

Barry, Frank G.; Kearney, Colm

Working Paper

A portfolio analysis of industrial structure

Centre for Economic Research Working Paper Series, No. WP03/09

Provided in Cooperation with:

UCD School of Economics, University College Dublin (UCD)

Suggested Citation: Barry, Frank G.; Kearney, Colm (2003) : A portfolio analysis of industrial structure, Centre for Economic Research Working Paper Series, No. WP03/09, University College Dublin, Department of Economics, Dublin, <https://hdl.handle.net/10197/1262>

This Version is available at:

<https://hdl.handle.net/10419/72391>

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.

CENTRE FOR ECONOMIC RESEARCH

WORKING PAPER SERIES

2003

A Portfolio Analysis of Industrial Structure

Frank Barry, University College Dublin and
Colm Kearney, Trinity College Dublin

WP03/09

March 2003

**DEPARTMENT OF ECONOMICS
UNIVERSITY COLLEGE DUBLIN
BELFIELD DUBLIN 4**

A Portfolio Analysis of Industrial Structure

Frank Barry
University College Dublin

and

Colm Kearney
Trinity College Dublin

March 2003

Abstract

Industrial sectors producing income-elastic products can grow rapidly but are highly vulnerable to fluctuations in the world economy. Policymakers need to take into account this trade-off between output and employment growth over the longer term and volatility in the short to medium term. We bring the principles of portfolio theory to bear on the issue. Our analysis is applied to Irish manufacturing employment where growth has been concentrated in foreign-owned sectors such as Office and Data Processing Equipment, Pharmaceuticals and Professional Instruments. We show that, increased volatility notwithstanding, the country's high-tech FDI-driven strategy has brought the economy's industrial portfolio closer to the mean-variance efficiency frontier.

Keywords: Industrial Structure, Portfolio Analysis.

JEL Classification: O21, R30, G11.

Corresponding author: Dr Frank Barry, Department of Economics, University College Dublin, Belfield, Dublin 4, Ireland.

Ph: (353-1) 716-8239. Email: Frank.Barry@ucd.ie

Earlier versions of this paper were presented at a CEPR /Centro Luca d'Agliano workshop on Labour Market Effects of European Foreign Investments in Turin in May 2002 and at the 2002 Annual Meetings of the Irish Economic Association. We are grateful to participants – particularly Paul Walsh, Eric Strobl and Giorgio Barba Navaretti – for helpful discussions.

1. Introduction

Trade theory suggests that countries should specialise in line with (static and/or dynamic) comparative advantage, while portfolio theory emphasises the benefits of diversification. Together these perspectives suggest that any drawbacks from industrial specialisation in terms of employment- or income-risk for households should be offset by wealth diversification across countries. Given that a typical country's wealth holdings tend not to be strongly diversified internationally however, it is arguable that industrial policy should be concerned with sectoral volatility as well as with income and/or employment creation. Another reason for the authorities to be concerned with volatility is that a more stable environment is easier to plan for, in terms of manpower policy for example, and reduces the adjustment costs associated with physical investment.

Accordingly, the principles of portfolio theory – which are concerned with the balancing of risks and returns – can also be brought to bear on the optimisation problems that a country's industrial development agencies face. In this paper we introduce one such application of portfolio theory, to evaluate the changing risk and return characteristics of Ireland's industrial structure over recent decades. Ireland represents an interesting example of structural change in that the economy, particularly over the course of the 1980s and 1990s, has developed one of the strongest preponderances of high-tech industry in Europe. Much of the high-tech presence, furthermore, is accounted for by the strong presence in Ireland of foreign-owned multinational companies. Indeed the country's development strategy has been focused on attracting such companies, through a low corporation-tax regime, aggressive industrial targeting by the Irish development agencies, and integrated infrastructural and human-capital development policies; Barry (2000), Mac Sharry and White (2000).

Concern has recently begun to be expressed however about Ireland's specialisation in a narrow range of such sectors, which have proved to be highly vulnerable to fluctuations in the world economy. There is thus a trade-off between output and employment growth over the longer term and volatility in the short to medium term. This study evaluates the contribution of individual industrial sectors – distinguished

by nationality of ownership and by the sophistication of technology usage – to the overall risk and return of the country’s industrial structure. In conducting our analysis we recognise however that there are important conceptual differences between a country’s industries and an investor’s stocks of financial assets. *First*, the make-up of an investment portfolio is subject to fewer constraints than is a country’s inherited industrial structure. For example, portfolio theory solves for the most efficient combinations of assets in terms of their return and risk characteristics, without requiring the investor to hold positive amounts of any particular assets. Indeed, efficient portfolios are frequently constructed with ‘short sales’, whereby some assets are held in negative quantities. A country’s industrial structure, however, cannot be changed at will as can a portfolio of financial assets. In the Irish case, however, this issue arguably raises fewer problems than it does elsewhere, because the country’s foreign-owned sectors have been explicitly targeted by the state’s industrial development agencies; Mac Sharry and White (2000). Our analysis is therefore interpretable as examining the efficiency of the employment-generating aspects of the policy of attracting multinational companies to locate production facilities in Ireland, where efficiency is defined for present purposes in terms of the mean-variance properties of overall manufacturing employment growth.

A *second* difference is that an investor’s choice of portfolio does not influence the returns and variances of the individual stocks. Although portfolio theory assumes that all assets supplies are fixed, the assumption of atomistic markets ensures that any individual’s asset demand configurations do not impact on the overall market. In the context of a country’s industrial structure, however, fixed or inelastic factor supplies imply that as some industries grow, others must inevitably decline. Once again, however, this raises fewer problems in the Irish case than elsewhere, because both the Irish labour market and the Irish capital market are amongst the most open in the world, meaning that Ireland can be viewed, in this sense, as a regional rather than a national economy; Krugman (1997).¹ In the Irish context, therefore, little or no ‘crowding-out’ of indigenous employment by foreign-sector employment need arise.²

¹ The extent of labour mobility can be gauged for example from the fact that Ireland has the highest net emigration rate in Western Europe (after Portugal) in the 1960s (with an absolute value 7 times higher than that of the UK), and has had the highest immigration rate (after Luxembourg) during the “Celtic tiger” period.

² Indeed employment in both ownership categories has risen over the “Celtic Tiger” era.

In applying the insights of portfolio theory to Ireland's industrial structure, we examine 25 years of Ireland's manufacturing employment data at various levels of aggregation over the period 1974 to 1999. We measure "return" as the average rate of employment growth over the period, and "risk" as the standard deviation of the employment growth rate.

The essential questions we ask are threefold. *First*, how does Ireland's current industrial structure compare with the 'minimum risk portfolio' of sectors. *Second*, how has the policy of attracting foreign multinational companies altered the risk-return characteristics of the country's manufacturing employment growth rates? *Third*, has the greater average job growth been achieved at a cost in terms of its variability that compares favourably to the relative cost that would be borne on an efficient mean-variance frontier?

Our paper is structured as follows. In the next section, we discuss previous relevant research. In Section 3, we present data on how Ireland's industrial structure compares to that of the rest of the EU. The dataset is described in Section 4. Our mean-variance analysis of industrial structure is presented in Section 5. The final section summarises our arguments and draws together the conclusions.

2. Previous Research

There exists a considerable literature on industrial structure, the role of trade, and the importance of multinational corporations in domestic growth and employment. The vast bulk of this research has focussed on the first moment of the relevant variables. Only a small number of papers have taken the second moment into account. Goldberg and Levy (2000) analyse the EU as a portfolio of countries, in which each country is described by the average growth path and variance of its GDP. Our analogy, by contrast, is between industries (rather than countries) and financial assets. Gunther and Robinson (1999) adopt this perspective in studying the diversification effects of cross-border mergers among US banking groups. Meon and Weill (2001) use a similar approach to judge whether portfolio benefits have emerged from the evolution of industrial diversification across EU member states.

While close in principle to our approach, Meon and Weill (2001) use output data (which is suspect in the Irish case due to the transfer pricing behaviour of foreign multinational corporations) and disaggregate into 6 sectors: agriculture, forestry and fishing; oil and gas extraction; manufacturing; construction, and market and non-market services. We focus on the manufacturing sector, and work with more disaggregated sectoral employment data. We differ from Meon and Weill (2001) in a more important way also. They define a sector's return and variance as we do, but in terms of its performance across the whole EU. Means and returns for an individual country are then given by the EU wide performance of each sector weighted by the sector's importance in that country. Implicitly, this attempts to net out country-specific shocks, which we do not wish to do.

In our approach the sources of 'shocks' is irrelevant. It makes no difference whether a sector is more vulnerable to country-specific disturbances or is instead more prone to worldwide sectoral disturbances. This may be a deficiency in that within EMU, for example, country-specific shocks may decline in importance, or, with the product life-cycle, some existing sectors may become more vulnerable to sectoral disturbances in the future. In response to this, we point out that there is a substantial literature that attempts to distinguish between sectoral and country-specific shocks, and there is as yet no agreed method of doing so. See, for example, Stockman (1988), Palley (1992), Ghosh and Wolf (1997), and the substantial work emanating from the Lilien (1982) hypothesis. As with conventional portfolio theory, however, we must accept that "past performance is no guide to future returns".

3. Ireland in the EU Context

One of the questions with which we are concerned is whether Ireland can be thought to be overspecialised in certain industrial sectors. A first take on this issue is to look at the absolute degree of specialisation of the various EU economies. A conventional measure used to analyse this is the Herfindahl index. Letting α_i represent the share of industry i in total manufacturing employment in a country, we define the Herfindahl index H as:

$$H = \left[\sum_{i=1}^n \alpha_i^2 \right] * 100 \quad (1)$$

This index will lie between 0 and 100. For example if all employment is in only one sector, α_i is 1 and the index is 100. If half of employment is in each of two sectors, $H = [(1/2)^2 + (1/2)^2]*100 = 50$. The lower the value of H therefore, the less specialised is the country.

Based on a classification of employment into 30+ NACE 2-digit sectors, Table 1 provides our findings for the EU in 1996. Since we would generally expect larger economies to be less specialised, the countries whose positioning appears odd in this table are Belgium and – to a lesser extent – Austria and Finland. These small economies are less specialised than might be expected. On the face of it, Ireland appears to be about where it should be in the country rankings. This measure, however, says nothing about whether Ireland or any other country is specialised in the higher employment growth sectors, or in the sectors with more volatile employment growth.

A perspective closer to that of the present paper is adopted by Barry and Bergman (2002). They look not at the degree of specialisation of an economy as captured by the Herfindahl index, but at various measures of the relative volatility of different economies. The simplest measure of country employment instability is to look at the standard deviation of total manufacturing employment growth over the sample period. The rankings here are presented in Table 2. The Spearman rank correlation coefficient between a country's ranking in terms of the Herfindahl index and the standard deviation of total manufacturing employment growth is 0.36, which suggests that country specialisation can have a strong influence on employment instability.³

Barry and Bergman (1992) also explore more complex formulations of employment instability. Following Ghosh and Wolf (1997), they define an *individual-micro shock* as the shock to the (employment) growth rate of an individual sector in an individual country. This is defined as the residual of an autoregression of the current growth rate on a constant and on its own lag. A *country-micro shock* is then defined as the weighted average across all sectors of the *absolute value* of the individual-micro

³ The Spearman coefficient has a value of +1 if country rankings are the same along the two dimensions, a value of –1 if rankings are perfectly negatively correlated, and a value of 0 if there is no correlation.

shocks in that country.⁴ These country-micro shocks are shown in Table 3. The Spearman correlation coefficient for rankings in terms of the Herfindahl index and the country micro shocks is 0.442. Hence the degree of specialisation of a country is an even stronger candidate explanation for employment instability as measured in this way.

In an attempt to separate out sectoral from country-specific shocks, the second column weights the sectoral micro-level fluctuations found for each country not by the sectoral weights in each country but instead by their weights across the EU. It will be seen that in each case the latter weighting scheme would imply higher fluctuations. Thus we can conclude that each country has a lower weighting than the EU average in the sectors that are most volatile in that country. We suggest that this can be taken as evidence that adjustment costs associated with sectoral employment volatility do indeed matter, as we have hypothesised.

A third way to measure a country's employment volatility, again following Ghosh and Wolf (1997), is to define the average country shock as the absolute value of the weighted average of *actual* rather than *absolute* shocks to sectors in that country. This allows for positive and negative shocks within a country to cancel each other out. The ranking of countries in this regard is shown in Table 4. The Spearman rank correlation coefficient for rankings in terms of the Herfindahl index and actual country shocks is 0.1560, suggesting that country specialisation exerts a weaker influence on employment instability as measured in this way.

4. The Data

The data set for this study consists of 25 years of annual data on Irish manufacturing employment over the period 1974 to 1999. The employment data is available in NACE 4-digit format, and covers 33 manufacturing sub-sectors. In order to facilitate analysis of this data, these 33 sectors have been consolidated into 10 groups that closely correspond to NACE 2-digit codes. The following sub-sectors have been created from the database:

⁴ The absolute value of the country shock based on *actual* micro shocks will be substantially lower than the value of the country-micro shock based on the *absolute* value of the state-micro shocks, because the aggregate country shock is reduced by "diversification" across sectors.

- Food, beverages and tobacco
- Textiles, clothing, leather products and footwear
- Paper, printing and publishing
- Chemicals, rubber and plastics
- Pharmaceuticals
- Iron, steel and metal products
- Ships, cars, aircraft and transport nec
- Professional instruments
- Office computer equipment and electrical
- Miscellaneous

Table 5 provides an overview of employment developments between 1974/5 and 1998/9 in (i) indigenous companies, (ii) foreign companies and (iii) all companies. The table shows that total manufacturing employment increased moderately over the period, with employment in indigenous manufacturing companies declining by 21,000 and employment in foreign companies rising by over 38,000. Thus the foreign share climbed from one-third to one-half over the period. The Textiles, Clothing and Footwear sector is seen to have shed most jobs, followed by Food, Beverages and Tobacco. Both indigenous and foreign firms shed jobs in both of these sectors. Employment losses here were more than compensated for by strong growth in the Office and Computer Equipment and Electrical sectors, in Professional Instruments and in Pharmaceuticals. Employment in these latter three sectors, furthermore, rose in both foreign and indigenous companies.⁵

An alternative presentation of the data categorises the sectors as either low tech or high tech, rather than as indigenous or foreign. Following OECD definitions, the low-tech sectors are:

- Food, beverage and tobacco
- Textiles, clothing, leather products and footwear
- Paper, printing and publishing
- Iron, steel and metal products, and
- Miscellaneous

and the (medium and) high-tech sectors are:

- Chemicals, rubber and plastics,

⁵ This is consistent with the view that growth in foreign companies has crowded-in indigenous employment in these sectors; Gorg and Strobl (2002).

- Pharmaceuticals,
- Ships, cars, aircraft and transport nec,
- Professional instruments, and
- Office computer equipment and electrical.

In 1974-75, the low-tech sectors accounted for over ¾ of all manufacturing jobs, with less than ¼ in high-tech sectors. By 1998-99, the low-tech and high-tech sectors each accounted for around one half of manufacturing employment. The picture here closely resembles that concerning the indigenous-foreign company split. This indeed is no coincidence, as indigenous Irish companies are concentrated in low-tech sectors while most FDI in Ireland has been into high-tech sectors. It follows that the implications of our analysis are similar whether we focus on the indigenous-foreign ownership split or on the split between low-tech and high-tech industry. This will become clearer in the next Section.

5. Mean – Variance Analysis

The concepts of expected return and risk from portfolio theory can be readily applied to the growth and volatility of employment in Irish manufacturing sectors. Let G_i denote the percentage growth in employment in sector i in any given year, with sectors subscripted $i = 1 \dots N$. A given industrial structure, A , is described by a set of weights, X_i , reflecting sector i 's share of total manufacturing employment. The mean rate of employment growth generated by sectoral configuration A is then described by equation (2), where E denoting the expectations operator.

$$E(G^A) = E\left(\sum_{i=1}^N X_i G_i\right) \quad (2)$$

The variance of employment growth in sectoral configuration A is described by equation (3).

$$\sigma_A^2 = \sum_{i=1}^N X_i^2 \sigma_i^2 + \sum_{i=1}^N \sum_{\substack{j=1 \\ j \neq i}}^N X_i X_j \sigma_{ij} \quad (3)$$

The variance is made up of two terms. The first is the sum of the variances of employment growth in each sector multiplied by its squared weight in the sectoral configuration A . The second term on the right hand side of equation (3) is the sum of the covariance terms multiplied by the product of their weights. This term introduces the possibility that sectors with employment growth that covaries negatively can form a ‘hedge’ that reduces the variance of the growth of overall employment.

An efficient set of possible sectoral configurations that yields the highest rates of employment growth for a given variance, or alternatively, that yields the lowest variance for a given level of employment growth, can be obtained by solving the optimisation problem in equation (4) subject to the constraints (5) to (7).

$$\text{Minimise } \sum_{i=1}^N X_i^2 \sigma_i^2 + \sum_{i=1}^N \sum_{\substack{j=1 \\ j \neq i}}^N X_i X_j \sigma_{ij} \quad (4)$$

subject to,

$$\sum_{i=1}^N X_i E(G_i) = E(G_A) \quad (5)$$

$$\sum_{i=1}^N X_i = 1 \quad (6)$$

$$X_i \geq 0, \quad i = 1, \dots, N \quad (7)$$

This is the standard Markowitz quadratic programming problem of portfolio theory with no riskless asset and no short sales permitted; see e.g. Elton and Gruber (1995). It minimises the variance of employment growth subject to the constraints that the expected growth of employment in the overall sectoral configuration is the sum of its expected growth in each sector multiplied by the sector’s weight (5), that the sum of the sectoral weights is unity (6), and that there are no negative weights (7). There are many standard packages available to solve this problem, and we use the *VisualMvo*

programme of *Efficient Solutions Inc* which solves for the efficient set and traces it out by varying G_A between the minimum variance sectoral configuration and the maximum employment growth configuration.

5.1 The Indigenous-Foreign 2-Sector Model

We begin by considering just two sectors - indigenous and foreign. Both Figure 1 and Table 5 show that employment in the indigenous sector has been declining over most of our data period, 1974-1999, while employment in the foreign sector has been rising. Accordingly, the return (average annual growth rate of employment) on the indigenous sector has been negative, while that on the foreign sector has been positive. Interestingly, however, the variability of foreign-sector employment growth as measured by its standard deviation is higher than that for the indigenous sector. This is the sense in which commentators refer to the foreign sector as being riskier than the indigenous sector.⁶ This does not mean, however, that the foreign sector makes Irish employment growth more risky overall. As Figure 2 shows, the rates of employment growth in the two sectors are less than perfectly correlated, so together they have the potential to form an employment growth hedge.

The efficient frontier for the 2-sector model is depicted in Figure 3. The top part of the Figure shows that the indigenous sector, represented by point '1', has a mean rate of employment growth of -0.65 percent and a standard deviation of 0.0277 . By contrast, the foreign sector, represented by point '2', has a mean rate of employment growth of 1.74 percent and a standard deviation of 0.0291 . The foreign sector is growing faster, but is more volatile. The correlation coefficient of 0.86 confirms that the sectors form an employment growth hedge, implying that a judicious combination of the indigenous and foreign sectors could yield a higher rate of employment growth than is available from the indigenous sector alone, combined with a lower standard deviation than is available within either sector alone. Such a point would lie on the efficient frontier to the left of point 'A'. The minimum variance configuration at 'B' is one such point, corresponding to a mean employment growth rate of 0.13 percent with a standard deviation of 0.0272 , which is less than that for either sector alone.

⁶ For an alternative perspective on this see Gorg and Strobl (2003).

Because there are only two sectors in this model, all points except point ‘2’ at the north-east frontier of the efficient locus will include both sectors. (This will not be the case when we disaggregate further below). The 1974/75 configuration (by which we mean the indigenous and foreign sector employment shares, 67 percent and 33 percent respectively, that actually prevailed in 1974/75) lies at point ‘C’, close to the minimum variance configuration at ‘B’. The 1998/99 configuration lies further to the north-east at point ‘D’, though still to the north-west of the risk-return combination that characterises the indigenous asset alone. This reflects the fact that Ireland’s manufacturing portfolio has shifted over time towards the foreign sector, which now comprised 48 percent of employment. These changes allowed the manufacturing sector to grow more rapidly, though at the cost of some increase in volatility.

5.2 The Indigenous-Foreign 20-Sector Model

By working with only 2 sectors, we have forced the optimisation programme to include both sectors on the efficient frontier. All sectors are much less likely to be ‘held’ when we disaggregate into a larger number of sectors. As described above, our database consists of 60+ industries, half of them foreign and half indigenous. This is too many to allow us retain controllability, so we have aggregated them into the 10 sectors described earlier. Our choice of aggregation is based on our desire to remain close to the standard set of 2-digit NACE sectors, without aggregating subsectors that behave quite differently with respect to their means and variances. The weights in each are given in Table 6, with returns (average employment growth in the sector) and standard deviations also shown.

Again, we wish to ask the following questions. *First*, for the actual rate of employment growth generated by the portfolio, what alternative portfolio would have given us the minimum variance possible, and would it have contained more or less foreign sectors? *Second*, for the variance of the actual portfolio, what alternative portfolio would have given us the highest rate of employment growth, and would this portfolio have contained more or less foreign sectors? Figures 4 and 5 provide the answers.

Consider Figure 4, which shows the efficient frontier for the 10 indigenous and 10 foreign sectors. The return-risk characteristics of each sector are depicted in the boxes labelled '1' to '20'. The bottom panel describes the minimum variance portfolio, which contains 10 sectors – 7 indigenous and 3 foreign. This is consistent with the 2-sector model depicted in Figure 3 that described the indigenous sector as less variable than the foreign sector. It is noticeable that the top right hand corner point of the efficient frontier contains only sector 18 – the foreign Professional Instruments sector, which has the highest growth rate with a relatively large standard deviation. Interestingly, moving along this efficient frontier reveals that indigenous sectors 9 never features as part of any optimal portfolio of industries.

Figure 5 replaces these sectors with 2 others – these are the actual industrial configurations that existed at the beginning (1974/75) and end (1998/99) of the data period. The minimum variance configuration is depicted as point 'A'. As in Figure 4, the minimum variance portfolio at 'A' consists of 7 indigenous sectors and 3 foreign sectors. As we move north eastwards along the efficient frontier, the relative weightings of the indigenous sectors decline and those of the foreign sectors rise. For example, at point 'B', there are only 2 indigenous sectors – pharmaceuticals and professional instruments. When we reach point 'C', there are no indigenous sectors included in any efficient configurations.

The actual industrial configuration that existed in 1974/75 is labelled point 'D' in the Figure, and the configuration that existed in 1998/99 is labelled point 'E'. The 1974/75 configuration delivers a mean employment growth rate of -0.008 percent with a standard deviation of 0.024. Clearly, a more optimal mix of sectors would have delivered better employment growth with less risk anywhere in a north westerly direction from this point, and it would have featured more foreign sectors. By the end of the period, however, Ireland's industrial structure had shifted to point 'E', which contains more foreign sectors and delivers significantly higher employment growth of 0.017 percent with a higher standard deviation of 0.030.

Figure 6 'zooms in' on the shift that occurred in Ireland's manufacturing sector between 1974/75 (labelled point 'A') and 1998/99 (labelled point 'B'). It answers the most important question posed in the introduction; namely whether the greater

average job growth associated with the more recent sectoral configuration has been achieved at a cost in terms of volatility that compares favourably to the relative cost that would be borne on an efficient mean-variance frontier. Point ‘A’ (Ireland’s industrial configuration in 1974/75) delivers mean annual employment growth of – 0.008 percent and a standard deviation of 0.024. Point ‘B’ (its configuration in 1998/99) delivers mean annual employment growth of 0.017 percent and standard deviation of 0.030. In order to see whether the shift from ‘A’ to ‘B’ has raised employment growth relative to volatility at a greater or lesser rate than would be achieved on the efficient frontier, we can consider two industrial configurations that lie on the efficient frontier vertically above ‘A’ and ‘B’ at points ‘C’ and ‘D’. Configuration ‘C’ has the same variability as ‘A’, and point ‘D’ has the same variability as ‘B’. Point ‘C’ delivers mean annual employment growth of 0.037 percent with a standard deviation of 0.024. Point ‘D’ delivers mean annual employment growth of 0.056 percent with a standard deviation of 0.030. The policy of attracting foreign multinational companies – illustrated by the move from ‘A’ to ‘B’ – has raised mean employment growth relative to its variance by a greater amount (0.025 percent) than is implied by a shift along the efficient frontier from ‘C’ to ‘D’ (0.019 percent). Using the level of manufacturing employment in 1999 (236,800) as a base, this extra growth relative to what could have been achieved on the efficient frontier with the same increase in variability yields an extra 7,750 jobs after 5 years, rising to an extra 17,284 jobs after 10 years. In this sense, Ireland’s policy of attracting multinational manufacturing firms has raised manufacturing employment growth relative to its variability at a faster rate than would be implied by a movement along the efficient frontier. The policy can therefore be determined to have brought the economy closer to the efficient frontier.

5.3 The Low-tech/High-tech 10-Sector Model

Figure 7 illustrates the workings of the model when employment is divided into low- and high-tech rather than indigenous and foreign categories. The sectors are numbered [1] – [12] in the Figure, and the bottom panel shows that [1] – [5] are the low-tech sectors and [6] – [10] are the high-tech sectors. The points labelled [11] and [12] describe the industrial technology configuration that obtained at the start of the period in 1974/75 – with 77 percent of employment in low-tech and 23 percent in

high-tech industries – and at the end of the period, when 52 percent of employment was in low-tech and 48 percent in high-tech sectors. These sectoral configurations are very close to the indigenous-foreign configurations, particularly at the end of the period. Thus the trade-off between greater employment growth and greater variability in employment that has occurred as the economy moved from point [11] to [12] is very similar to that which exists in the corresponding move from points [A] to [B] in Figure 6.

5. Summary and Conclusions

We argue that a country's industrial structure can be viewed as a portfolio of industries, and the principles of portfolio theory brought to bear on the trade-off between sectoral employment growth and volatility. We apply our analysis to the case of Irish manufacturing, in which about one-half of current employment is in foreign-owned (predominantly high-tech) sectors. Employment growth has been strong in these sectors, though its volatility has been higher than in indigenous industry.

We showed nevertheless that the presence of both sectors acted as a hedge in reducing the volatility of employment growth below what it would have been had only the lower-volatility domestic sector been present.

Furthermore, Ireland's FDI-driven development strategy, though it increased the volatility of manufacturing employment growth, can be determined to have brought the economy closer to the mean-variance efficiency frontier.

Figure 1
Employment in Irish Manufacturing
Annual Data, 1974 – 1999

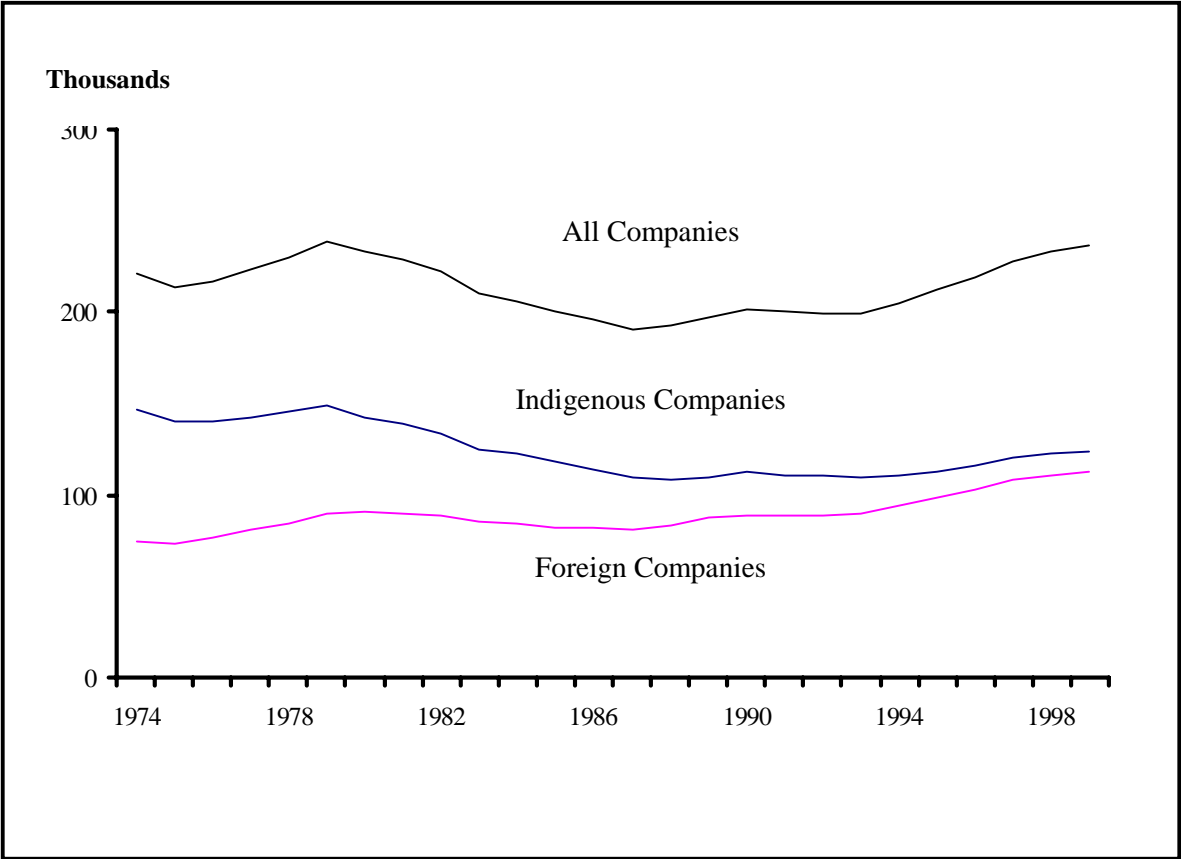


Table 1
Herfindahl Indices for EU Sectoral Employment, 1996

Denmark	8.6
Netherlands	7.3
Greece	7.0
Portugal	6.9
Ireland	6.9
Sweden	6.8
Unweighted country average	6.4
Germany	6.3
Finland	6.1
Spain	6.0
Austria	5.9
Italy	5.7
France	5.7
UK	5.5
Belgium	5.5

Table 2
**Standard Deviation of Total Manufacturing
Employment Growth, 1971-1996**

Spain	3.94
Sweden	3.56
Greece	3.54
Finland	3.49
Denmark	2.95
UK	2.85
Portugal	2.70
Ireland	2.67
Germany	2.32
Italy	2.23
Austria	1.92
Netherlan	1.88
Belgium	1.85
France	1.60

Table 3
Within-Country Micro Shocks: Absolute Values

	<i>Country weights</i>	<i>EU weights</i>
	(AR)	(AR)
Portugal	4.316	6.362
Sweden	3.909	4.22
Finland	3.853	4.421
Ireland	3.759	4.517
Spain	3.753	3.788
Denmark	3.73	4.085
Greece	3.685	4.463
Austria	3.339	3.9
Average	3.233	3.697
UK	3.166	3.188
Italy	2.749	2.955
Netherlands	2.524	3.086
Belgium	2.508	2.697
Germany	2.39	2.394
France	1.582	1.682

Table 4
Within-Country Shocks: Absolute Values

Portugal	0.357
Austria	0.139
Sweden	0.101
Finland	0.079
Ireland	0.079
Spain	0.071
Denmark	0.064
UK	0.051
Italy	0.040
Germany	0.023
France	0.018
Greece	0.015
Netherlan	0.011
Belgium	0.006

Table 5
Employment in Irish Manufacturing Industry,
Annual Data, 1974-1999

	<i>Average 1974/75</i>		<i>Average 1998/99</i>		<i>Change</i> (<i>'000</i>)
	<i>Jobs</i> (<i>'000</i>)	<i>Share</i> (<i>%</i>)	<i>Jobs</i> (<i>'000</i>)	<i>Share</i> (<i>%</i>)	
<i>Indigenous companies</i>					
Food, beverage and tobacco	43.315	0.30	34.874	0.28	-8.441
Textiles, clothing and footwear	29.446	0.21	9.133	0.07	-20.313
Paper, printing and publishing	13.817	0.10	12.526	0.10	-1.291
Chemicals, rubber, plastics	8.687	0.06	8.828	0.07	0.141
Pharmaceuticals	0.409	0.00	0.944	0.01	0.535
Iron, steel, and metal products	11.725	0.08	14.660	0.12	2.936
ship, cars, aircraft and transport nec	4.287	0.03	4.379	0.04	0.092
professional instruments	0.799	0.01	2.261	0.02	1.462
Office, computer equipment and electrical	8.219	0.06	13.212	0.11	4.994
Miscellaneous	22.851	0.16	22.173	0.18	-0.679
Total indigenous companies	143.552	1.00	122.987	1.00	-20.565
<i>Foreign companies</i>					
Food, beverage and tobacco	18.518	0.25	12.153	0.11	-6.365
Textiles, clothing and footwear	12.438	0.17	5.896	0.05	-6.542
Paper, printing and publishing	2.723	0.04	1.792	0.02	-0.931
Chemicals, rubber, plastics	7.581	0.10	10.344	0.09	2.763
Pharmaceuticals	2.450	0.03	11.829	0.11	9.379
Iron, steel, and metal products	7.066	0.10	5.132	0.05	-1.934
ship, cars, aircraft and transport nec	7.621	0.10	7.717	0.07	0.096
professional instruments	3.035	0.04	12.688	0.11	9.653
Office, computer equipment and electrical	7.158	0.10	40.750	0.36	33.592
Miscellaneous	5.037	0.07	3.715	0.03	-1.323
Total foreign companies	73.624	1.00	112.014	1.00	38.390
<i>All companies</i>					
Food, beverage and tobacco	61.832	0.28	47.027	0.20	-14.805
Textiles, clothing and footwear	41.883	0.19	15.028	0.06	-26.855
Paper, printing and publishing	16.539	0.08	14.318	0.06	-2.222
Chemicals, rubber, plastic	16.268	0.07	19.171	0.08	2.904
Pharmaceuticals	2.859	0.01	12.773	0.05	9.914
Iron, steel, and metal products	18.790	0.09	19.792	0.08	1.002
ship, cars, aircraft and transport nec	11.907	0.05	12.096	0.05	0.189
professional instruments	3.834	0.02	14.948	0.06	11.114
Office, computer equipment and electrical	15.377	0.07	53.962	0.23	38.586
Miscellaneous	27.888	0.13	25.887	0.11	-2.001
Total all companies	217.176	1.00	235.001	1.00	17.825

Figure 2
Employment in Irish Manufacturing
Annual Data, 1974 – 1999

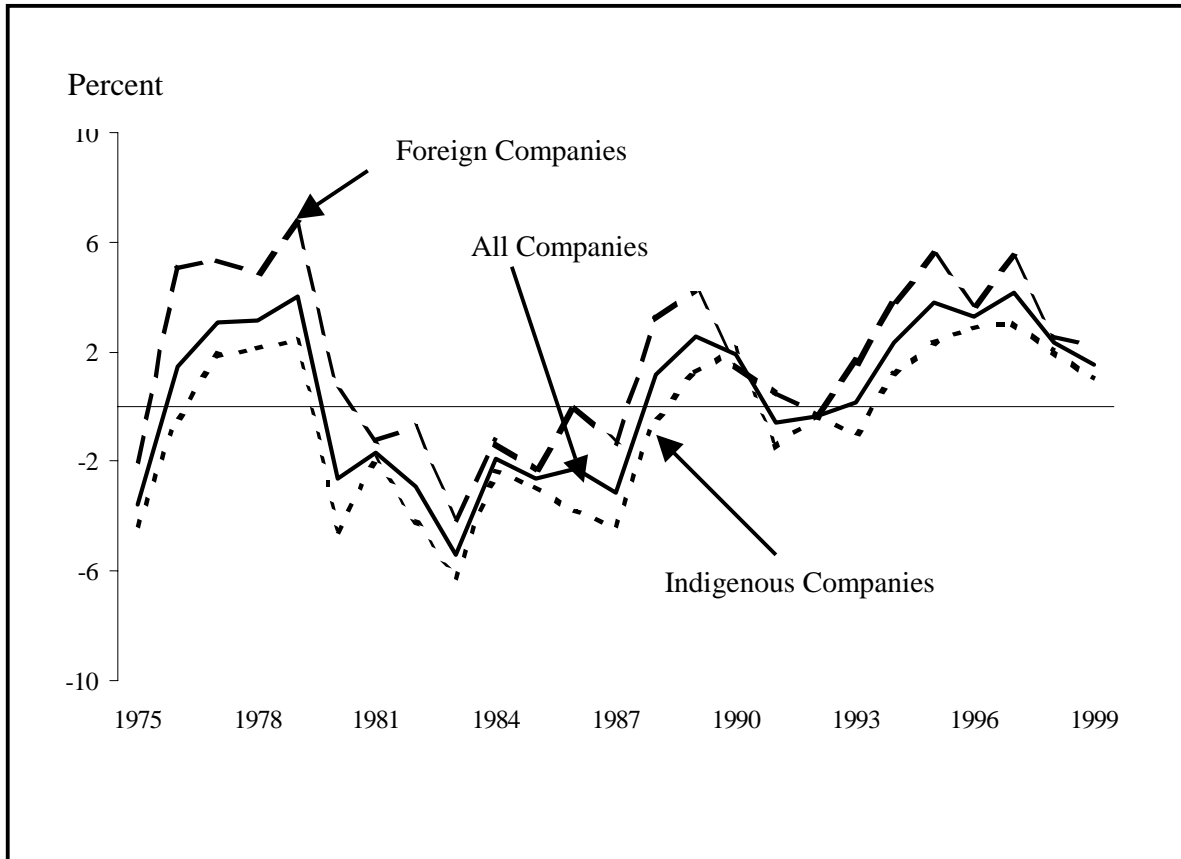


Figure 3
Portfolio Characteristics of the 2 Sector Model

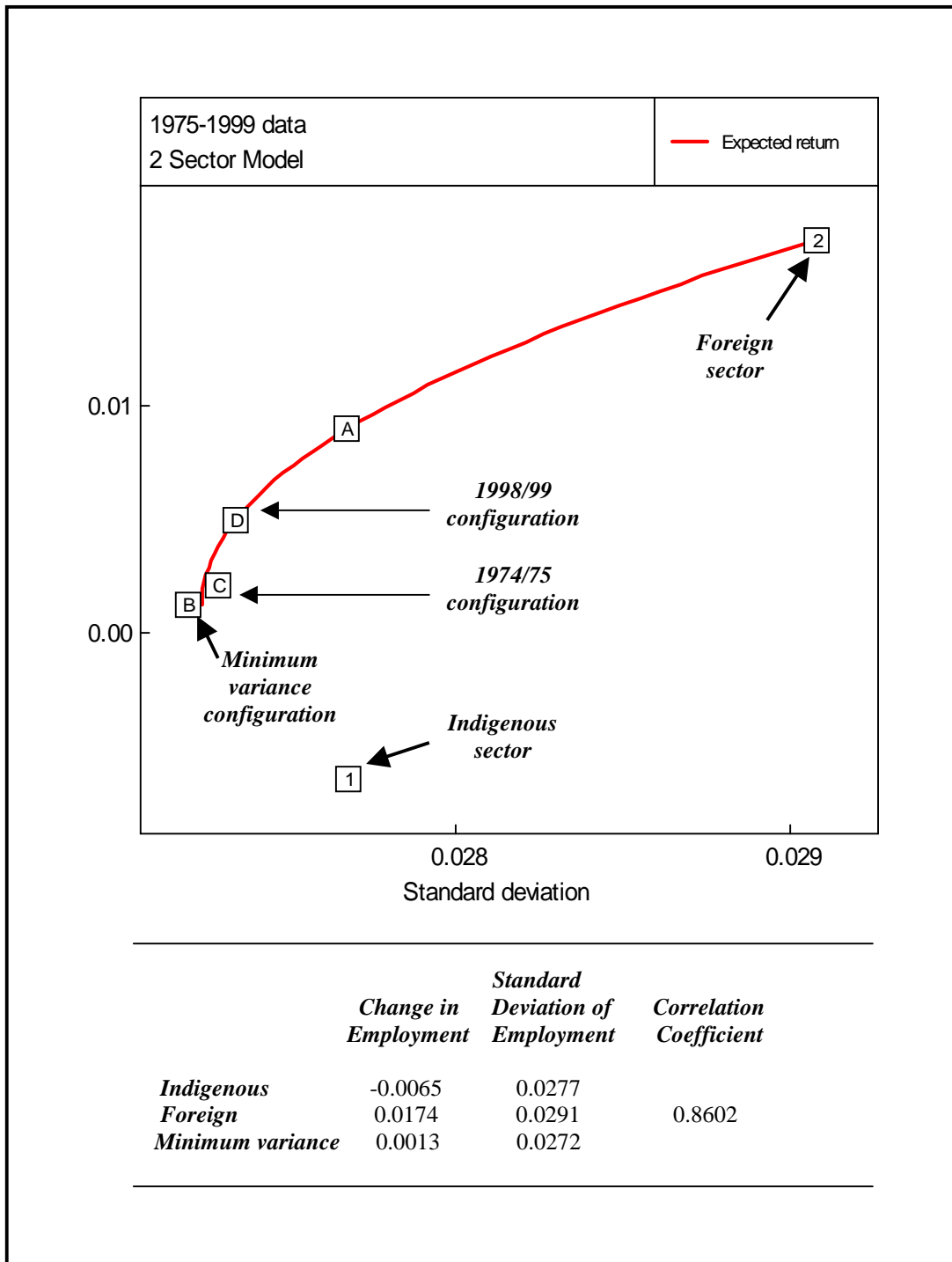


Table 6
Characteristics of Actual Portfolios in the 10 Sector Model

	<i>Weight at start</i>	<i>Weight at end</i>	<i>Mean</i>	<i>Standard deviation</i>
<i>Indigenous sector</i>				
Food, beverage and tobacco	0.20	0.15	-0.008	0.024
Textiles, clothing and footwear	0.14	0.04	-0.050	0.044
Paper, printing and publishing	0.06	0.05	-0.004	0.025
Pharmaceuticals	0.00	0.00	0.039	0.092
Iron, steel, and metal products	0.05	0.06	0.011	0.063
ship, cars, aircraft and transport nec	0.02	0.02	0.002	0.064
professional instruments	0.00	0.01	0.049	0.068
Office, computer equipment and electrical	0.04	0.06	0.020	0.049
Miscellaneous	0.11	0.09	0.000	0.042
Chemicals, rubber, plastics	0.04	0.04	-0.001	0.040
<i>Foreign sector</i>				
Food, beverage and tobacco	0.09	0.05	-0.016	0.024
Textiles, clothing and footwear	0.06	0.03	-0.033	0.066
Paper, printing and publishing	0.01	0.01	-0.016	0.061
Pharmaceuticals	0.01	0.05	0.072	0.050
Iron, steel, and metal products	0.03	0.02	-0.013	0.072
ship, cars, aircraft and transport nec	0.04	0.03	0.002	0.080
professional instruments	0.01	0.05	0.064	0.075
Office, computer equipment and electrical	0.03	0.17	0.077	0.070
Miscellaneous	0.02	0.02	-0.012	0.062
Chemicals, rubber, plastics	0.03	0.04	0.014	0.049

Figure 4
Portfolio Characteristics of the 20 Sector Model

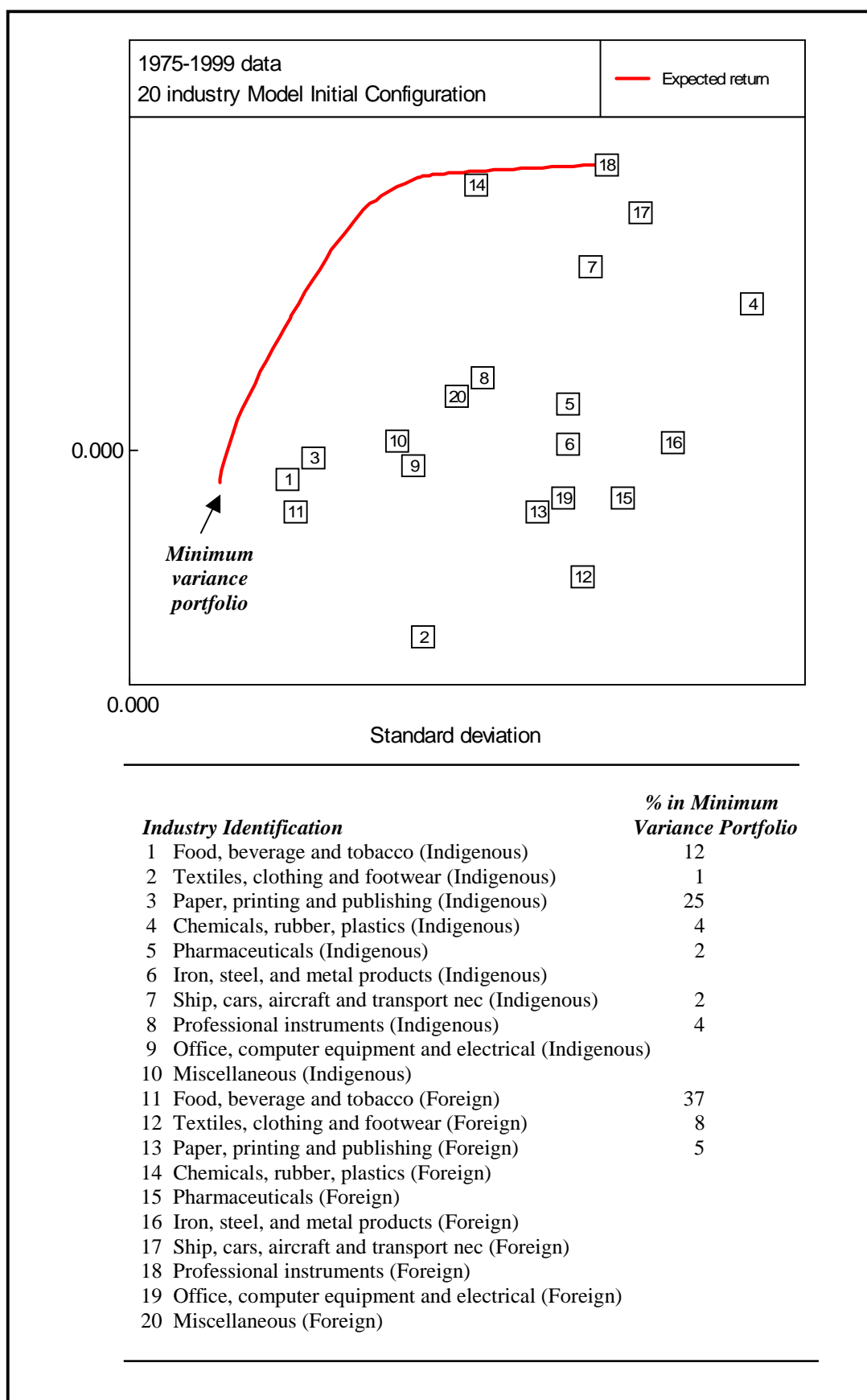


Figure 5
Ireland's Industrial Structure Modelled within the 20 Sector Model

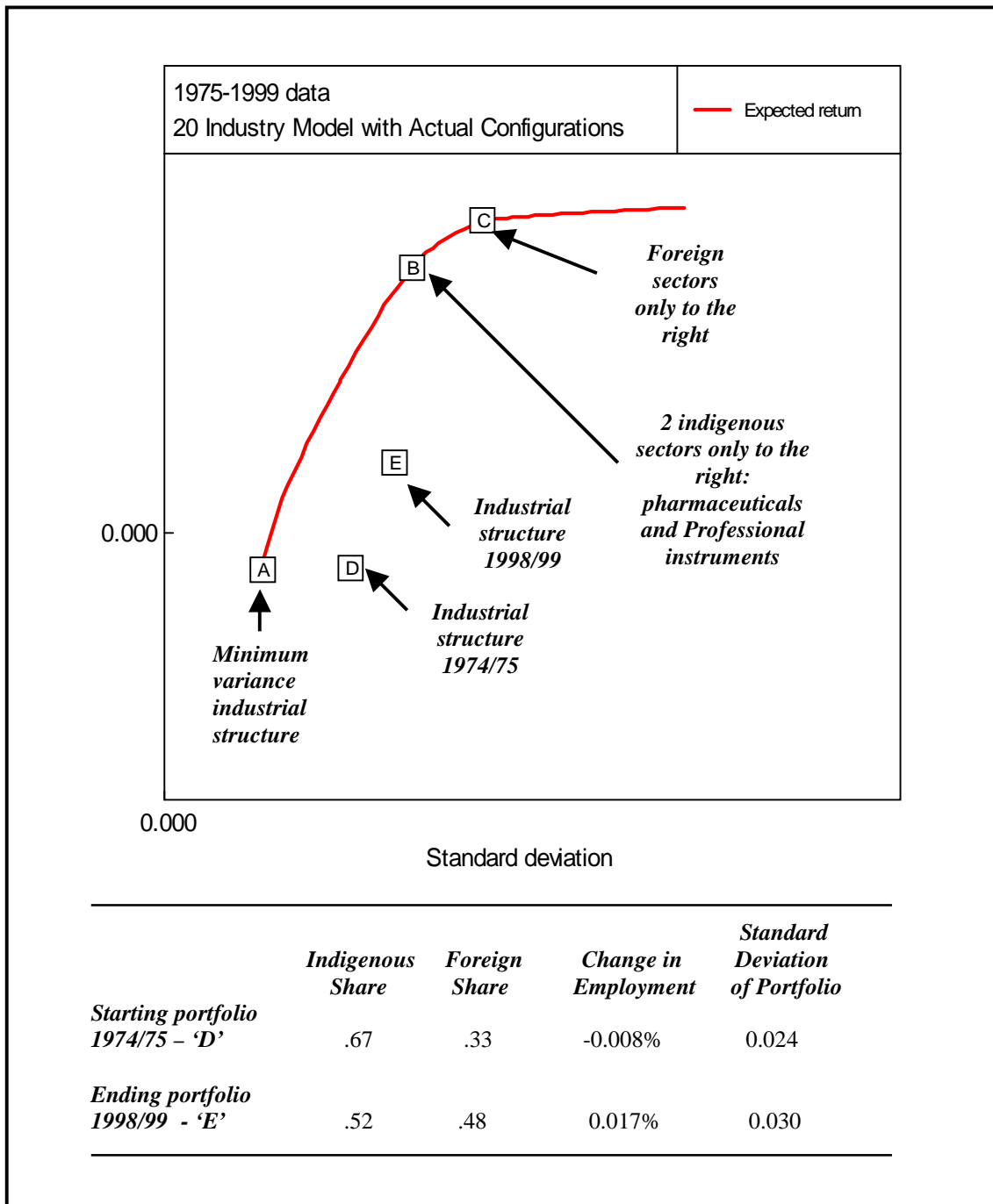


Figure 6
Efficiency Gain in Ireland's Industrial Structure

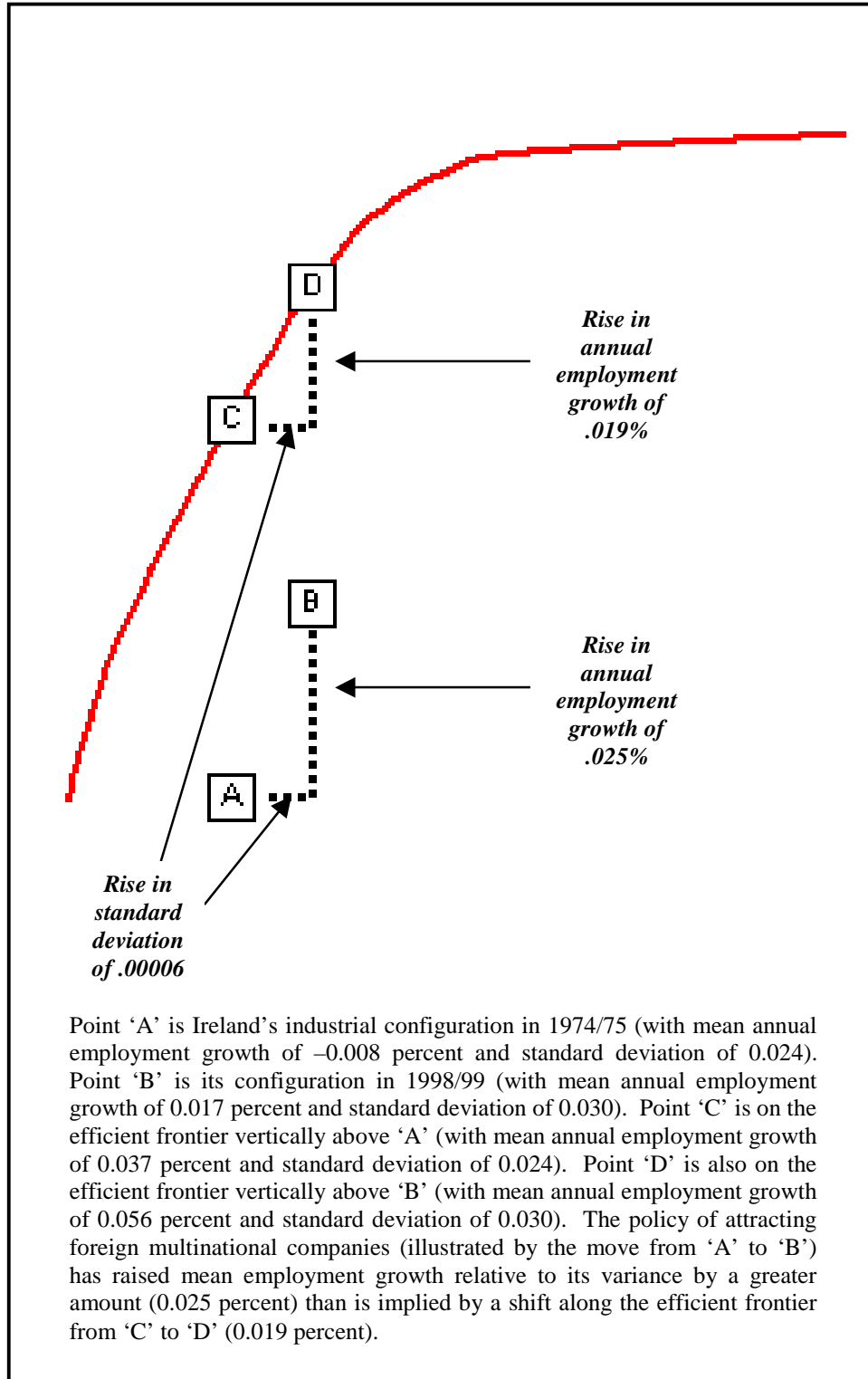
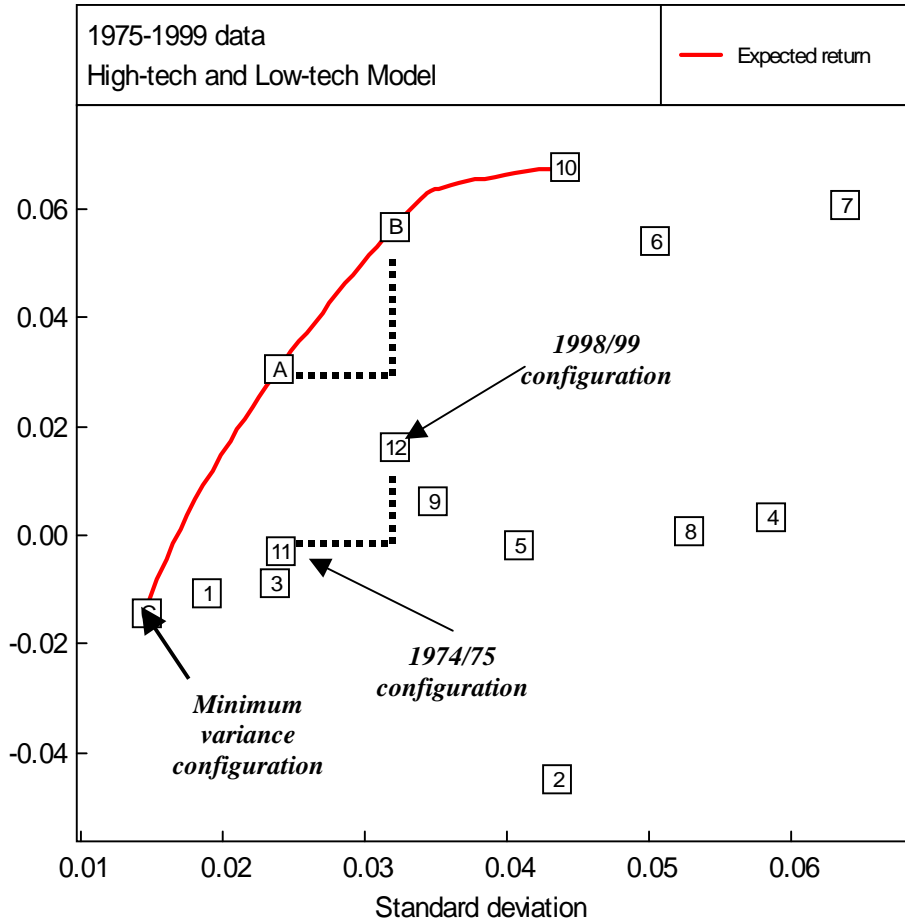


Figure 7
Portfolio Characteristics of the 10 Sector Model
 With 5 Low-Tech and 5 High -Tech Sectors



- [1] Food, beverage and tobacco
- [2] Textiles, clothing, leather products and footwear
- [3] Paper, printing and publishing
- [4] Iron, steel and metal products
- [5] Miscellaneous
- [6] Chemicals, rubber and plastics
- [7] Pharmaceuticals
- [8] Ships, cars, aircraft and transport nec
- [9] Professional instruments
- [10] Office computer equipment and electrical
- [11] Total Low-tech
- [12] Total High-tech

	<i>Low-tech Share</i>	<i>High-tech Share</i>	<i>Change in Employment</i>	<i>Standard Deviation of Portfolio</i>
<i>1974/75 - '11'</i>	.77	.23	-0.006%	0.024
<i>1998/99 - '12'</i>	.52	.48	0.017%	0.032

Bibliography

Barry, F. 2000. Convergence is not Automatic: Lessons from Ireland for Central and Eastern Europe, *World Economy*, 23 (10), pp. 1379-1394.

Barry, F., and M. Bergman (2002) "Determinants of Sectoral and National Employment Volatilities", unpublished ms., Lund University.

Elton, E.J and M.J Gruber (1995), *Modern Portfolio Theory and Investment Analysis*, John Wiley & Sons Inc, New York.

Ghosh, A., and H. Wolf (1997) "Geographic and Sectoral Shocks in the US Business Cycle", NBER Working Paper 6180.

Goldberg, M., and M. Levy (2000) "The European Union as a Country Portfolio", *European Journal of Political Economy*, 16, 411-427.

Gorg, H., and E. Strobl (2002) "Multinational Companies and Indigenous Development: An Empirical Analysis", *European Economic Review*, 46, 1305-1322.

Gorg, H., and E. Strobl (2003) "Footloose Multinationals?", *Manchester School*, 71, 1, 1-19.

Gunther, J., and J. Robinson (1999) "Industry Mix and Lending Environment Variability; What does the Average Bank Face?", *Economic and Financial Review*, Federal Reserve Bank of Dallas, Q2, 24-31.

Krugman, P. (1997) "Good News from Ireland: A Geographical Perspective", in Alan Gray (ed.) *International Perspectives on the Irish Economy*, Dublin: Indecon.

Lilien, D. (1982) "Sectoral Shifts and Cyclical Unemployment", *Journal of Political Economy*, 90, 777-93.

Mac Sharry, R. and P. White. 2000. *The Making of the Celtic Tiger: The Inside Story of Ireland's Booming Economy*, Dublin, Mercier Press.

Meon, P.G., and L. Weill (2001) "Has European Integration led to Macroeconomic Risk Diversification? A Portfolio Approach", unpublished paper, presented at the Annual Money and Macro Conference, Queen's University, Belfast.

Palley, T. (1992) "Sectoral Shifts and Cyclical Unemployment: A Reconsideration", *Economic Inquiry*, 30, 117-133.

Stockman, A. (1988) "Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries", *Journal of Monetary Economics*, 21, 387-409.