ECONSTOR
Make Your Publications Visible.

A Service of

ZBW Leibniz-Informationszentrum Wirtschaft
Leibniz Information Centre for Economics

Görg, Holger; Ruane, Frances P.

Working Paper

Globalisation and fragmentation: Evidence for the electronics industry in Ireland

Trinity Economic Paper, No. 1999,11

Provided in Cooperation with:
Kiel Institute for the World Economy – Leibniz Center for Research on Global Economic Challenges

Suggested Citation: Görg, Holger; Ruane, Frances P. (1999) : Globalisation and fragmentation: Evidence for the electronics industry in Ireland, Trinity Economic Paper, No. 1999,11, Trinity College, Department of Economics, Dublin

This Version is available at:
https://hdl.handle.net/10419/2367

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

WWW.ECONSTOR.EU

Mitglied der Leibniz-Gemeinschaft

GLOBALISATION AND FRAGMENTATION: EVIDENCE FOR THE ELECTRONICS INDUSTRY IN IRELAND

Trinity Economic Papers Series
Paper No. 99/11
JEL Classification: F14, L63

Frances Ruane
Department of Economics
Trinity College
Dublin 2
Ireland
email: fruane@tcd.ie

Holger Görg
School of Public Policy, Economics and Law
University of Ulster at Jordanstown
Newtownabbey BT37 0QB
Northern Ireland
email: h.gorg@ulst.ac.uk

Abstract

This paper examines fragmentation and globalisation in the context of the electronics industry in Ireland. Fragmentation refers to the breaking-up of vertically integrated production processes into various components. We find empirical evidence of fragmentation in a number of data sources. Data on inward processing trade indicate that production in the Irish electronics industry is globally fragmented, and that the scale of such fragmented production is growing. Furthermore, Ireland's share of fragmentation is rising faster than that in the EU generally, especially in the electronics industry. Other firm survey data show that the scale of local fragmentation has risen relative to global fragmentation as firms in different Irish intermediate goods producing sectors trade increasingly on the local Irish market. Looking more specifically at the computer manufacturing sector, we find evidence of fragmented production in this sector in that the ratio of bought-in materials to total sales has risen significantly over the past decade.

Acknowledgements

Our thanks for valuable comments are due to Ron Jones, Henryk Kierzkowski, Sven Arndt and Francis O'Toole. We are grateful to Adrian Redmond of the CSO, and Denis Sleator and Niall O'Donnellan of Forfás for assistance with the data. We are particularly indebted to Frank Ryan and Peter Lillis of IDA Ireland for providing a valuable insight into the historic development of the electronics industry in Ireland. Financial support from Forfás is gratefully acknowledged. The views expressed are those of the authors and do not necessarily reflect the views of the Department of Economics, Trinity College.

1 Introduction

"Globalisation" is one of the key words of the late 20th century. Recently, the importance of fragmentation in production processes as one of the reasons for the increased globalisation of the world economy has been discussed in the literature (for example, Jones and Kierzkowski, 1998). In this context, "fragmentation" refers to the breaking-up of production processes into various components, the production of which can be located in different locations around the globe.

This paper looks at fragmentation and globalisation in the context of the electronics sector in Ireland. We focus on the electronics sector for several reasons. Firstly, it is a sector which is expanding rapidly and whose effects are permeating the production structures of virtually every activity in the manufacturing and service sectors. Recent data for the sector in Table 1 show that its growth rate in the period 1995-7 continues to exceed the growth in real GDP world-wide and in the US and Europe. Secondly, it appears to be a sector in which the process of fragmentation has been quite dramatic, especially over the past 20 years - as evidenced by the "downsizing" and increasing specialisation of the world's largest electronics producers, such as IBM. Thirdly, it is a sector which in principle has a high level of globalisation potential. Its production is effectively footloose, being virtually independent of resources other than capital, for which there is now a global market, and labour, both skilled and unskilled. Finally, because of the relative weightlessness of many of the products of the sector, transportation costs, which can often play a vital role in linking production to consumption, are a trivial part of total costs. For these reasons, differences in factor costs, effectively the costs of skilled and unskilled

labour, can drive the global production location decisions for different fragments in the production process.

[TABLE 1]

Ireland is chosen to illustrate how the fragmentation process has developed over the past two decades. As the electronics industry has developed globally over the past decade, Ireland has become a significant production base for this sector world-wide, despite its small size (population of 3.5 million and GDP of ECU 61.3bn), and its peripheral location. As Table 1 shows, the growth rate in production in the electronics sector in Ireland has exceeded the growth rate in electronics in the aggregated country groupings. Ireland now accounts for one per cent of total world electronics production and almost five per cent of electronics production in Western Europe. It hosts the European base of two of the key enabling technology companies, namely, Microsoft and Intel, as well as a battery of major companies from many sub-sectors within electronics. Multinational companies (MNCs) locating in Ireland have been entirely responsible for developing this sector, supported by Ireland's industrial development policy which recognised in the 1970s that the growing fragmentation within this sector could provide a role for indigenous Irish-owned firms, acting as sub-suppliers of fragmented parts of the final or intermediate products (see Killeen, 1975 and White, 1982).

Section 2 discusses the issues arising in applying concepts of fragmentation generally and in the context of the electronics sector. Section 3 presents some background on the evolution of the electronics sector in Ireland, while Section 4 presents the empirical evidence for fragmentation in the Irish electronics industry. Finally, Section 5 summarises and draws some conclusions from the analysis.

2 Applying Concepts of Fragmentation

Fragmentation, as discussed in some detail by Jones and Kierzkowski (1998), refers to the breaking-up of vertically integrated production processes into various components. Different stages of production do not need to take place under one roof in the same plant but may be contracted out to different plants of either the same firm or of altogether different firms. While this process of itself is long recognised in the industrial economics literature,[1] what is new is the global scope of the fragmentation that is taking place in this decade, and the consequent implications for the international distribution of production, for international trade and capital flows, and for income distribution (both national and international). Continuing advances in production and telecommunication technology, together with reductions in transport and telecommunication costs as well as in barriers to trade (especially services trade), underlie the dramatic development of globalised, fragmented production. As evident in the papers in this volume, the literature on fragmentation has focused on a range of different aspects of its relationship to globalisation. In addition to explaining why fragmentation takes place, this literature examines the welfare effects of increased fragmentation, the differences in industrialisation between core and peripheral countries (Krugman and Venables, 1995), and the distribution of income among skilled and unskilled workers following the sourcing of low-skill intensive inputs from developing countries (see, for example, Jones and Engerman).

Two conceptual distinctions are particularly appropriate when applying the concept of fragmentation. Firstly, fragmentation can take an intra-firm or

[1] These ideas, though with an altogether different focus, are implicit in Coase (1937) and more explicit in Williamson (1975).

inter-firm form.[2] In the case of the former, plants belonging to the same firm but operating at different locations specialise in the production of different components which are then brought together for final assembly. On the other hand, where different firms engage in such specialisation, sometimes as part of a production network or an industry agglomeration and other times as suppliers of standardised components to a globalised market, fragmentation can be said to be "inter-firm". This type of fragmentation is also frequently referred to as "outsourcing".

Secondly, fragmentation can take place across borders or within the same country. While international fragmentation arguably offers more possibilities for exploiting differences in comparative advantages across countries, fragmentation within the same economy may, on the other hand, involve lower transaction costs.[3] Where this process is intra-firm and takes place across borders, we are effectively dealing with MNCs, where production units specialise in different stages of the production process.[4] Global sub-supplying, either inter or intra firm, is most likely to happen among countries which have factor costs differences and when fragments of production involve different factor intensities.

Firms engage in fragmented production processes when it is profitable for them to do so. As the technological possibilities of fragmentation emerge, a firm, which is currently engaged in integrated production and opts for fragmentation, will choose between intra- and inter-firm fragmentation in

[2] See also Kierzkowski (1998).

[3] As Jones and Kierzkowski (1998) argue, fragmentation is made possible due to the utilisation of services (for example, transportation and communication), and costs for these services can be assumed to be lower if fragmentation takes place nationally rather than internationally

[4] Global MNC activities do not necessarily indicate fragmentation as plants in different countries may simply replicate plants elsewhere and be independent of their production activities. This is especially likely to be the case where transportation costs are high and where production is driven by establishing behind tariff barriers.

response to the particular transaction costs involved.[5] These costs include the direct transaction costs of fragmented production as well as the risk costs of undesired spillovers of proprietary capital.

In the case of intra-firm fragmentation, the transaction is internal to the firm which precludes any negative external market effects which could occur due to, for example, the transfer of technology or know-how to the intermediate-producing plant. This is likely to be more important when the fragmented product is non-standard. However, intra-firm fragmentation may involve diseconomies of scope, i.e., the attempt to produce all necessary components of the good within the same firm may lead to higher costs. This is especially likely to happen when products are complex and there are large information costs associated with producing at each level of the production chain. Also, sunk costs involved with setting up an own plant in another location (possibly abroad) may be substantial, such that economies of different locations, e.g., low wages in developing countries, may not be fully exploited if a firm engages in intra-firm fragmentation. Furthermore, an exclusive intra-firm strategy will preclude the firm from readily multi-sourcing, thereby leaving itself exposed to possible sub-supply risks, e.g., a strike at a particular plant or a national disaster at the location of such a plant.

In the case of inter-firm fragmentation, a firm is free to choose from where to source intermediate inputs and may, therefore, be able to reap the benefits of international specialisation more fully. However, in addition to the possible negative external effects noted above, there may also be additional transactions costs where a firm outsources intermediates, especially from abroad. Communication and transportation costs may be higher and, while

[5] See Williamson (1975).

new technologies have led to a reduction of these cost factors, differences in culture (both firm and national) and, not least, language may impose additional costs on the firm engaging in global fragmentation.

There are many case-study examples of the apparent successes and failures of fragmentation in the electronics industry, from the perspective of an individual firm. For example, IBM experienced the possible negative external effects of inter-firm fragmentation in the 1980s when it produced personal computers (PCs) assembled using various components from intermediate producers. The “open architecture” technology allowed competitors (starting with Compaq) to engage in "backward engineering" and produce machines similar to IBM's at substantially lower costs. However, IBM also experienced the possible diseconomies of scope associated with intra-firm fragmentation in the production of mainframe computers in the 1980s. The production of all parts in-house appears to have led to a X-inefficient and inflexible organisational structure.

The electronics industry also provides ample evidence of across-border fragmentation, with PC producers such as Compaq, DELL and Gateway 2000 using monitors, keyboards, hard-disks etc. which are all produced by different firms across a range of countries according to those countries' comparative advantages. Much of this fragmentation is inter-firm, involving standardised parts, which are sourced from a low-cost location. There are also examples of intra-firm cross-border fragmentation, e.g., Intel, which produces silicon wafers at its plant in Ireland, using skill-intensive and capital-intensive production methods, while the cutting of such wafers into individual micro-processors, which is highly labour intensive, is undertaken by an Intel plant in Malaysia.

3 Growth of the Electronics Industry in Ireland

Before discussing the development of the electronics industry in Ireland it is necessary to define what we consider to be part of this industry. There is no single definition of what comprises the electronics industry and our data, coming from widely different sources, relate to several different definitions. In this section, overall employment data coming from Forfás, the policy and advisory board for industrial development in Ireland, relate to three manufacturing sectors, namely, computers, office machinery, and electrical engineering (NACE Rev. 1 30-31). Trade data from the Central Statistics Office (CSO) relate to the office machines and automatic data processing (ADP) machines & units sectors (SITC section 75), while the capital expenditure data from the US Department of Commerce are for the electric and electronic equipment sector (SIC code 36). Even though the data are based on different definitions, they indicate a consistent pattern and give a reasonably good indicator of the overall development of the electronics industry in Ireland over time.

[TABLE 2]

Regardless of the data source used, it is obvious that the development of the Irish electronics industry is a relatively recent phenomenon. As the employment figures in Table 2 show, employment in the manufacturing electronics sector accounted for only 1,000 employees in 1974 but grew to 22,700 in 1997; that represents an annual average increase of 13.7 per cent, compared with an annual average increase in total employment in Ireland of 1.5 per cent during the same period. The figures also indicate that this development has been driven by foreign-owned multinationals locating in Ireland; the increase in employment in these companies in the late 1970s is

seen to have had positive effects on the development of indigenous firms.[6] For example, Cogan and Onyemadum (1981) in their analysis of the emergence of indigenous firms in the Irish electronics industry also provide evidence for such a positive effect of foreign MNCs on indigenous firms. They argue, based on a small case-study survey of a number of Irish-owned firms in the electronics sector, that foreign MNCs act as "incubators" for indigenous firms with previous employees of MNCs acting as the main initiators for a number of Irish-owned electronics firms.

The trade data in Table 2 also indicate the increasing significance of the electronics industry for the Irish economy. In the context of Ireland's having a very open economy, we note that the share of imports and exports attributed to the electronics industry rose from roughly 5 per cent in the mid-1970s to 16 per cent and 21 per cent for imports and exports respectively in the mid-1990s. The significant and growing gap between the export and import figures indicates the development of Ireland as a manufacturing base for electronics.

As the data in Table 2 indicate, most of the employment in the electronics industry is in foreign-owned firms and inspection of the data on capital expenditures by US MNCs indicates that Ireland appears to be a particularly attractive location for US companies. In the mid-1990s, around 25 per cent of all capital expenditures made by US electronics companies in the EU were in Ireland, while Ireland's share of EU GDP in the same period was around 1 per cent. Many reasons have been suggested in the literature as to why Ireland attracts such a high level of foreign investment. The most frequently discussed reasons are Ireland's membership of the EU, its

[6] Such a process has recently been formally modelled by Markusen and Venables (1999). They argue that, if there are backward and forward linkages between foreign and indigenous firms, foreign firms can foster the development of indigenous firms in the same or in related sectors.

relatively cheap and well-skilled labour force, and the fiscal and financial supports available to foreign investors (discussed below). A further reason why Ireland has been so attractive as a base for US firms is the common language and relatively similar culture.[7] The common language/culture effectively reduce substantially the transaction costs of international fragmentation for firms compared to, for example, a location in Eastern Europe where English, while becoming more and more common especially among younger people, is by no means as widely spoken.

These factors alone, however, would not be sufficient to explain why Ireland has been an extremely attractive base particularly for investment in the electronics sector.[8] Krugman (1997) links this phenomenon to the "changing geography of the world economy". His arguments suggest that industries which have negligible transportation costs are more likely to move to peripheral countries than other heavy industries and, as pointed out by Quah (1997), the electronics industry is such an industry where transportation costs do not play an important role. In this context, it is perhaps less surprising that Ireland, given its other location advantages has been attractive to firms in the electronics industry.

In any evaluation of the factors which have contributed to Ireland's success over the past decade in attracting foreign direct investment (FDI) from foreign MNCs, particularly in the electronics sector, the role of policy is clearly important. Any review of Irish industrial policy over the past forty years would identify it as being ***pro-globalisation***, i.e., pro-trade and pro-FDI, and ***pro-active***, i.e., supportive of industrial expansion in an

[7] See, e.g., Krugman (1997) and McAleese (1998).
[8] As pointed out above, Ireland received, on average, 25 per cent of US capital expenditures in the EU in the electronics sector between 1992 and 1995, compared with 5 per cent in total manufacturing.

interventionist manner.[9] Pro-globalisation policy is evident in Ireland's trade policy, its policy towards MNCs and the freedom of capital movements. Pro-active policy is evident in Ireland's having stable low corporate tax rates for *internationally-traded* goods and services for more than two decades and the use of grants and other financial instruments to support investment in these traded activities. The low corporate tax rate is available to all firms ***automatically*** while the grants and other financial supports are ***discretionary***. The grants, linked to a combination of capital and labour, are available up to certain maxima (determined by legislation) and implemented at the discretion of the Industrial Development Authority (IDA Ireland), on the basis of a formal project evaluation.

In effect, industrial policy in Ireland for over forty years has operated at project level and it has become increasingly pro-active and selective since the 1980s. While good projects in virtually all sectors of internationally-tradable economic activity are in principle eligible for financial support, not only has the level of grant support varied, but personnel resources have been increasingly deployed to distinguish suitable international projects on a market-driven basis, i.e., where market growth potential is greatest, projects are footloose and transportation costs relative to product values are low. This has typically meant projects with significant EU markets. The precise pattern of MNC projects which come to Ireland is thus strongly influenced by this process, which could be described as "market-led intervention".[10]

In the mid-1970s the IDA identified the electronics sector as providing the most promising opportunities for foreign investment projects for Ireland.[11]

[9] There are various extant reviews of Irish policy towards foreign investment, the most recent substantial ones being found in Foley and McAleese (1991). Other recent commentaries include O'Sullivan (1995), Ruane (1991), and Ruane and Görg (1999).

[10] IDA Ireland personnel have described this as a "fast-follower" approach.

[11] Ireland had a very limited electronics sector in the 1960s and its potential was not recognised at this point. Key MNCs, such as General Electric and Westinghouse had plants in Ireland in the 1970s based

The very fact that production processes in this sector were becoming highly fragmented contributed to its attractiveness to the policy makers as it was seen that Ireland could, over a period of time, move up the spectrum of product-quality and product-complexity. Thus production started with simple labour intensive sub-assembly activities in the early 1970s, based on assembling complete component kits, sourced globally by the headquarters of the electronics firms in the US. Even at this stage in the evolution of the industry it was not possible for Ireland to compete in the production of many types of passive components which, because of unit labour costs, could only be produced profitably in really low-wage countries in Asia. However, certain parts of the components industry could be sourced in Ireland, and an indigenous sub-supply industry did develop during this period.

During the 1980s as the mini computer industry went into decline with the growth in the PC market, the sector had to restructure. A crucial element of policy was to attempt to attract key companies, with crucial enabling technologies, to establish their European bases in Ireland. This succeeded with the establishment of the sole European outlets for Microsoft and Intel at the end of the 1980s, leading rapidly to the location of a wide range of commercial electronics industry activities in Ireland during the 1990s. The range excludes (i) activities which required very low labour costs (in particular, passive components, especially in consumer electronics), (ii) instrumentation, where Ireland was perceived as having no comparative advantage because of the absence of a military industry, and (iii) for the most part, high R&D-intensive activities.[12] Furthermore, the domestic

primarily on Ireland's low labour costs. According to IDA personnel, the training of Irish management by these companies turned out to be crucial in the 1970s in the development of the mini computer industry (Digital, Wang, etc.) and in the growth of the PC industry in the 1980s. This echoes the findings of Cogan and Onyenadum (1981) in their survey referred to above.

[12] Exceptions are the certain R&D activities currently being established by IBM and Xerox. The recent establishment of the Microsoft R&D facility in Cambridge UK, leaving the European localisation facility

potential associated with the fragmentation of the sector was recognised by policy makers in increasing the likelihood of linkages between domestics and foreign firms which occurred in practice (see Crowley, 1996 and Görg and Ruane, 1998). The US was identified as the most likely market source for such projects, both because of its leadership role in the sector (compared with European countries) and because of the common language which reduces the costs of operating complex and fragmented inter- and intra-firm production processes.

In the context of the fragmentation literature, it is perhaps interesting to note that by the late 1970s, the policy makers had developed their objective for the sector as creating industrial clusters in particular sub-sectors of electronics. They set out to attract large industrial players in these sub-sectors, using the presence of one player to support the attraction of another. In some instances the basis for the attraction has been the direct trade facilitated by these companies; more often, it has been the creation of a pool of skilled labour which had attracted new investors.

It has been argued recently (Barry and Bradley, 1997; Krugman, 1997; McAleese, 1998) that one of Ireland's advantages for MNCs is the existence of agglomeration economies, particularly in the electronics sector. Barry and Bradley (1997) argue that, for foreign firms, the "location decision is now strongly influenced by the fact that other key market players are already located in Ireland" (p. 1804). This point was also taken up by Krugman (1997), who referred to this as "Demonstration Effects and Cascades" (p. 49). For example, computer firms located in Ireland include Apple, Compaq, Dell, Gateway 2000, Hewlett Packard and IBM, while the silicon chip manufacturers Intel and NEC as well as software companies, such as

---

in Ireland, has increased the emphasis among policy makers on marketing Ireland as a base for higher skill intensive activities.

Microsoft, Lotus and Oracle, also have significant production facilities in Ireland. At this point, it appears that the Irish policy of creating clusters in the electronics sector has been successful.

4 Evidence of Fragmentation in the Electronics Industry in Ireland

In this section we present some empirical evidence on the extent of fragmentation in the Irish electronics industry. In looking at the evidence, we attempt to provide answers to a set of questions related to fragmentation in the electronics sector in Ireland. We attempt to establish whether Ireland is a base for fragmented production in electronics and whether fragmentation is relatively more important in Ireland than in the rest of the EU. Given the concern in the literature that fragmentation leads to the location of low-skill production in the country in which fragmented production is located, we attempt to shed some light on this issue for the Irish electronics sector. A related question is whether Ireland has maintained its competitiveness in terms of labour, which is, as pointed out above, the crucial local factor for the location of electronics firms. Furthermore, we investigate whether there is any evidence to show that local fragmentation takes place in the electronics sector and we examine in some more detail whether there is evidence of local fragmentation taking place in the computer sector, a sector where one would *a priori* expect a high level of fragmentation to occur.

One way of establishing whether projects in an EU country are involved in global fragmentation is to examine the level of outward or inward processing trade (OPT/IPT) in the country. OPT are goods which are temporarily exported to a country outside the EU for processing and are subsequently re-imported for sale on the EU market. As such, OPT indicates whether a country is a source for fragmentation. IPT are imports that enter an EU country for the sole purpose of being processed and subsequently re-

exported to another destination outside the EU. To analyse Ireland's importance as a base for fragmentation, we examine the extent of IPT, which gives a good indication of the extent of fragmentation across borders. Unfortunately, we cannot infer from these data whether this fragmentation is inter- or intra-firm. Our benchmark for Ireland is its IPT compared with the EU average, both for manufacturing overall and for electronics. To analyse IPT we use data available from the Eurostat Comext data base; the data for the electronics sector relate to the ADP machines & parts sector (Combined Nomenclature sections 8471 and 847330).

[TABLE 3]

The data presented in Table 3 indicate that IPT going into Ireland increased roughly four-fold between 1988 and 1997, compared with a doubling of IPT in the EU overall over the same period. IPT in the electronics sector in Ireland increased six-fold between 1988 and 1997, compared with an increase of less than two-fold for the total EU. This indicates the increasing importance of IPT in Ireland, and its being a relatively attractive destination for IPT in the EU. In 1997, 6.4 percent of total IPT entering the EU went into Ireland, and this share is 22.6 per cent in the electronics sector. The importance of IPT for Ireland is also mirrored in terms of total Irish imports; in 1997, almost one-third of imports in the electronic sector were IPT imports. These IPT data clearly suggest that fragmentation is highly important for production in the Irish electronics sector, and this conclusion is substantiated further by the fact that almost half of total IPT into Ireland in 1997 were IPT electronics imports, compared with under 15 per cent for the total EU.

As pointed out above, fragmentation can lead to a shift of low-skill production into the country in which fragmentation takes place. We have

available some firm level data to examine whether that is what has been happening in the Irish electronics sector. Our data here cover both manufacturing and service activities (including software) and are taken from the Employment Survey, which is an annual survey of all manufacturing and internationally-traded services firms in Ireland, collected by Forfás, the policy and advisory board for industrial development in Ireland. The data are classified into 12 electronics sub-sectors, which we have aggregated according to their level of skill intensity into low-, medium- and high-skill intensive.[13] There is only one sector operating in Ireland categorised as low-skill intensive, namely, Peripherals and Media. As shown in Table 4, seven sectors are defined as medium-skill intensive, while four sectors, namely, Semiconductors, IT related Services, Software Development and Software Production are said to be high-skill intensive.

[TABLE 4]

The figures in the first part of Table 4 suggest that since 1986 employment in the high-skill intensive sectors has been growing faster than the average rate of growth for electronics, in the case of both Irish and foreign firms. However, foreign firms also enjoyed faster growth in employment in the low-skill intensive sectors. This suggests that Ireland attracts investment projects for different reasons. One possibility is that firms in the low-skill sectors may be seeking a European base, and that in this context they find Irish labour costs relatively low compared with other European locations.[14] By contrast, low-skill activities which do not require a European base may choose to locate in lower wage countries, e.g., in South-East Asia. High-

[13] This aggregation is based on the views of industry specialists. Sectors are classified as low-skill intensive if less than 30 percent of their employees are graduates; medium skill if the graduate content is more than 30 but less than 50 percent and high-skill intensive if the graduate content is 50 percent or more.

[14] In effect, for such projects, Ireland is competing for investment projects only with other European countries and not globally.

skill intensive sectors are attracted to Ireland because of the existence of skilled labour at relatively low wages and agglomerations of firms in the Irish electronics sector.

These results are mirrored in the data in the second part of Table 4 which show the share of employment in each sub-sector. While medium-skill intensive sectors still account for the highest share of employment it is apparent that this share has declined since 1981, as the share of the high-skill intensive sectors has risen. In the early 1990s, 33 and 39 percent of employment in the electronics sector was in high-skill intensive industries in Irish and foreign firms respectively, compared with 9 and 25 percent respectively in the early 1980s. Thus, our results seem to indicate that there is a shift towards high-skill intensive production Ireland, although we note that low-skill production still occurs, especially in the foreign-owned sector.[15]

If production in Ireland develops towards high-skill intensive sectors using highly-skilled labour, one would expect wages to rise as highly-skilled workers are being paid their marginal product. This begs the question as to whether this has happened in Ireland and, if so, whether Ireland will be able to maintain its competitiveness in terms of labour costs. While the data on hourly compensation costs for manufacturing workers in the "electronic and electrical equipment" sector, available from the US Department of Labor, indicate that the absolute level of compensation in Ireland has risen, Figure 1 shows that the costs in Ireland relative to other countries, which may be seen as Ireland's competitors in attracting foreign investment in electronics, have not. Irish hourly compensation costs in the electronics sector are lower than

[15] One needs to exercise caution in interpreting these results as there may be skill differences within sectors which are hidden from our analysis. Kearney (1997) and Figini and Görg (1999) find that multinationals seem to increase the demand for skilled labour in Ireland, a result that also indicates that production by multinationals uses high-skilled rather than low-skilled labour.

in the UK and Germany and the ratio remained virtually constant between 1975 and 1994. The picture is even starker if one compares Ireland with one of its competitors in South-East Asia. The ratio of Irish to Taiwanese costs has decreased considerably since 1975; while Irish costs were almost six times as high as Taiwanese costs in 1975 they were only twice as high in 1994.[16] This indicates that Ireland, despite the massive influx of foreign investment in the electronics sector, seems to have been able to maintain its competitiveness which must be in large measure due to the fact that labour has been in relatively abundant supply in Ireland, because of its exceptionally high unemployment rates and the increasing participation of women in the workforce.

[FIGURE 1]

Looking at the electronics sector overall, we can find evidence of domestic fragmentation among Irish-owned firms and MNCs producing intermediate components, in the evolution of their domestic sales ratios. If the intermediate goods produced in these firms are directed to the domestic market, this may be interpreted as evidence that there is fragmentation taking place *within* the economy. Most of this fragmentation can be expected to be inter-firm as there are few Irish multi-plant firms. Table 5 presents data on the percentage of domestic sales, which suggest that fragmentation occurs in some of the sectors. A number of sectors, including both Irish and foreign-owned firms, have increased their domestic sales ratios, such as Irish firms producing components and foreign firms producing components and semiconductors as well as foreign firms engaging in printed circuit board assembly (PCBA). This suggests that there has been a relative

[16] Of course, this is to most part due to the rapid increase in hourly compensation in Taiwan particularly over the last decade.

increase in domestic fragmentation compared with cross-border fragmentation in these sub-sectors.

[TABLE 5]

We now turn to look in some more detail at one example of a sector in which one would particularly expect to find evidence of fragmentation, *viz.*, the computer manufacturing sector. As there are no data available on this sector for Irish firms (due to the limited number of Irish-owned firms in that sector) the data relate exclusively to foreign firms. Figure 2 shows that the ratio of inputs (materials and components) to turnover has increased considerably since 1982 and was 71 percent in 1995. This may be seen as indicating the increasing importance of fragmentation for production in this sector, as more components and raw materials are purchased for further processing in the production plant in Ireland. While we have no way of telling whether this total level of fragmentation is inter- or intra-firm, we can distinguish whether it is domestic or across borders. The lower line in Figure 2 shows the percentage of inputs purchased abroad in terms of percent of turnover, so that the difference between the two lines represents the extent of inputs sourced in Ireland as a percentage of turnover. While the percentage of imported inputs increased between 1982 and 1995 and reached 53 percent in 1995, locally purchased inputs increased at an even faster rate and amounted to 18 percent of turnover in 1995.[17] As most MNCs located in Ireland have only one production plant in the country we may infer that this domestic fragmentation is inter-firm fragmentation. The increased level of local fragmentation provides support for the responsiveness of firms to the potentially lower service costs associated with

[17] In their econometric analysis of linkages in the Irish electronics industry, Görg and Ruane (1998) find that, at individual firm level, domestic sourcing of inputs has also increased in the total electronics sector.

fragmentation within rather than across country boundaries, as foreign firms have increased their purchases from firms located within Ireland.[18]

[FIGURE 2]

5 Conclusions

The growth in the possibilities of fragmentation in production have greatly increased the potential for the globalisation of industries, as different segments of production can be better matched to the factor supplies of individual locations. Such globalisation has maximum potential in the situation where the industry concerned is internationally footloose in production terms, i.e., factor requirements are such that it can potentially locate anywhere, and whose value to volume ratio is high, i.e., relative transportation costs are low.

In this paper we have looked at the electronics sector, arguably the manufacturing sector which has greatest potential to fragment and to globalise. Looking at the development of this sector in Ireland, we found empirical evidence of fragmentation in a number of data sources. IPT data indicate that production in the Irish electronics sector is globally fragmented, and that the scale of such fragmented production is growing. Furthermore, Ireland's share of fragmentation is rising faster than that in the EU generally and most especially in the electronics sector. Other firm survey data show that the scale of local fragmentation has risen relative to global fragmentation as firms in different Irish intermediate goods producing sectors trade increasingly on the local Irish market. Since there are few multi-plant firms located in Ireland, we can conclude that much of this trade is inter- rather than intra-firm. Looking more specifically at the computer

[18] These firms include both Irish owned firms or other MNCs located in Ireland. Unfortunately none of our data sets allow us to distinguish how much is inter-MNCs and how much is between MNCs and

manufacturing sector, we find evidence of fragmented production in this sector in that the ratio of bought-in materials to total sales has risen significantly over the past decade. Furthermore, as this has happened, the scale of domestic fragmentation has risen relative to global fragmentation.

Are there any lessons to be learned from the Irish analysis? Clearly globalisation through fragmentation has been very positive for Ireland, in allowing the development of an entirely new sector. Furthermore, following on from global fragmentation has come the opportunity for local fragmentation, giving domestic firms an opportunity to act as sub-suppliers to local MNCs. In addition, Ireland has attracted investment both in high-skill and low-skill intensive sectors and appears to be managing to move up the skill spectrum, by moving from lower to higher skill segments of the fragmented production structure. This raises the issue of whether or not it can continue this progression over time.

Any evaluation of the Irish case needs to take account of the fact that Ireland has actively promoted MNC investment since the early 1950s and established itself as a strong base for multinational production in Europe. Furthermore, the strategy which it formulated back in the 1970s anticipated the developed of electronics as a fragmented production structure and attempts were made to match over time the skill intensity of the sector with the domestic skill supply. The fact that English is the spoken language in this sector which is so clearly globalised undoubtedly assisted in the process and enhanced the potential of Ireland as a beneficiary of the process of fragmentation.

Irish-owned companies.

Tables

Table 1: Overview of the Electronics Industry World-Wide

	1995	1996	1997
Real Growth of Electronics Industry (Production)			
World	3.8	5.9	3.4
US	4.0	7.2	5.3
Europe	1.0	3.7	4.1
Ireland	35.0	8.7	-
Growth of Real GDP			
OECD	2.2	2.6	3.0
US	2.0	2.4	3.6
EU	2.4	1.6	2.3
Ireland	10.3	7.3	6.7

Source: Calculated using data from Reed Electronics Research (1998) and OECD Economic Outlook 61, June 1997.

Table 2: Development of the Electronics Industry in Ireland

(i) Employment by Nationality of Firm Ownership

	1974	1979	1984	1989	1994	1997
Irish	238	180	897	1810	2163	3236
Foreign	766	3263	6427	7423	9525	19497
Total	1004	3443	7324	9233	11688	22733

*(ii) Trade in Electronics as percentage of Total Trade**

	1974-78	1979-83	1984-88	1989-93	1994-97
Imports	5.21%	4.91%	10.40%	10.19%	16.49%
Exports	5.15%	9.24%	19.00%	17.93%	20.83%

*(iii) Ireland's Share of US Capital Expenditures in the EU**

1974-78	1979-83	1984-88	1989-93	1994-95
2.12%	4.01%	5.75%	13.63%	25.08%

* averages

Source: Calculated using data from (i) Forfás, (ii) Central Statistics Office and (iii) US Department of Commerce.

Table 3: Inward Processing Trade (Imports) in Ireland

	1988	1990	1992	1993	1994	1995	1996	1997
Value of IPT (million ECU)								
IRL Total	588.6	808.4	895.9	1,366.7	2,125.6	2,849.9	2,917.1	3,057.9
EU Total	24,601.6	27,743.2	28,434.5	31,361.5	37,063.1	37,903.4	45,055.2	48,093.6
IRL Electronics	207.4	242.6	297.5	497.5	988.9	1,467.2	1,550.8	1,464.6
EU Electronics	2,348.3	2,726.0	2,801.2	3,469.9	4,584.7	5,803.3	6,566.1	6,488.7
IPT in Ireland as percentage of total EU								
Total IPT	2.4%	2.9%	3.2%	4.4%	5.7%	7.5%	6.5%	6.4%
Electronics	8.8%	8.9%	10.6%	14.3%	21.6%	25.3%	23.6%	22.6%
IPT as percentage of total imports								
IRL Total	3.8%	4.4%	4.1%	-	7.4%	8.5%	7.8%	6.6%
EU Total	2.7%	2.6%	2.5%	-	2.9%	2.7%	3.0%	2.8%
IRL Electronics	20.4%	17.9%	23.0%	-	38.0%	37.4%	38.2%	29.2%
EU Electronics	6.6%	6.3%	5.9%	-	8.4%	9.4%	9.9%	8.1%
IPT in Electronics as percentage of Total IPT								
IRL	35.2%	30.0%	33.2%	36.4%	46.5%	51.5%	53.2%	47.9%
EU	9.5%	9.8%	9.9%	11.1%	12.4%	15.3%	14.6%	13.5%

Source: Eurostat: Intra- and extra-EU trade (combined nomenclature). CD Rom.

Table 4: Employment in the Electronics Industry

	Irish firms			Foreign firms		
	1982-85	1986-90	1991-95	1982-85	1986-90	1991-95
Employment Growth (averages)						
Peripherals and Media	**354.8%**	**-34.3%**	**16.9%**	**41.5%**	**51.2%**	**60.7%**
Components	124.0%	50.9%	40.0%	75.2%	28.5%	0.0%
Computers	173.9%	-32.9%	37.0%	154.3%	-8.9%	-19.3%
Consumer Electronics	-29.7%	-24.0%	28.9%	23.9%	41.8%	7.0%
Instrumentation	21.9%	41.2%	13.9%	25.3%	53.7%	11.6%
Networking/Data Communication	433.3%	59.4%	4.5%	28.3%	54.1%	237.2%
PCBA	284.9%	7.4%	-9.2%	1416.7%	286.7%	82.1%
Telecommunications	53.5%	-1.0%	128.6%	52.9%	28.2%	-9.9%
Medium Skill	**42.4%**	**9.7%**	**29.6%**	**85.4%**	**23.8%**	**5.1%**
Semiconductors				67.4%	29.1%	25.0%
Services	94.1%	73.2%	61.8%	40.5%	24.1%	26.8%
Software Development	239.6%	160.0%	85.5%	13.2%	95.3%	72.9%
Software Production	-	219.0%	131.3%	395.0%	665.6%	65.6%
High-skill	**157.9%**	**138.5%**	**84.8%**	**40.1%**	**72.8%**	**49.9%**
Total	**59.2%**	**28.4%**	**45.5%**	**66.4%**	**39.8%**	**27.3%**
Employment Shares (averages)						
Peripherals and Media	**4.2%**	**3.2%**	**1.7%**	**12.1%**	**11.6%**	**13.8%**
Components	11.8%	14.2%	14.7%	14.1%	13.8%	9.9%
Computers	2.5%	1.9%	0.9%	24.2%	21.7%	11.2%
Consumer Electronics	31.6%	14.7%	13.7%	6.7%	5.1%	7.3%
Instrumentation	8.7%	10.8%	10.2%	5.2%	6.0%	5.1%
Networking/Data Communication	1.9%	2.9%	2.8%	2.2%	2.2%	1.7%
PCBA	18.6%	18.4%	11.5%	0.8%	2.8%	4.3%
Telecommunications	11.4%	9.8%	11.2%	9.5%	7.3%	7.8%
Medium Skill	**86.5%**	**72.7%**	**65.0%**	**62.6%**	**58.9%**	**47.4%**
Semiconductors	0.0%	0.0%	0.0%	9.3%	9.0%	10.3%
Services	4.7%	5.3%	5.6%	6.0%	6.7%	6.0%
Software Development	4.6%	17.5%	24.2%	9.5%	10.7%	14.4%
Software Production	0.0%	1.3%	3.5%	0.5%	3.0%	8.1%
High-skill	**9.3%**	**24.1%**	**33.3%**	**25.3%**	**29.5%**	**38.8%**
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: Calculated from Forfás Irish Economy Expenditure Survey data.

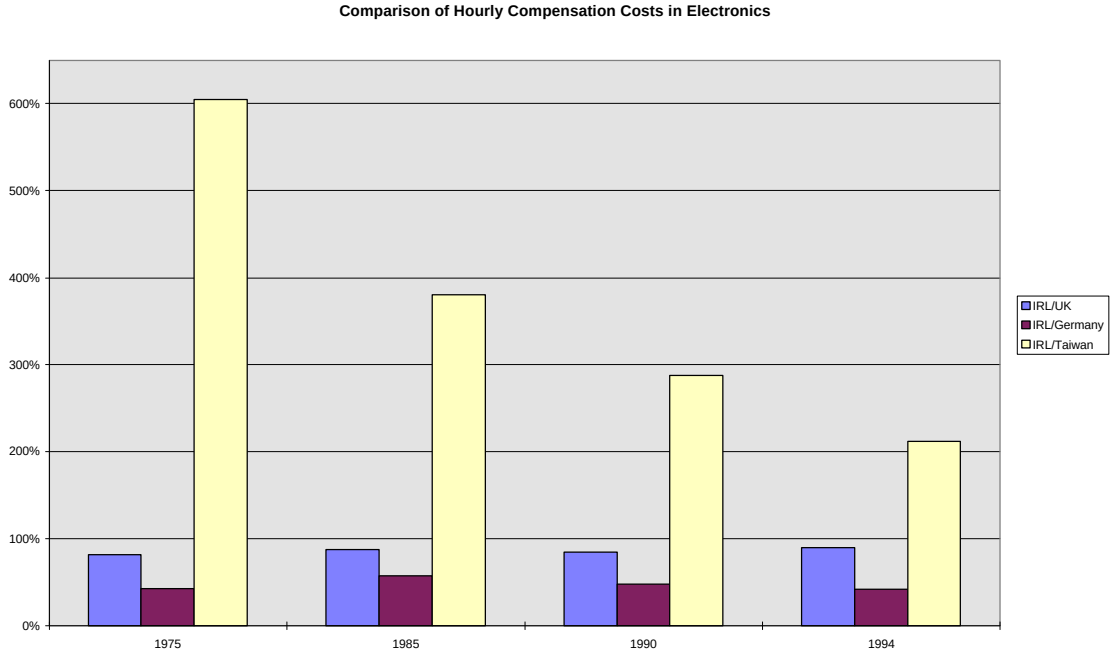
Table 5: Domestic Sales Ratios in the Electronics Industry (Averages)

	Irish firms			Foreign firms		
	1982-85	1986-90	1991-95	1982-85	1986-90	1991-95
Peripherals and Media	**0.0%**	**5.0%**	**14.3%**	**1.8%**	**10.1%**	**23.2%**
Components	7.7%	32.8%	39.8%	3.9%	5.7%	10.9%
Computers	-	-	-	0.7%	1.0%	2.8%
Consumer Electronics	14.8%	34.4%	47.2%	8.8%	7.0%	5.1%
Instrumentation	-	-	35.4%	2.8%	0.8%	0.9%
Networking/Data Communication	-	56.9%	68.6%	-	0.3%	0.3%
PCBA	85.8%	36.4%	48.1%	0.0%	13.7%	47.3%
Telecommunications	86.0%	38.8%	4.1%	12.7%	9.5%	5.2%
Medium Skill	**48.6%**	**39.9%**	**40.5%**	**4.8%**	**5.4%**	**10.3%**
Semiconductors	-	-	-	0.1%	0.0%	2.7%
IT Services	-	9.4%	15.7%	0.0%	1.9%	15.6%
Software Development	-	-	40.3%	42.8%	65.2%	6.6%
Software Production	-	-	35.0%	-	1.0%	1.2%
High-skill	**-**	**9.4%**	**30.4%**	**14.3%**	**17.0%**	**6.5%**
Total	**27.4%**	**37.6%**	**33.6%**	**3.9%**	**3.0%**	**6.4%**

Source: Calculated from Forfás Irish Economy Expenditure Survey data.

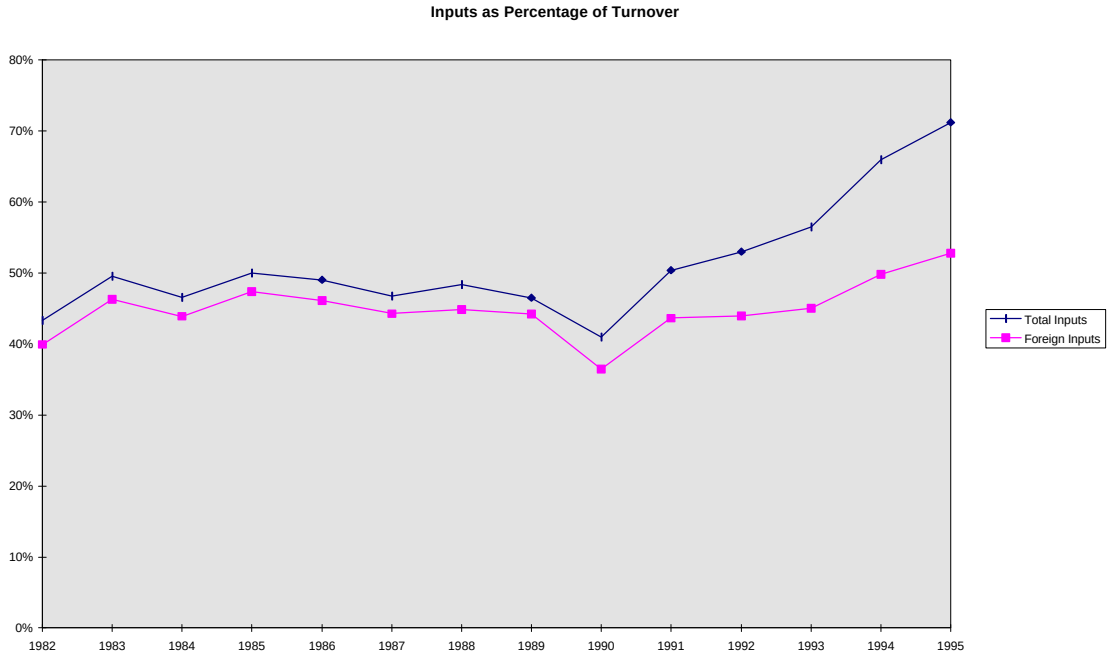
Figures

Figure 1: Cross-Country Comparison of Hourly Compensation Costs



Source: US Department of Labor: "Hourly Compensation Costs for Production Workers in Manufacturing". June 1996.

Figure 2: Inputs as Percentage of Turnover in Computer Manufacturing Sector



Source: Calculated from Forfás Irish Economy Expenditure Survey data.

References

Barry, F. and Bradley, J. (1997): "FDI and Trade: The Irish Host-Country Experience". *Economic Journal*. Vol. 107. pp. 1798-1811.

Coase, R.H. (1937): "The Nature of the Firm". *Economica.* Vol. 4. pp. 386-405.

Cogan, D.J. and Onyenadum, E. (1981): "Spin-off Companies in the Irish Electronics Industry". *Irish Journal of Business and Administrative Research*. Vol. 3. pp. 3-15.

Crowley, M. (1996): *National Linkage Programme: Final Evaluation Report*. Dublin: Industry Evaluation Unit.

Figini, P. and Görg, H. (1999): "Multinational Companies and Wage Inequality in the Host Country: The Case of Ireland". *Weltwirtschaftliches Archiv*. Vol. 135. pp. 594-612.

Foley, A. and McAleese, D. (eds.) (1991): *Overseas Industry in Ireland*. Dublin: Gill and Macmillan.

Görg, H. and Ruane, F. (1998): "Linkages between Multinationals and Indigenous Firms: Evidence for the Electronics Sector in Ireland". Trinity Economic Papers, Technical Paper No. 98/13. Trinity College, Dublin.

Jones, R.W. and Engerman, S. (1996): "Trade, technology and wages: A tale of two countries". *American Economic Review*. Vol. 86. pp. 35-40.

Jones, R.W. and Kierzkowski, H. (1998): “A Framework for Fragmentation”. Mimeo. University of Rochester.

Kearney, I. (1997): "Shifts in the Demand for Skilled Labour in the Irish Manufacturing Sector: 1979-1990". Working Paper 83. Economic and Social Research Institute, Dublin.

Kierzkowski, H. (1998): “Joining the Global Economy: Experience and Prospects of the Transition Economies”. Mimeo. Graduate Institute of International Studies, Geneva.

Killeen, M.J. (1975): "Contribution to the Symposium on Increasing Employment in Ireland". *Journal of the Statistical and Social Inquiry Society of Ireland*. Vol. XXIII. No. III. pp. 50-64.

Krugman, P.R. (1997): "Good News from Ireland: A Geographical Perspective". In: Gray, A.W. (ed.): *International Perspectives on the Irish Economy*. Dublin: Indecon. pp. 38-53.

Krugman, P. and Venables, A.J. (1995): "Globalization and the Inequality of Nations". *Quarterly Journal of Economics*. Vol. CX. pp. 857-880.

Markusen, J.R. and Venables, A.J. (1999): "Foreign Direct Investment as a Catalyst for Industrial Development". *European Economic Review*. Vol. 43, pp. 335-356.

McAleese, D. (1998): "Global Integration, Factor Mobility and EMU: Implications for the Irish Economy". Trinity Economic Papers, Policy Paper No. 98/1. Trinity College, Dublin.

O'Sullivan, M. (1995): "Manufacturing and Global Competition". In: O'Hagan, J.W. (ed.): *The Economy of Ireland: Policy and Performance of a Small European Economy*. Dublin: Gill and Macmillan. pp. 363-396.

Quah, D.T. (1997): "Increasingly Weightless Economies". *Bank of England Quarterly Bulletin*. February 1997. pp. 49-56.

Reed Electronics Research (1998): *Yearbook of World Electronics Data 1998*. Vol. 1 and 2. Surrey: Reed Electronics Research.

Ruane, F. (1991): "The Traded Sector: Industry". In: O'Hagan, J.W. (ed.): *The Economy of Ireland: Policy and Performance*. Sixth edition. Dublin: Irish Management Institute. pp. 345-377.

Ruane, F. and Görg, H. (1999): "Irish FDI Policy and Investment from the EU". In: Barrell, R. and Pain, N. (eds.): *Investment, Innovation and the Diffusion of Technology in Europe*. Cambridge: Cambridge University Press. pp. 44-67.

White, P.A. (1982): "A Concept of Industrial Development in the 1980s". *Journal of the Statistical and Social Inquiry Society of Ireland*. Vol. XXIV. No. V. pp. 51-59.

Williamson, O.E. (1975): *Markets and Hierarchies: Analysis and Antitrust Implications.* New York: The Free Press.