatic in Israel but discretionary in Ireland (e.g. Teubal, 1993). Israel is divided into three distinct areas according to priority: the central area, including mainly those areas characterised by large population concentrations and the urban areas of Tel Aviv and Haifa. Development area B (intermediate areas) that separates the main urban areas from the periphery, and development area A – primarily Israel's Northern and Southern peripheries including the Jerusalem metropolitan area due to her unique preferential status. Capital Grant rates then depend on the location of the plant[1]. In Ireland, no such formal regional distinction exists and grant rates are discretionary and determined according to the attractiveness of the investment, its location and potential contribution to creating jobs (Ruane and Gorg, 1997).

Tax breaks and rebates are also available in both countries but are only used as a regional policy tool in Israel. For new externally-owned plants established in both countries the current corporation tax rate is 10 per cent. In Ireland this tax rate applies in all areas of the country but in Israel a zero tax rate applies for two years if the plant is located in a peripheral area (i.e. Development Area A). For investors who are prepared to forgo capital grants, Israel also has an alternative track that also has a strong regional dimension. Externally-owned plants investing in the peripheral areas of Israel can enjoy full tax remission for 10 years, compared to 2 years in central areas[2].

Another area of government policy of particular concern to high-tech industries is the support available for R&D. As with capital grants, rates of R&D support grant in Israel are based on a fixed rate of 50% of the expense of an approved R&D programme (OCS, 1997), while in Ireland R&D grants are discretionary up to a maximum ceiling of 35% of expenditure. Also like capital grant, R&D grant in Israel has a regional dimension with higher grant rates (60 per cent) available in peripheral areas. Aside from this regional

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[1] In recent years plants locating in the central district of Israel have attracted no capital grant. Rates have remained around 10 per cent in the intermediate zone and 20-24 per cent in more peripheral areas.

[2] Little evidence is available on the impact of these tax reductions on FDI or local investment in Israel. For Ireland, however, Ruane and Gorg (1997) note that: *'Comparing tax incentives with other incentives, various surveys have concluded that the tax incentives are the most important incentive encouraging manufacturing investors to locate in Ireland. For example, a recent Deloitte Touche Tohmatsu survey indicated that almost 60 per cent of foreign companies interviewed found the ten per cent rate to have been very influential in their location choice. Furthermore, IDA Ireland personnel would suggest that tax incentives are particularly popular with US firms'.*

dimension the differential in R&D grant rates between Ireland and Israel (and the automatic nature of Israeli R&D grant support) means that the average R&D grant rate is substantially higher in Israel. In 1994, for example, government support of industrial R&D in Israel accounted for 26.1% of total civilian expenditure on R&D, compared to only 10% in Ireland (Roper and Frenkel, 2000, Table 6).

In addition to the regular support for industrial R&D, Israel also applies an intensive policy programme encouraging start-up firms. The 1984 law encouraging industrial R&D defines a special track for supporting R&D in such plants by providing a larger grant (66%) than that available to established plants (50%). Support of start-up plants in Israel has increased since 1991, with the establishment of a network of technological incubators by the Office of the Chief Scientist (OCS). These are located throughout Israel and provide a grant of 85% of the cost of each project to a maximum of $333,000 for two years (Shefer and Modena, 1998; Roper, 1999). Specific support for high-tech start-ups in Ireland has been more limited. Such firms have been eligible for the standard range of R&D and capital supports, and small incubator units have operated alongside the universities and at the National Technology Park in Limerick.

Other aspects of the support regime for high-tech industry in each country are also important but have no specific regional dimension in either country. Both governments support firms' export development, for example, by assisting with marketing expenses etc. Similarly, both countries have promoted collaborative industry-university research projects in generic technologies, i.e. the Magnet programme in Israel and the Projects in Advanced Technologies or PATs in Ireland. Both countries also participate in international co-operative programmes for R&D etc. participating in EU programmes and Israel also having an extensive network of other bilateral R&D co-operation agreements.

4 Characteristics of High-Tech Firms in Ireland and Israel

To provide a detailed comparison of the nature and activities of firms in the high-tech sectors in Ireland and Israel survey work was undertaken in each country. Both surveys collected data on plants' product and process innovation activity, R&D and a number of performance and characteristics indicators such as ownership type, plant size, number of years since establishment etc. Plants were said to be innovative if, during the last three years, they had introduced new or improved products. Included in this definition are activities leading to the development of new products, the adoption of products that are new to the market, and the substantial improvement of existing products (i.e. the

development of the next generation of products). These activities emanate from in-house investments in R&D, or the purchase of outsourced R&D services. Plants that dealt exclusively with developing or adopting innovative processes, or with adopting new products not requiring R&D investment, were not classified as innovative plants.

In Israel, the survey focussed specifically on high-tech plants (i.e. electronics, precision instruments, optics and electro-optics) in the Northern part of the country and was conducted through personal interviews with senior managers in 86 plants (see also Shefer and Frenkel, 1998). In Ireland, data for the same sectors was taken from a larger postal survey covering all manufacturing sectors (see Roper and Hewitt-Dundas, 1998 and 1998a). The overall response rate for the Irish postal survey was 30% of which 119 plants from the Republic of Ireland and Northern Ireland belong to the high-tech sectors.

Table 1 summarises the key characteristics of high-tech plants in the two countries. Significant statistical differences were found for all of the attributes examined, except for the percentage of export sales from turnover. For example, on average, high-tech plants in Ireland are more than twice as large as those in Israel, in terms of both their employment and turnover. Irish plants, however, invest relatively little in R&D compared to Israeli plants, which, on average, invest ten times as much in R&D as their Irish counterparts. In general, R&D investment accounted for about 30% of the turnover of a typical Israeli plant, compared to only 1% in Ireland. A notable difference also exists in investment in R&D as measured by the number of employees. The Israeli plants employ ten times as many R&D workers as does a comparable plant in Ireland. About a quarter of the employees in an Israeli high-tech plant are engaged in R&D, compared to less than 2% in an Irish high-tech plant.

The much larger size and lower R&D intensity of Irish high-tech plants points to significant differences in the orientation of the high-tech sector in each country. In Ireland, high-tech plants tend to be large-scale manufacturing facilities typically involved in the production of computers, computer components or accessories. In general these plants rely on R&D conducted elsewhere and have limited local R&D capability. In Israel on the other hand, manufacturing facilities tend to be smaller and more oriented towards research-driven markets such as that for telecommunications or medical diagnostic equipment (Roper and Frenkel, 2000). These contrasts are consistent with the orientation of the industrial and regional policy regimes of the two countries. In Ireland, capital grants and the availability of low corporate tax rates have tended to attract plants operating in the mass-market, exploitation phase of the international electronics

value-chain. In Israel, on the other hand, high levels of guaranteed support for R&D (along with plentiful qualified manpower) have attracted investment in more research-driven sectors where R&D expenditure is highest.

Table 1: t-test for selected attributes of Israeli and Irish hi-tech plants†

Plant's attributes	Ireland	Israel	t value
1. Age of plant – number of years since establishment	18.3 (119)	15.3 (86)	1.754**
2. Plant's size – number of workers	223 (112)	113 (86)	2.788*
3. Plant's size – annual turnover (in million of $.)	43.8 (106)	13.7 (82)	3.001*
4. Annual turnover per employee (in thousands of $)	184.9 (102)	85.9 (82)	4.590*
5. % growth in turnover in the last 3 years	52.6 (106)	23.5 (78)	2.721*
6. Export sales (in million of $.)	28.74 (108)	9.98 (83)	2.570*
7. % of Export sales from turnover	49.5 (108)	51.4 (79)	-0.330
8. R&D expenditures (in million of $.)	0.22 (107)	2.22 (86)	-2.602*
9. R&D expenditures per worker	1,265 (107)	15,362 (82)	-6.763*
10. % of R&D expenditures from total turnover	1.0 (105)	29.6 (78)	-3.692*
11. Number of R&D workers in the plant	2.4 (109)	22.5 (86)	-3.238*
12. % of R&D workers from total employees	1.7 (109)	24.3 (86)	-8.813*

† Figures in parentheses are the number of observations.
* Significant at the 5% level.
** Significant at the 10% level.

Source: Company Survey Data

The different characteristics and market orientation of the Israeli and Irish high-tech sectors suggest very different factor requirements etc. In particular, the high level of R&D employment and investment in the Israeli firms suggests that these firms might benefit much more from agglomeration advantages or a location close to a university or major conurbation than their Irish counterparts (e.g. Frenkel and Shefer, 1996). This should be evident in a stronger locational influence on innovation in Israel, with Israeli

firms in more peripheral areas likely to be more constrained in their innovation activity than similarly located Irish firms. In the next section we investigate this proposition using a multivariate approach.

5 Locational Effects on Plants' Innovation Activities

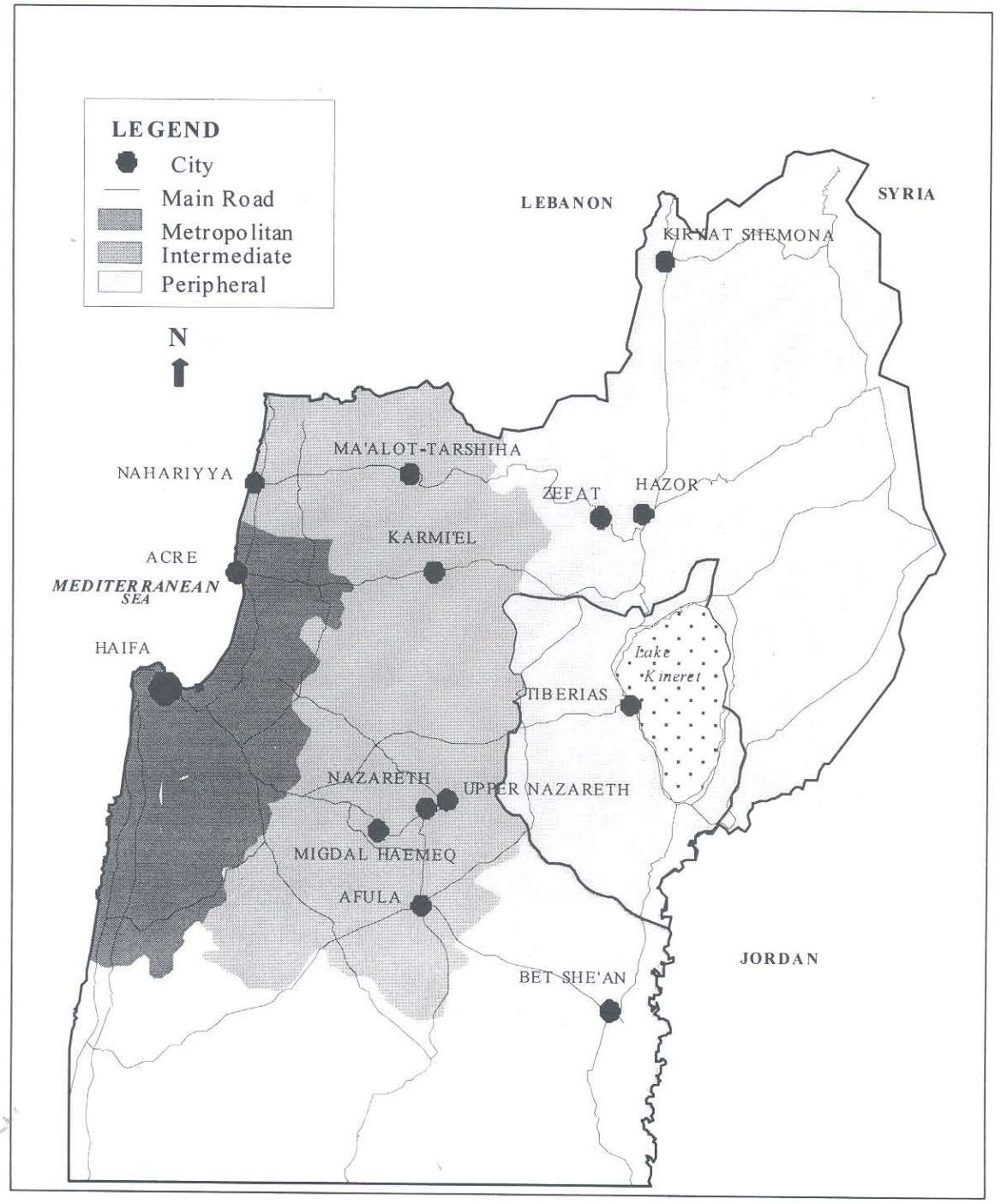
Previous studies have highlighted a number of factors, in addition to location, which may influence the probability of innovating. In particular, we consider two groups of 'conditioning' variables that, along with location, may influence the probability of innovating P_i. This suggests a model of the form

$$P_i = \beta_0 + \beta_1 R_j + \beta_2 A_{ix} + \beta_3 T_{iy} + \varepsilon_i \qquad (1)$$

Where: R_j is a vector of locational variables or indicators, A_{ix} represents the attributes of plant i (for example, size, age, proportion of skilled labour working at the plant, annual turnover etc.), and T_{iy} is a measure of the technological level at plant i (for example, the proportion of employees engaged in R&D, the extent of investments in R&D etc.). The main parameters of interest in the model are β_1, the coefficients on the locational terms.

More specifically we hypothesise that because of agglomeration economies and the availability of highly skilled labour urban or metropolitan locations will tend to positively influence the rate of innovation (Ciccone and Hall, 1996). Plants that are located within metropolitan areas are therefore expected to show a higher rate of innovation than plants located in the other more peripheral areas, *ceteris paribus*. To test this hypothesis we differentiate the location of firms in the Israeli and Irish samples into three different types of sub-regions (see Map 1): the metropolitan area, the intermediate zone and the peripheral zone. In Israel, the metropolitan area centres on Haifa, the main urban core in the North. The non-metropolitan area includes the intermediate zone, comprising the areas that surround the Haifa metropolitan area, (on the fringe of the metropolitan area, within an acceptable commuting distance) and the peripheral areas, comprising the less developed areas of the Northern region. These areas are removed from the metropolitan influence, and are not within an acceptable commuting distance. In Ireland, the metropolitan areas include the two main urban areas, Belfast and Dublin. Both are characterised by a high population density and a high proportion of the workforce with professional and technical expertise. The intermediate area surrounding the core areas of Belfast and Dublin conurbations is characterised by intermediate population densities and above average levels of professional and technical employment. Outside, and

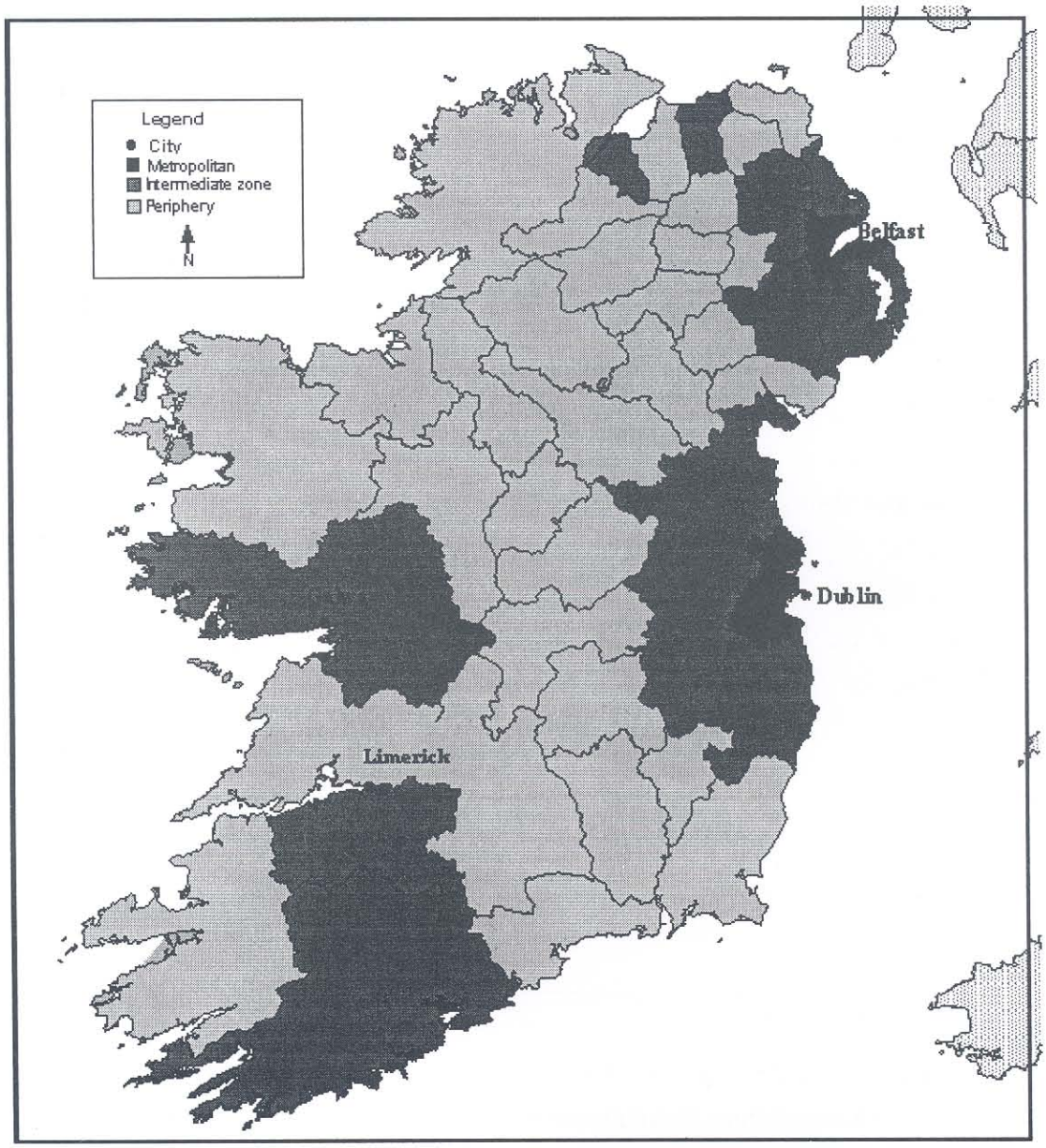
Map 1: Metropolitan, Intermediate and Peripheral Areas of Northern Israel



geographically distinct from the main urban centres of Belfast and Dublin, there are also important secondary centres characterised by relatively high population densities, above average proportions of people employed in professional and technical occupations and

important university campuses (Derry, Coleraine, Limerick and Cork, Galway). Following Shefer and Frenkel, (1998), and taking into account both the quantitative and qualitative characteristics of each of these areas, they were also classified as intermediate zones (see Map 2). Finally, the more peripheral areas were characterised by below average population densities and lower than average proportions of people employed in professional and technical occupations.

Map 2: Metropolitan, Intermediate and Peripheral Areas of Ireland



In the Logit models plants' location was represented by two alternative indicators, a set of dummy variables identifying plants in the metropolitan, intermediate and peripheral zones and, an index designed to proxy agglomeration economies (which was constructed as the square of population density for each sub-region). Other variables were included to capture the potential effects on innovation of plant characteristics and technological capability. Young firms for example may engage in more innovation activities, so we include plant vintage in the equations expecting a negative coefficient. Similarly, previous studies have suggested that larger plants have a higher probability of innovation than smaller firms (e.g. Oakey, 1984; Santarelli and Sterlacchini, 1990), a factor which may be particularly important in the Ireland-Israel comparison due to the difference in the average size of high-tech plants in the two countries (Table 1). In the models we include two alternative indicators of firm size, employment and turnover, expecting a positive coefficient.

Differences in the nationality of ownership of high-tech industry in Israel and Ireland, and other studies which have suggested that external-ownership may be linked to the probability of innovating, also suggest the potential value of including an 'ownership' variable in the model. The direction of any 'ownership' effect, however, is uncertain with arguments that external ownership restricts the autonomy of local plants limiting their willingness and ability to innovate (Malecki, 1980; Howells, 1984; and, Harris, 1991) contradicted by two recent studies which concluded that externally-owned establishments were more likely to innovate than their locally-owned counterparts (Harris and Trainor, 1995; Love *et al*, 1996). Finally, to reflect plant's technological capability we also include either the level of investment in R&D or the number of employees undertaking R&D in each plant. In both cases we anticipate a positive coefficient.

Table 2 reports Logit models for the probability of innovating in Israel and Ireland. Three models are presented in the table for each country. The alternative specifications allow us to test the central hypothesis relating to the impact of location on plants' innovation capability with different combinations of the (highly correlated) conditioning variables. For example, in model A, expenditure in R&D was used and in model B we include the number of workers in R&D. Likewise, in model A annual turnover was used as a proxy for plant size, and in model B, we include the total number of workers. Dummy variables were used to identify plants' location in models A and B, and in model C we use the population density-squared index of agglomeration.

Table 2: Results of the Dual-nation Logit Model Analysis †

Independent Variable	Israel			Ireland		
	Model A	Model B	Model C	Model A	Model B	Model C
Constant	-2.539 (1.444)**	-1.444 (1.104)	-1.682 (0.719)	-1.929 (0.919)*	-2.004 (0.911)*	-2.434 (0.994)*
R&D expenditures	19.164 (6.106)*	———	2.472 (0.957)*	29.481 (10.903)*	———	34.360 (12.32)*
Number of worker in R&D	———	0.441 (0.127)*	———	———	0.006 (0.003)*	———
Location in metropolitan area (Dummy variable)	2.141 (1.114)*	1.582 (0.912)**	———	-1.118 (0.772)	0.053 (0.725)	———
Location in inter-mediate zone (Dummy variable)	2.006 (1.378)	0.419 (0.943)	———	0.171 (0.811)	0.386 (0.781)	———
Agglomeration index	———	———	6.19E-07 (3.34E-0.7)**	———	———	1.24E-07 (2.07E-07)
Annual turnover in million of $	-0.609 (0.187)*	———	———	0.010 (0.007)	———	———
Size of Firms (in number of workers)	———	-0.159 (0.005)*	-0.116 (0.043)*	———	0.006 (0.003)*	0.052 (0.028)**
Age of firms (in years)	0.060 (0.051)	0.018 (0.034)	-0.004 (0.030)	0.015 (0.024)	-0.004 (0.023)	0.012 (0.024)
Foreign ownership (Dummy variable)	-2.572 (9.693)	0.363 (1.670)	0.269 (1.460)	2.150 (0.715)*	1.636 (0.701)*	2.027 (0.723)*
Growth (% change in turnover in the last 3 years)	0.029 (0.027)	0.044 (0.024)**	0.040 (0.022)**	0.003 (0.034)	0.0002 (0.003)	0.0009 (0.003)
N	74	78	76	92	94	95
-2 Log Likelihood	29.922	49.414	60.367	70.040	74.822	69.731
Goodness of fit	35.374	48.338	52.065	60.508	63.635	62.437
Cox & Snell - R^2	0.566	0.440	0.351	0.384	0.369	0.401
Nagelkerke - R^2	0.797	0.626	0.496	0.539	0.521	0.563

† Figures in parentheses are the number of observations.
* Significant at the 5% level.
** Significant at the 10% level.

Source: Company Survey Data

Looking first at the locational terms, we find a marked difference between the two countries but a consistent pattern of evidence between the two locational indicators. In Israel, the probability of innovating is strongly related to plants' location with firms in the metropolitan area significantly more likely to be innovative than those in more peripheral areas. A similar inference can be drawn from the positive and significant coefficient on

the agglomeration index in Model C, i.e. Israel high-tech firms are more likely to innovate if located in areas of high population density. In Ireland, by contrast no significant locational effects were evident either from the dummy locational variables or the agglomeration index. One possible explanation for this contrast relates to the very different characteristics and market orientation of Israeli and Irish high-tech firms. Specifically, a metropolitan or urban location may confer most advantage on firms operating in the R&D-intensive sectors that characterise Israeli high-tech industries. For firms in Ireland engaged in less R&D intensive activities these urban or metropolitan advantages are less pronounced.

The contrary influence of other plant characteristics on the probability of innovating in the two countries reinforces this impression. In Ireland, as in other studies, plant size is positively related to the probability of innovating. In Israel, however, small plants are significantly more likely to innovate than their larger counterparts. This can be vividly seen by the highly significant negative sign obtained for the estimated variables' coefficients of the annual turnover (model A) and number of workers (models B and C). One possible explanation for this difference is that the Israeli sample included a number of firms during the early stages of development most of whose work was in pre-competitive R&D activity aimed ultimately to lead to development of new products. Observed during a later stage of development these firms are likely to be more production oriented and to have a more stable product portfolio.

Another notable difference between the Israeli and Irish equations, with important implications for the impact of FDI on overall levels of innovation, relates to the effect of ownership. In Israel, no statistically significant difference was identified between the probability of innovating of externally-owned and locally-owned firms. In Ireland, however, externally-owned companies were significantly more likely to be innovating than their locally-owned counterparts. Other features of the equations highlight commonalities between high-tech firms in the two countries. First, in both countries the scale of firms' financial and manpower investments in R&D had a strong positive effect on the on the probability of hi-tech plants developing new products. Secondly, no statistical association was found in either country between the age of the plant and its probability of innovating. This may be connected to the fact that the high-tech industry in both countries is relatively young, and its tendency to engage, or not to engage in innovation has not yet developed clear patterns.

6 Conclusions

Marked differences are evident between the historical development and current regional and industrial policy regimes in Israel and Ireland. In Ireland, low corporation tax rates and an openness to large-scale inward investment have been accompanied by relatively low levels of support for business R&D. In Israel by contrast, a strategic desire to strengthen the countries indigenous technological capability, and a geo-political situation which until recently discouraged large-scale foreign direct investment, has been accompanied by higher levels of automatic R&D grants. Comparative analysis of the characteristics of hi-tech plants in Israel and Ireland highlights the impact of these contrasting policy regimes. Although high-tech plants in both countries are relatively young, mostly established since the second half of the eighties, and rely to a very considerable extent on external markets for exporting their products there are few other similarities. High-tech plants in Ireland are large and established mostly by foreign investors. They concentrate primarily on production and undertake relatively little in-plant R&D. By comparison, Israeli high-tech plants tend to be smaller, have much higher levels of R&D activity, and were mostly established by local investors. These contrasts are consistent with the orientation of the policy regimes of the two countries. In Ireland, capital grants and the availability of low corporate tax rates seem to have attracted plants in the exploitation phase of the international electronics value-chain. In Israel, high levels of guaranteed support for R&D have attracted investment in more research-driven sectors where R&D expenditure is highest.

Irish and Israeli industrial and regional policy regimes also differ in terms of the type of instruments which have been used to influence firms' location decisions. In Ireland, although there was an effective policy of 'dispersal' throughout the 1970s and 1980s the grant component of this policy is unclear due to the discretionary nature of R&D and capital grants. In Israel, by contrast, automatic grant rates for R&D and capital investment were, and remain, higher in more peripheral areas. Israel also offers larger tax rebates or reductions to plants locating in more peripheral regions. Regional policy of this type offers clear benefits in terms of the development and regeneration of more peripheral areas. For high-tech plants, however, a more urban or metropolitan location may offer substantial advantages in terms of a large pool of skilled labour and proximity to academic institutions, technological research institutes etc. Encouraging high-tech plants to locate in more peripheral regions may reduce their ability to innovate, an effect which may differ depending on the R&D intensity of the activity being undertaken. More specifically, the high level of R&D employment and investment in Israeli high-tech firms

suggests that these firms might benefit more from a metropolitan location than their Irish counterparts.

Logit analysis of the probability of innovating supports this hypothesis with the probability of innovating in Israeli high-tech firms strongly related to location, a relationship which is not evident in Ireland. The implication is that, given the characteristics of high-tech industry in Israel and Ireland, a policy of dispersal of high-tech industry in Israel is likely to be more 'costly' in terms of its negative impact on innovation than in Ireland where the effect is insignificant. For policy-makers in Ireland this is a heartening conclusion, suggesting that the policy of dispersing high-tech activity throughout the country over the last three decades is likely to have had little detrimental effect on the overall level of innovative activity or on the innovation capability of the plants themselves. This is only the case, however, because the type of high-tech activity which has been attracted to Ireland is typically in less R&D intensive sectors. In policy terms this conclusion also suggests that there has been, a perhaps unwitting, consistency between Irish industrial and regional policy: industrial policy – reflected in the pattern of grant and tax incentives – has attracted a type of high-tech inward investment which has without detriment to its competitive position be dispersed throughout Ireland.

For Israel, however, more tension is evident between industrial and regional policy. The pattern of industrial incentives, and particularly high levels of public support for R&D, have stimulated investment in highly R&D intensive sectors. Our results suggest, however, that these firms are more innovative when they are located in metropolitan rather than more peripheral areas. Thus, while investment in high R&D intensity industries is welcome at a national level, operating conditions in more peripheral areas are unlikely to be able to sustain the innovativeness and competitiveness of such firms in the longer term. For these areas offering high levels of R&D support may actually be an inappropriate policy, at least in the absence of measures designed to improve other aspects of the operating environment for R&D intensive businesses (e.g. by developing local higher education institutions).

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