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# Integrated Logistics and Supply Chain Management: the State of Practice in Ireland

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**Integrated Logistics and Supply Chain Management: The State of  
Practice in Ireland**

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## **Integrated Logistics and Supply Chain Management: The State of Practice in Ireland**

**Keywords** – Competitiveness, transport, infrastructure, supply chain management.

### **Abstract**

The Republic of Ireland and Northern Ireland were provided with aid to offset locational disadvantages in the run up to the Single European Market. Since then the Republic has emerged as the fastest growing member of the E.U. Success has not been underpinned by the transport system, suggesting that business has had to overcome locational disadvantages by strong performance elsewhere in the supply chain. The evidence indicates that there are Irish firms operating supply chain management techniques at a truly international standard. The problem is that there are so few in that category Meeting Ireland's competitiveness challenge means closing the gap between the small group of large and foreign-owned firms, which display excellence in SCM, and the larger group of indigenous small and medium size businesses, which do not.

## **1. Introduction**

The Island of Ireland encompasses two economies, the Republic of Ireland (ROI) and Northern Ireland (NI), which is part of the United Kingdom. They share great similarities in terms of geography and location, and to lesser extent demographic conditions. Both were poor and viewed as being peripheral areas of the then European Community when they were provided with substantial aid to offset their anticipated economic disadvantages in the run up to creation of the Single European Market. However, since then the Republic has emerged as the fastest growing member of the European Union for much of the last decade while Northern Ireland has languished as a relatively poor region within the United Kingdom.

During the peak of the 'Celtic Tiger', which refers to the Irish Republic in its accelerated growth phase in the 1990's, the economy was growing at a rate, which would effectively double its size in a decade. The emergence of the Celtic Tiger has been attributed to three main factors;

- EU accession offered opportunities to exploit the large agricultural sector and market diversification
- active promotion of inward investment
- the economy exploited both its natural assets and a supportive policy environment very successfully.

While much of Northern Ireland's difficulties can be attributed to some three decades of political unrest and violence, other factors, including dependence on growth fuelled by the public sector rather than the private sector, are increasingly

recognised as contributing to the gap in performance between NI and ROI which now puts the Republic well ahead of the North in terms of GDP and GNP. Indeed on the basis of GDP the Republic is now achieving significantly higher levels than the United Kingdom and most of the EU.

## **2. Overcoming Ireland's Locational Disadvantages and Economic Success.**

It is this unprecedented and unanticipated rate of economic development, which prompts the question, as to how in the face of Ireland's locational disadvantages and size has the Republic been able to achieve such success. Economic analysis suggests that key drivers of growth are the quantity and quality of an economy's productive factors and the way in which these are combined. These interactions determine the underlying rate of productivity growth. Factor accumulation and productivity growth, are also affected by the broader institutional environment. A key focus for small open market countries, too small and poor to support a rapid accumulation of labour and capital, is the promotion of exports. This can be accomplished most rapidly, by attracting foreign investment with an export bias to locate in the region. The productivity of the economy is improved through restructuring from low productivity traditional sectors to high productivity export oriented sectors.

Sustained growth is underpinned by competitiveness, innovation, skills, enterprise and infrastructure. It is widely argued that a key factor in explaining the Republic's success has been its generous fiscal regime, with company tax levels for instance, less than half those in NI and the UK generally. However, competitive advantage in attracting FDI is also influenced by factors other than company tax rates. Areas of

competitive advantage include: the education system, the role of the Government's Industrial Development Authority (IDA), the role of "soft" supports, and clustering and agglomerations including a pool of workers with requisite skills and technological spillovers with the clustering of high-technology industries in the country. (Krugman, 1997)

Language and a familiar institutional environment also represent a geographical bridge between the United States and the EU. Proximity between FDI home and host locations remains a significant determinant of FDI inflows (Slaughter, 2003 ; Krugman, 1997). Distance remains of importance today because of the impediments it places on the speed and ease of communication. Combined with a convenient time zone for companies with worldwide operations, these factors mean that the United Kingdom and Ireland are likely to remain favoured locations for US investors in Europe. However, notwithstanding these advantages Ireland has to offset locational disadvantages.

In a global economy infrastructural inadequacies undermine international competitiveness in several ways. Inward investment is diminished, as companies prefer locations with transport and communications links that allow for the efficient and cost-effective movement of goods, people and information. Inadequate infrastructure leads to increased costs and lower productivity across the enterprise sector. Firms have difficulty in getting raw materials and delivering finished goods. This affects their ability to respond rapidly to market demands. Opportunities for regional development cannot be fully exploited.

Poor quality public transport and a congested road network hamper labour mobility, impede labour market flexibility and have a negative impact on quality of life. As companies seek to employ skilled people, the need for labour mobility and labour market flexibility increases. As companies invest in subsidiaries and work with international outsourcing partners, the ease of travel in and between different countries is essential. Companies require world-class distribution networks and services to ensure cost-effective supply chains and reduced time-to-market for products.

The question which this poses is how much has infrastructure and option of best practice in supply chain management contributed to Ireland's remarkable economic performance in recent years. Addressing this question provides the focus of this paper.

### **3. Overcoming Ireland's Locational Disadvantages: Transport System and Infrastructure Performance**

According to the Irish report 'Ahead of the Curve' (Enterprise Strategy Group, 2004), enterprises will thrive only if the physical infrastructure and communications networks are efficient and adequate for international trade. How then does the ROI rate?

One objective measure of the state of a country's transport, energy and communications systems is infrastructure stock relative to national income. According to Ireland's National Competitiveness Council (NCC) Ireland ranks 11th out of 12 countries on the basis of this indicator (Figure 1).

Insert here: **Figure 1: Infrastructural Levels (Public Capital Stock as a % of GDP), 2002**

This position is in part explained by cuts in public investment during the late 1980s, which coupled with high GDP growth rates in the 1990s resulted in a steady fall in public capital stock as a percentage of GDP since that time (Figure 2).

Insert here: **Figure 2: Public Capital Stock as a % of GDP (1991-2001)**

In the last few years the position has changed remarkably. Ireland's total capital investment in infrastructure in 2005 was the third highest in the EU 25. The National Competitiveness Council (2005) confirmed government investment in Ireland is now significantly higher than in most developed economies (2nd/11). By contrast for some three decades in Northern Ireland, factor accumulation and in particular investment in new capital stock was undermined, by the fragile political environment associated with 'The Troubles'. This very substantial increase in spending is very evident in transport investment in the ROI through comparisons with NI, Scotland, Wales and the UK as a whole. After allowing for population differences Ireland is



now spending vastly greater sums than devolved governments in either Northern Ireland or Wales. The recently announced ten year spending programme for transport lifts capital spending in the ROI well ahead of the UK as a whole or any of the devolved territories in relation to new facilities.

Of greater significance however, is what the spending of taxpayers' money actually yields in terms of the performance of the system and the level of service offered to the user. Notwithstanding recent investment levels, coarse supply side indicators highlight the continuing relatively low levels of motorway and mainline railway provision in Ireland, compared to other EU member states. However, comparisons with countries such as Germany and France are not particularly meaningful. Comparisons with countries with smaller populations such as Scotland and Denmark put Ireland in a more favourable light.

Despite the recent high levels of investment in infrastructure however, a recent World Economic Forum survey (2005) found that Ireland's infrastructure is currently perceived to be poorly developed and inefficient relative to other developed countries. Infrastructure (including road, rail, air and sea transport) is perceived, as rather poor by many industrialists in Ireland (Figure 3).

Insert here: **Figure 3: Overall Infrastructure Quality, 2004 (Scale 1-7)**

The evidence offered above however provides a rather coarse and/or highly subjective basis on which to address the question posed in this paper; how much has infrastructure and option of best practice in supply chain management contributed to Ireland's remarkable economic performance in recent years. Let us consider more detailed evidence on the performance of Ireland's transport system and the wider supply chain.

#### **4. The NITL SCM Barometer Survey**

The remainder of this paper draws heavily on the National Institute for Transport and Logistics' (NITL) SCM Barometer survey and report 'Competitive Challenges: Chain Reactions (2005)' The survey elicited the satisfaction of individual businesses with elements of the transport system and the extent to which transport constrains business development. The core of the survey however, sought insights into awareness of SCM best practice and the extent of take up among companies across various activities including:

- Customer Service
- Demand Forecasting
- Procurement/Purchasing
- Warehousing
- Inventory Management
- Transport
- Finance
- Information Communication Technology
- Integration and Partnerships

as well as use of supplier key performance indicators (KPI's) and business performance. In addition the survey elicited data on company profile in terms of e.g. sector, size, ownership, and market locations.

The basis of the report was an island wide survey of businesses. 2,321 companies (both multinationals as well as small and medium sized companies), randomly selected from established industrial databases across all sectors in Ireland (see NITL, 2005). A response rate of 47% (1073 organisations) was achieved. The sample design was drawn up to inform an understanding of differences in adoption of SCM practice between sectors of the economy, including multi-national and indigenous firms, and between different areas of the island including cross border comparisons.

776 responses came from companies based in the ROI (with approx. 38% of companies from the Greater Dublin area), while 297 responses were obtained from companies based in NI. The sample is broadly representative for the population of Irish companies by e.g. firm size, ownership; sector and strategic classification.

## **5. The NITL SCM Barometer Survey: Evidence of the Performance of the Transport System**

Overall, levels of satisfaction with the transport system were higher in Northern Ireland than the Republic of Ireland. This can be attributed in part to differences in the level of economic activity and market reach and expectations of business the two economies. Overall the Republic's market reach globally is much more extensive than Northern Ireland.

Insert here: **Figure 4: Reported satisfaction with transport systems**

It is important to emphasise that the pattern of perceived performance is not uniform across all sectors of transport. For instance, internal public transport rates particularly poorly. In contrast external transport facilities are rated significantly better than internal facilities. Air transport, however, attracts a growing and significant market for freight by value, particularly among newer industries focusing on high value/low weight products attracted to Ireland in recent years. The reported satisfaction with air carriers is relatively high for both ROI and NI firms, especially in relation to the punctuality of carriers and fares. This is also confirmed by, the National Competitiveness Council in 2004, which ranked the quality of air transportation in Ireland 4<sup>th</sup> out of the 16 countries benchmarked. However, the availability of direct air services is for many firms not very satisfactory (See figure 5).

Insert here: **Figure 5: Reported satisfaction with air carriers**

Turning to the implications of the transport system for company performance now and in the future, 45% of firms in the ROI and 19% of businesses in NI claimed the state of transport infrastructure was constraining their business. The reported problems relate mainly to costs and ensuring deliveries on time (see 6). Once again the divergence between NI and the ROI can be linked to the much greater involvement of companies in the Republic in global markets and variations in the rate of growth in the two economies – high rates of economic growth almost inevitably puts pressure on existing infrastructure.

Insert here: **Figure 6: Reported transport infrastructure constraints**

It appears on the basis of the evidence assembled that economic success in the Republic of Ireland has not been underpinned by excellence in the transport system. This would tend to suggest that business has had to overcome locational disadvantage by strong performance elsewhere in the supply chain.

## 6. The NITL SCM Barometer Survey: SCM Performance among Businesses located in Ireland

### Characteristics of SCM Excellence

While there are many characteristics of SCM excellence, they can be summarised under the three headings on which the survey focused:

- ***Awareness and Integration*** of supply chain activities and information because it pays to do so.
- ***SCM a senior management function*** because SCM is a strategic activity.
- Establishment and measurement of supply chain ***key performance indicators (KPIs)*** because what gets measured gets done!

Excellence in these three SCM elements at the micro level can improve overall competitiveness of Irish firms at the macro level.

### ***Awareness and Integration of supply chain activities and information***

Overall company performance may be improved, by a high level of SCM awareness and integration. Respondents were asked to assess the importance of specific SCM elements. 'Upfront' functions, such as customer service, customer relationship management, after sales service or sales order processing were ranked highest, by companies both in NI and ROI. Warehousing and inbound transport scored less strongly. This may reflect extensive outsourcing of these activities, which has taken place in recent years.

The survey also investigated the perceived importance of specific supply chain management practices among Irish firms. Overall, conventional or traditional SCM activities such as JIT or on time deliveries were rated more important than more recent additions to the SCM toolbox such as information sharing with suppliers and customers. What is perhaps striking is that very few of these new measures were deemed to be definitely unimportant which perhaps suggest that attitudes could be changed by education and training.

Irish firms demonstrate a relatively low level of integration in certain supply chain activities. There are no significant differences between ROI and NI in this respect. There is scope however, to enhance links between warehousing, inbound transport, and new product introduction and demand forecasting, even if these are regarded as being of less importance.

Apart from the importance and the integration level of SCM elements, the perceived effectiveness was also assessed. Similar trends to those discussed above in relation to integration are evident and there are no statistically significant differences between ROI and NI.

The lower level of effectiveness in inventory management and demand forecasting for example may be partly explained by the low extent of customer involvement and supplier involvement. The extent of supplier and customer involvement in supply chain activities is low in the areas of forecasting, supply chain transparency and inventory management, a feature found among both ROI and NI companies. Involving suppliers and customers is one way of gaining strategic flexibility through

reduced cost, reduced concept-to-customer development time, improved quality, and access to innovative technologies that can help firms gain capture market share (Handfield et al., 1999).

### ***SCM Organisation: A Senior Management Function?***

Who is responsible within the company for SCM says much about the importance it is accorded within the firm. Quayle (2003) suggests that there is a need for a board level priority to be given to supply chain management. In the past it has been treated as a function more appropriately handled lower down the management hierarchy. At the strategic level, responsibility for SCM rests typically with the Managing Director. The survey revealed that only 8.5% of companies have a specialised SCM or logistics manager (ROI 8.8% and NI 7.6%). Most Irish based firms pay 'lip service' to the importance of the SCM elements and objectives but do not put in place the organisation structure to support the implementation.



### ***Establishment and Measurement of SCM Key Performance Indicators***

The measurement of anything, including cost is a fundamental element of management – ‘what gets measured gets managed’. While most companies realise the importance of SCM, few of them have clearly defined SCM Key Performance Indicators (KPIs).

Knowledge of supply chain costs is critical to assessing and maximising any business’s competitiveness and profitability. However, 58% of companies do not know their total supply chain costs (ROI = 59%; NI = 57%). Of those that report knowing their supply chain costs, these were reported to be on average 34% as a percentage of turnover (ROI = 34%; NI = 33%) and 40% of total costs (ROI = 38%; NI = 43%). However, this begs the question as to what SCM costs refer to. Respondents were asked to define what they included as comprising their SCM costs (see Figure 7)

Insert here: **Figure 7: What is included in the supply chain costs?**

For many companies SCM is seen as being synonymous with transport. Relatively few companies include other SCM elements as part of total SCM costs. However, transport and freight costs represent only a part of total SCM costs (Figure 8).

Insert here: **Table 1: Breakdown of SCM elements into average percentages of total supply chain costs**

Best practice in SCM is predicated on the potential for trade-offs between all the aspects of the supply chain. For instance, lower inventory levels and improved service levels can be balanced against higher transport costs. If other supply chain costs are not included as part of the total SCM costs then companies will continue to try to optimise the individual costs e.g. lower transport costs, at the expense of sub-optimising the total SCM cost.

Effective management of any SCM function depends on establishing key performance indicators (KPIs) and measuring performance against these on a regular basis. It would be expected in 'best practice' companies to have KPIs in place for all of the key SCM elements. The survey sought information from respondents on whether they had clearly established KPIs in place for the SCM elements.

Insert here: **Figure 8: Integration of key performance indicators for supply chain management**

In Northern Ireland for instance, the extent of use of KPIs measuring customer service is significantly lower than in the Republic of Ireland. Moreover, only 19% of respondents are carrying out or planning total supply chain management programmes or related projects (ROI = 23%; NI = 11%).

The survey offered insights on the measurement and contribution of a variety of SCM functions including:

- Customer Service
- Adoption of
- Procurement / Purchasing
- Inventory Management
- Warehousing
- Transport and distribution

Here we focus on the last of these. 59% of ROI firms claim to know their transport costs while the figure for NI is even lower, at 31% of firms. Transport costs represent on average some 7% of turnover in both the ROI and NI. However, only 30% of ROI firms and 15% of NI companies employ KPIs for transport management. The main KPIs used are on time order deliveries and total transport costs as a percentage of net sales value.

Differences in use of KPIs and knowledge of transport costs may be attributed to variations in the extent of outsourcing. A focus on 'core competencies' has led to 'non-core' activities such as transportation being outsourced. Recent years have seen a big move towards the outsourcing of transport activities to third party logistics (3PL) and fourth party logistics (4PL) service providers. 57% of respondents (ROI = 72%; NI = 32%) report contracting out transport. Respondents also anticipate outsourcing of transportation will increase in the next three years, along with just-in-time and overnight deliveries as well as shorter delivery times.

### ***Excellence in SCM: The Relationship with Company Performance***

In order to establish the extent to which best practice yielded business performance benefits a key element of the survey analysis involved definition of a composite index of company SCM performance designated 'supply chain practice'. The index with values in the range 6–90 is composed of scores relating to:

- Extent of integration of supply chain functions (such as customer service) and data.
- Whether SCM is viewed as a senior management function.
- Measurement of delivery performance KPIs.

Each of the three sections was given a maximum of 30 points. The distribution of index values for the overall sample of companies is exhibited in **Insert here:** Figure 9 below. Index values toward the upper end of the range indicate excellence in supply chain management practice.

Insert here: **Figure 9: SCM Excellence Index**

The profile of results points to a relatively small group of excellent firms (less than 6% of companies), another approx. 30% with reasonable levels of performance levels and the remaining two thirds of companies which have yet to establish best practice in SCM. ROI and NI firms score on average 58 points each. This finding suggests SCM improvement potential in particular for two thirds of the companies surveyed.

Overall the survey findings indicate there are Irish firms operating supply chain management techniques at a truly international standard. The problem is that there are so few in that category. For instance: less than 1 in 10 companies, usually large and often with foreign owners, are putting SCM techniques into effect in a completely sophisticated way; 1 in 4 businesses have taken on board SCM but have done so in a piecemeal manner; approximately two thirds of firms in Ireland have only a passing understanding of what constitutes SCM.

Turning to differences attributable to corporate structure, the survey suggests the bigger the company, the greater the evidence of pursuit of excellence in SCM. As a general rule, large and foreign-owned companies take a more advanced approach to SCM. There is a substantial overlap between these two categories but they are far from being synonymous. In a like for like comparison between large foreign-owned

firms and large Irish-owned firms it emerged that the non-indigenous companies had a more sophisticated approach to SCM.

Irish-owned businesses attach less importance to several key SCM techniques (particularly demand forecasting, warehousing, inventory management and new product introduction) than foreign-owned companies. In line with this integration of these supply chain functions is also lower in Irish firms than foreign-owned companies. However, whatever their ownership, larger companies tend to have higher levels of integration of these SCM elements. Furthermore, foreign-owned companies use KPIs to a greater degree. Only 5% of Irish-owned firms have a SCM or logistics director / manager in comparison to 17% of foreign owned firms.

Turning to the spatial dimension while generally speaking the approach to SCM is similar in NI and ROI there are some important differences worth remarking on. On average NI firms are less aware of some key SCM costs, have been slower to measure their SCM performance in a formal way and are more sceptical of the benefits of introducing the latest IT to enhance efficiency. This is partly explained by two linked factors. The average Northern Ireland company is smaller than its counterpart in the Republic. Secondly NI has a smaller proportion of multinational enterprises.

Just as Northern Ireland lags behind the Republic in the application of SCM techniques, so too within the Republic, companies located in areas away from the Greater Dublin Area (the Border-Midlands-West (BMW) region) fall some way short of the rest of ROI. At least part of the difference in performance is due to differences

in the industrial structure. Exports in the BMW region represent a smaller percentage of turnover (32%) than in the rest of the ROI (37%).

The survey also sought to establish the extent to which SCM excellence is correlated to the overall company performance. The findings reveal that excellence in Supply Chain Management is a key determinant of overall company performance i.e. firms employing best practice in SCM are more competitive, those that do not are at a competitive disadvantage.

Insert here: **Figure 10: Average SCM excellence score and overall company performance**

Overall, Irish firms score less on the SCM excellence index than foreign-owned companies. Irish companies also score lower in terms of overall company performance than foreign-owned companies.

## **7. Conclusions**

Sustained economic growth is underpinned by competitiveness, innovation, skills, enterprise and infrastructure. In a global economy infrastructural inadequacies undermine international competitiveness in several ways. It is evident that the economic success in the Republic of Ireland has not been underpinned by excellence in the transport system. NITL's SCM Barometer reaffirms evidence that excellence in Supply Chain Management is a key determinant of overall company performance. Business has had to overcome locational disadvantage by strong performance elsewhere in the supply chain.

The erosion of Ireland's competitiveness has become an undeniable threat to sustaining the country's economic success story. When it comes to market access, the Baltic and Central European Member States have some natural advantages over Ireland, most notably proximity to all the major European market and land routes to those markets. And, most importantly, they have a significantly lower cost base.

Looking over the horizon, one of the keys to industrial success for any country will be its managerial competence in advanced supply chain management skills. Ireland can rapidly fall behind eager new EU member states that are becoming a magnet for FDI-resourced economic development if it fails to adopt a more viable vision for its own manufacturing sector. The adoption of World Class SCM is a prerequisite to that vision. So too is continued improvement in key SCM infrastructure supports, namely broadband IT connectivity and air and freight transport on an island wide basis.



Irish companies must become better at how they manage their supply chains than companies in more favourable market locations. The challenge facing companies will vary greatly. For a small number of firms, the task will be to fine-tune what they already do. A third of companies are confronted with a much more wide-ranging review of their activities but at least they probably have some understanding of what's required and can reasonably easily learn what they have to. Meeting Ireland's competitiveness challenge must mean focusing on closing that gap between the small group of typically large and foreign-owned firms, which display excellence in SCM, and the much larger group of indigenous small and medium size businesses, which do not. Irish companies must become better at how they manage their supply chains than companies in more favourable market locations.

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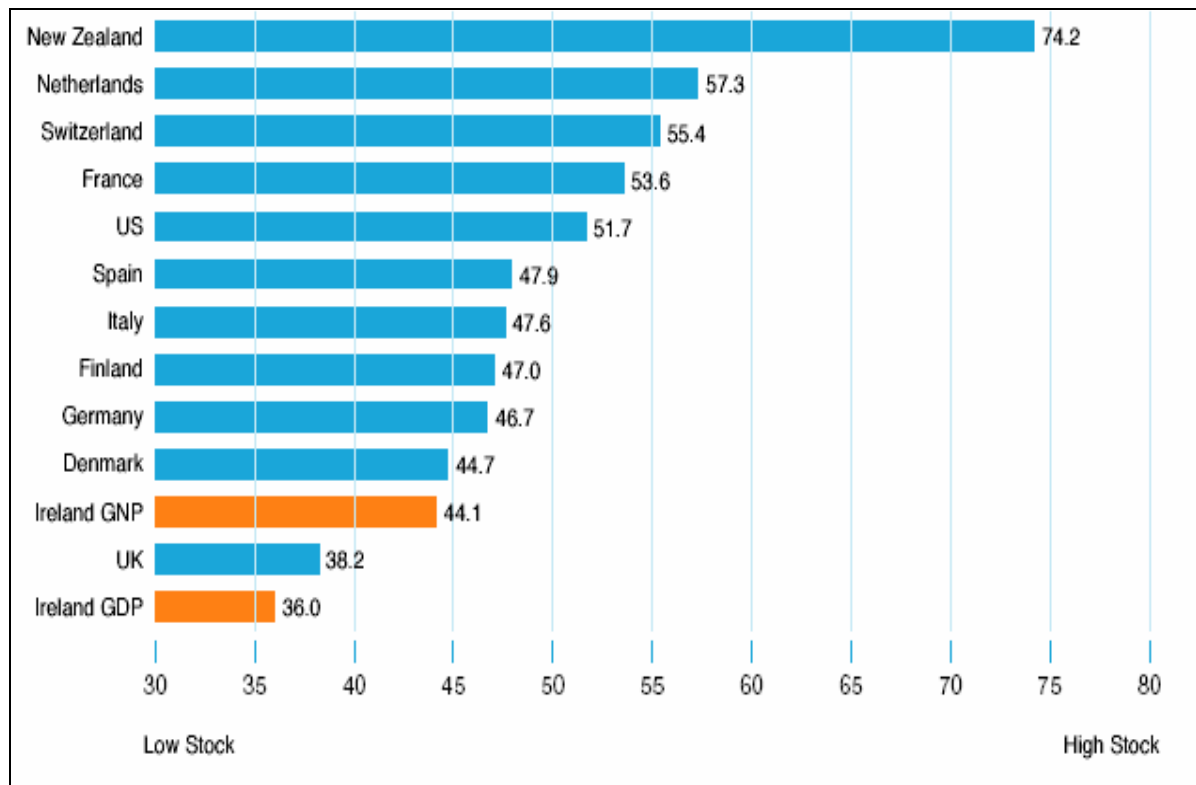
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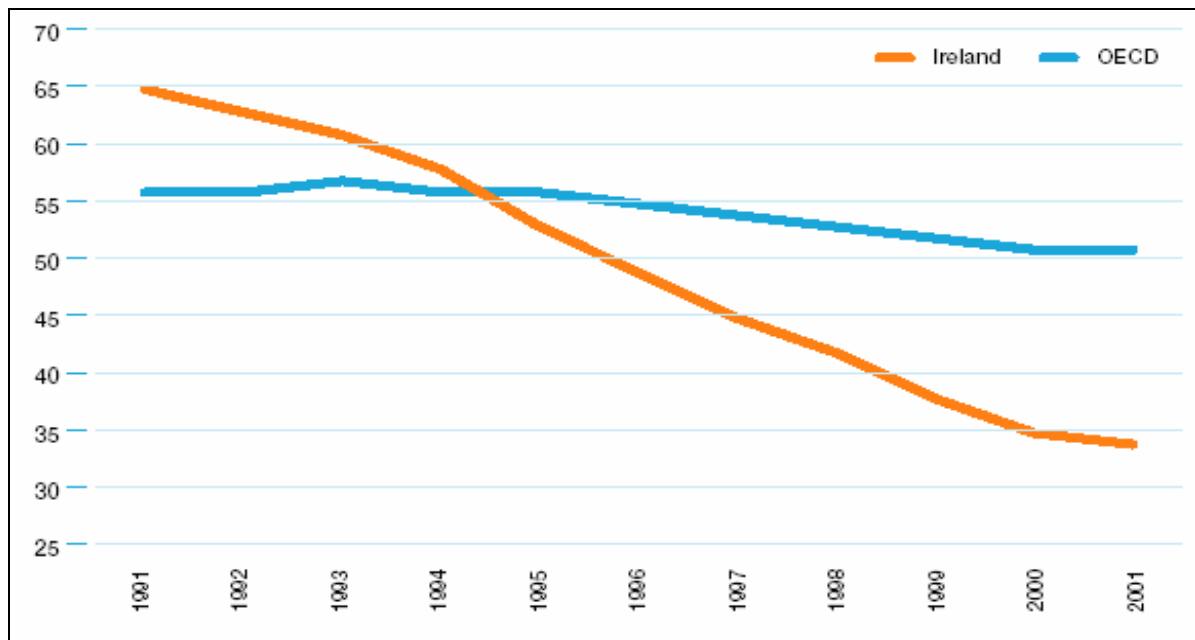
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**Figure 1**



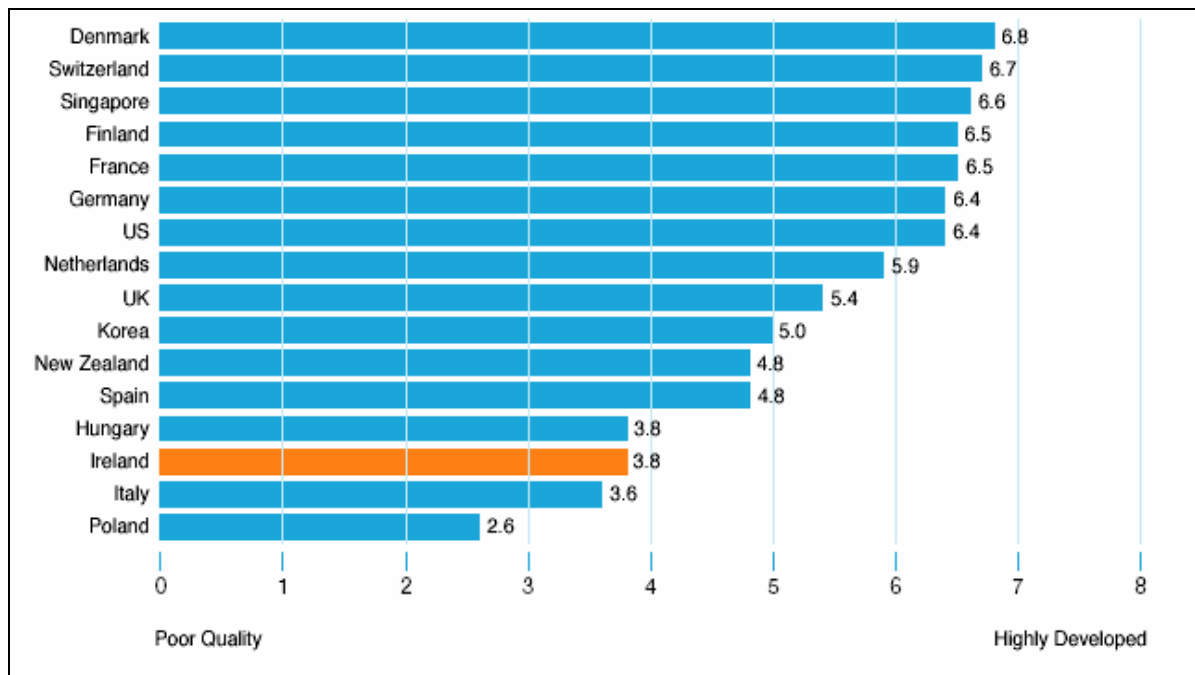
Source: National Competitiveness Council, 2005.

**Figure 2**



Source: National Competitiveness Council, 2005.

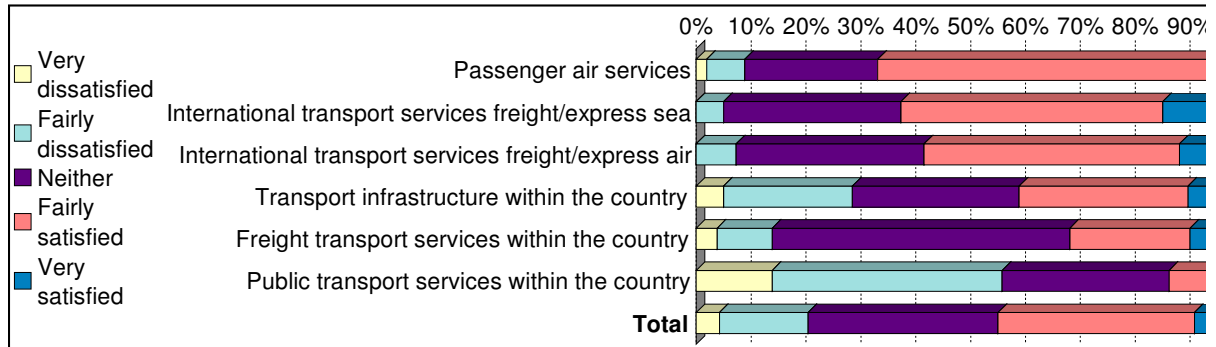
**Figure 3**



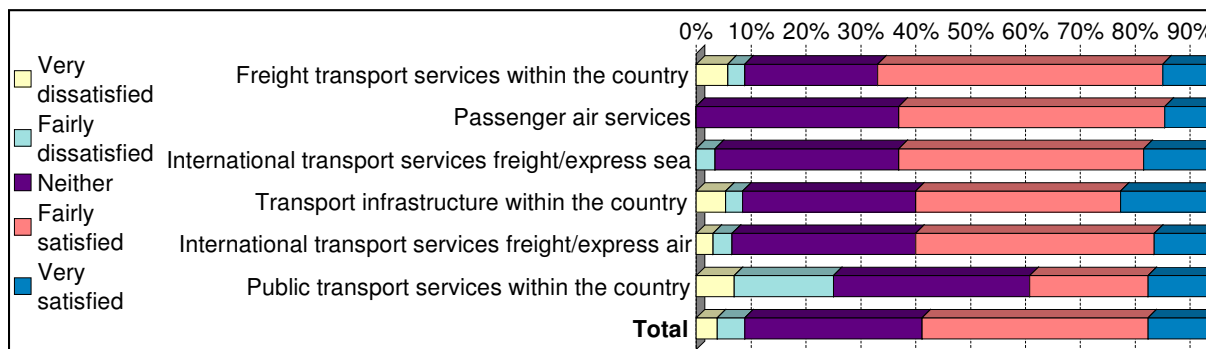
Source: World Economic Forum, Global Competitiveness Report, 2004/2005.

**Figure 4**

**% of ROI companies eliciting transport infrastructure constraints**



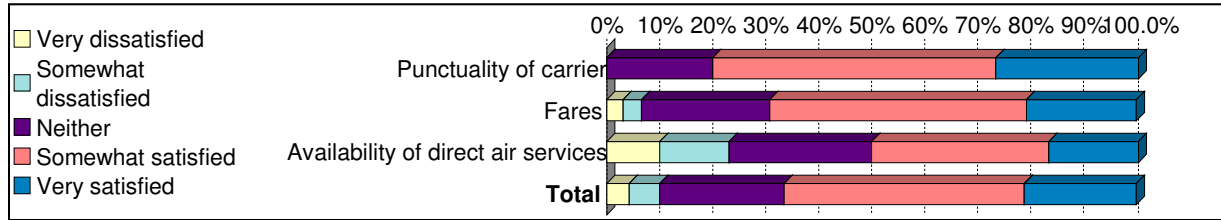
**% of NI companies eliciting transport infrastructure constraints**



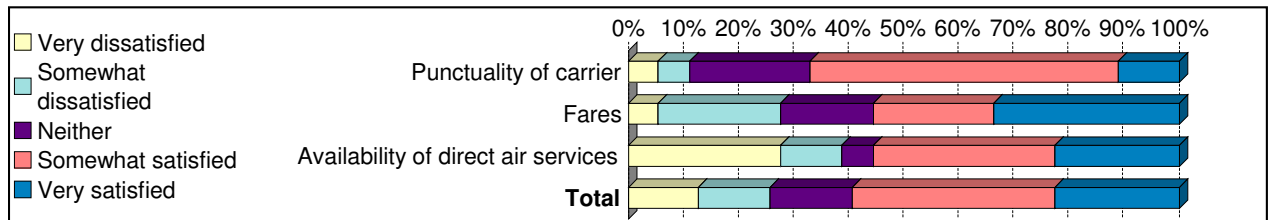
Source: NITL, Competitive Challenges: Chain Reactions, 2005.

**Figure 5**

**% of ROI companies eliciting satisfaction with air carriers**



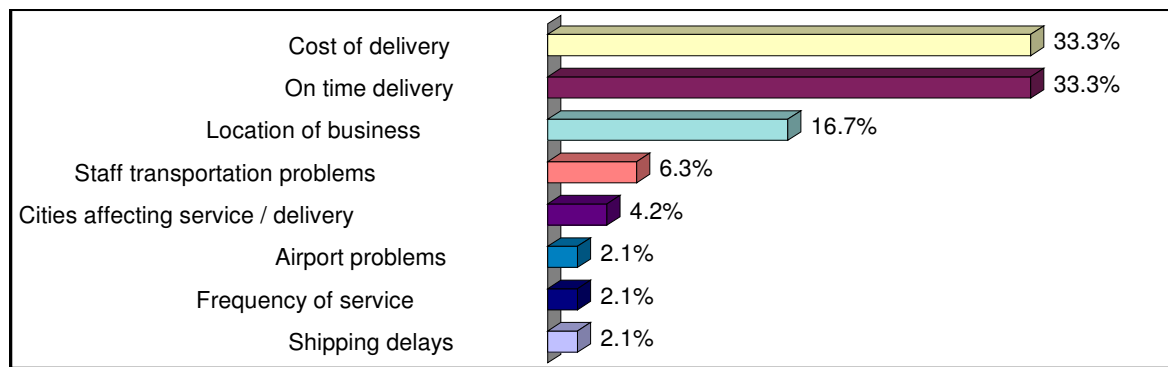
**(% of NI companies eliciting satisfaction with air carriers)**



Source: NITL, Competitive Challenges: Chain Reactions, 2005.

**Figure 6**

**% of companies eliciting transport infrastructure constraints**

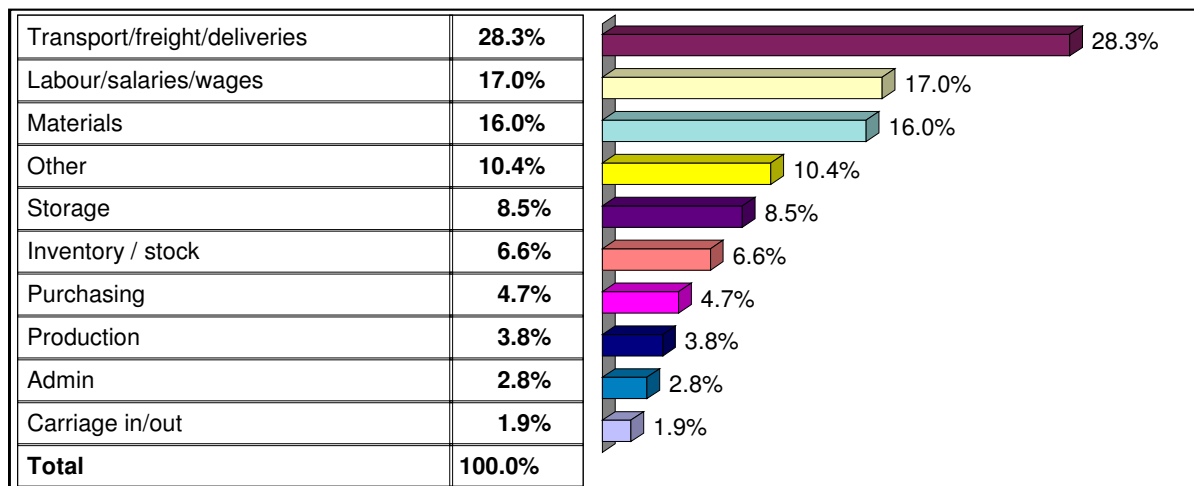


Source: NITL, Competitive Challenges: Chain Reactions, 2005.



**Figure 7**

**% of companies eliciting supply chain cost elements**



**Source: NITL, SCM Barometer 2005.**

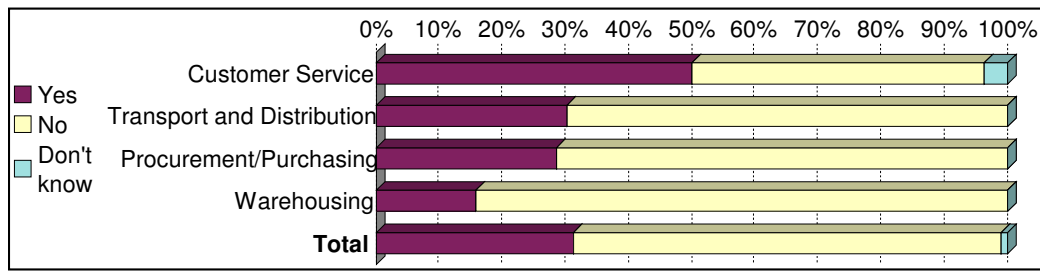
**Table 1**

	Average percentage of total supply chain cost (first item = transport/freight/deliveries)	Average percentage of total supply chain cost? (second item = labour/salaries/wages)	Average percentage of total supply chain cost (third item = materials)
ROI	56.71%	24.50%	10.83%
NI	60.91%	13.00%	18.00%
TOTAL	58.03%	20.67%	13.22%

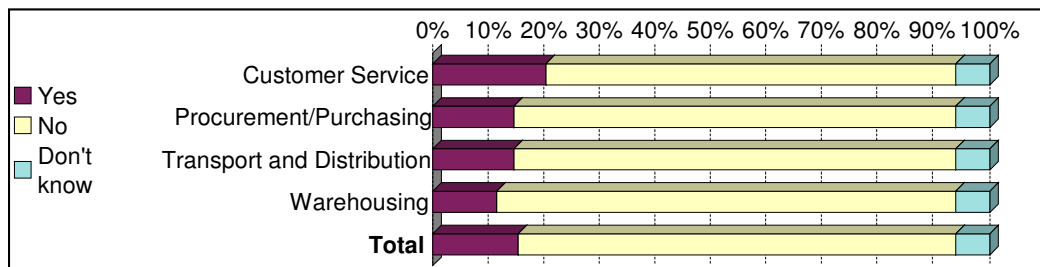
Source: NITL, SCM Barometer 2005.

**Figure 8**

**% of ROI companies eliciting integration of supply chain KPIs**



**% of NI companies eliciting integration of supply chain KPIs**

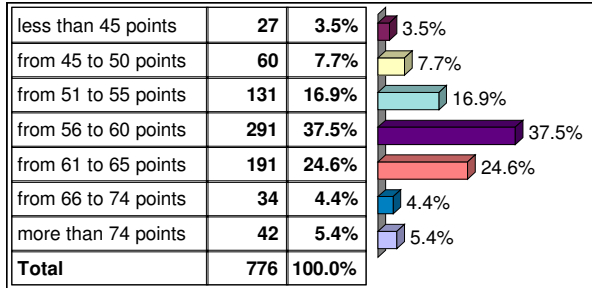


Source: NITL, SCM Barometer 2005.

**Figure 9**

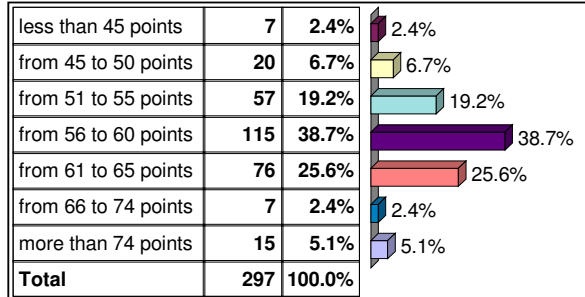
**SCM Excellence Index (ROI firms)**

N %



**SCM Excellence Index (NI firms)**

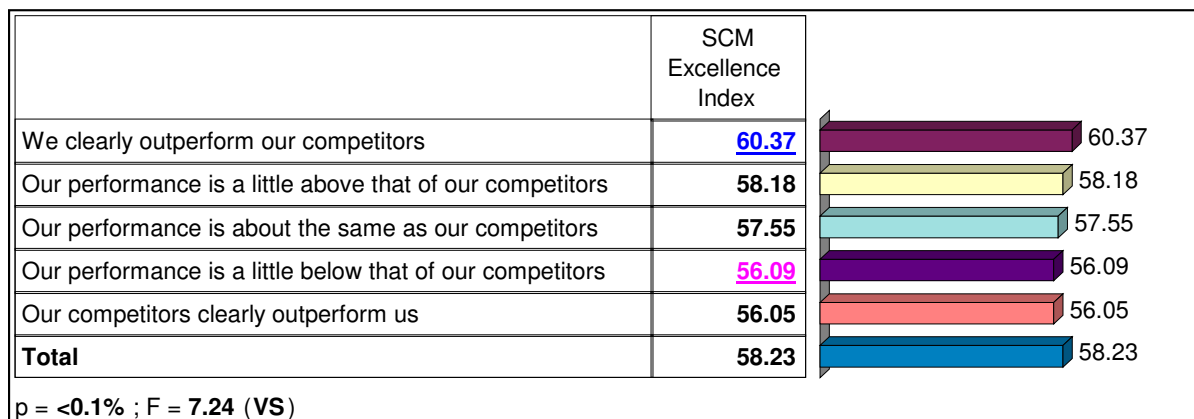
N %



**Source: NITL, SCM Barometer 2005.**

**Figure 10**

Average Score:



**Source: NITL, SCM Barometer 2005.**

**Figure 1: Infrastructural Levels (Public Capital Stock as a % of GDP), 2002**

**Figure 2: Public Capital Stock as a % of GDP (1991-2001)**

**Figure 3: Overall Infrastructure Quality, 2004 (Scale 1-7)**

**Figure 4: Reported satisfaction with transport systems**

**Figure 5: Reported satisfaction with air carriers**

**Figure 6: Reported transport infrastructure constraints**

**Figure 7: What is included in the supply chain costs?**

**Figure 8: Integration of key performance indicators for supply chain management**

**Figure 9: SCM Excellence Index**

**Figure 10: Average SCM excellence score and overall company performance**

**Table 1: Breakdown of SCM elements into average percentages of total supply chain costs**