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Grace Tyng-Ruu Lin^a, Yo-Hsing Chang^a & Yung-Chi Shen^a

^a Institute of Technology Management, National Chiao Tung University, Hsinchu, Taiwan, ROC

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Innovation policy analysis and learning: Comparing Ireland and Taiwan

Grace Tyng-Ruu Lin*, Yo-Hsing Chang and Yung-Chi Shen

*Institute of Technology Management, National Chiao Tung University,
Hsinchu, Taiwan, ROC*

Taiwan and Ireland are regarded as being similar in their geographic positions and economic performances. Both countries moved from being agricultural economies to become major regional players, and are often pointed to as examples of positive national development and innovation. The main purpose of this article is to compare the two island countries' innovation policies in a national context. The taxonomy of innovation policy proposed by Rothwell and Zegveld [1981, *Industrial innovation and public policy*. London: Frances Printer Ltd.] was adopted as the analysis framework for this study. The comparison shows that Taiwan's government employs more top-down policy instruments such as providing government research funding and resources to target industries. The Irish government successfully creates an innovation-friendly environment to attract foreign direct investment (FDI) to facilitate research and development at the firm level. Finally, this article provides policy implications and recommendations based on what was learned from the comparison of the two countries.

Keywords: national innovation policy; country studies; Taiwan; Ireland

1. Introduction

As small island countries, both Taiwan and Ireland have been regarded as locations that have performed economic miracles; one, Taiwan, was part of high growth 'Asian Tiger' economies that included Hong Kong, Singapore, Taiwan, and Korea. The other gained the nickname the 'Celtic Tiger' as its sudden economic rise during the 1990s mirrored the growth of the Asian Tigers during the 1980s. Growing from agricultural economies to major regional players in western and oriental worlds, both have been studied as examples of national development and innovation (Preston 1997; Hsu 2005; Hu and Mathews 2005; Lodge 2005). In particular, studies have documented the remarkable progress of Taiwan and cited government innovation policies as a major factor in this success (Kraemer, Gurbaxani, and King 1992).

National innovation policies are considered especially relevant for small developing economies as part of their adjustment to the changing international, economic, and technological order as well as improvements to their own economic and technological situation (Pack 1992; Davenport and Bibby 1999). According to

*Corresponding author. Email: gtrl@faculty.nctu.edu.tw

the Global Competitiveness Report 2006–2007, published by the World Economic Forum (WEF), Taiwan ranks 9th and Ireland 19th in the field of innovation among the 125 countries included in the study worldwide. In Asia, Taiwan ranks second, behind only Japan (Porter, Schwab, and Sala-I-Martin 2007).

It is usually agreed that innovation is the key driver of economic performance (Schumpeter 1942). As nations achieve higher levels of gross domestic product (GDP) per person, the main source of this change becomes innovation. Porter and Stern (2001) thus describe competitive changes and innovation in advanced countries as the challenges of creating and commercializing new products and processes, shifting the technological frontier as fast as their rivals can catch up. In addition, statistical comparisons of economic performance among countries show that the intensity of national innovative activity is correlated with higher rates of standards of living and productivity growth (Furman, Porter, and Stern 2002).

Recognizing the relationship between innovation and economic performance, we then wish to explore how actual innovation-related factors drive the competitiveness of these two small but relatively fast-growing economies separately. The research effort is devoted to the main task of assessing and analyzing the innovation policies of Taiwan and Ireland, highlighting their specific strengths, weaknesses, and effectiveness in the specific economic and institutional contexts in which they operate. The underlying hypothesis is that the benefits of each country's science, technology, and innovation policies, including specific policy instruments, cannot be adequately assessed outside the specific national context for which they are designed.

The following paragraph describes the organization of this article. Section 2 observes how Taiwan and Ireland have developed their national innovation policies respectively from an evolutionary perspective. Section 3 reveals the current economic, innovation, and industrial profiles or trends between the two countries. Section 4 reviews prior research into the assessment of national innovation policy through different proposed models. Sections 5, 6, and 7 compare the innovation policy in the two countries on the supply side, environmental side, and demand side, respectively. We provide a holistic view of the national innovation policy using a mixture of quantitative and qualitative evidence and indicators and demonstrate how this relates either to the current policy mix or to likely policy changes in the immediate future. Sections 8, 9, and 10 are devoted to conclusions, policy implications, and suggestions.

2. Innovative development: Taiwan and Ireland

2.1. *Taiwan*

During much of the 1950s, economic goals did not rank particularly high with the Taiwanese leadership. The government was preoccupied instead with the reconquest of mainland China. By the end of the decade, it had become clear that the communist regime on the mainland was firmly entrenched. Taiwan's party elders came to see that economic development could be a better guarantee of the party's survival (Wade 1990). At this point, the government turned its energies to eliminating many investment-detering distortions (such as multiple exchange rates and macroeconomic instability). Taiwan was well endowed with a highly skilled labor force but was capital poor, and it had a coordination problem that inhibited growth.

A major milestone early in Taiwan's development was the Nineteen-Point Reform Program instituted in 1960. This contained a range of subsidies for investment and signaled a major shift in government attitudes toward investment (Lin 1973). The most important direct subsidies in Taiwan came in the form of tax incentives. The Statute for Encouragement of Investment (enacted in 1960 in conjunction with the nineteen-point program mentioned above) represented a 'sweeping extension' (Lin 1973) of the prevailing tax credit system for investment. Among other things, the maximum business income tax paid by enterprises was reduced and tax holidays on new investments were increased. These investment incentives were further expanded in 1965, when business income tax was reduced in all priority sectors listed in the investment law, and specified manufacturing sectors (basic metals, electrical machinery and electronics, machinery, transportation equipment, chemical fertilizers, petrochemicals, and natural gas pipelines) were given complete exemption from import duties on plant equipment.

Various policy measures have also been designed to enhance firms' innovative activities, beginning first with the establishment of Hsinchu Science-based Industrial Park (HSIP) to provide an environment conducive to the development of the island's high-tech industry. Among these, its 'local industrial clustering' which is often cited as the major source of Taiwan's success is the main feature with especially the information industry, which has already been well-documented (Hobday 1995; Kraemer et al. 1996; Kim and Tunzelmann 1998). Continuous capability building allowed Taiwan to maintain its position as the dominant manufacturing base in the global PC industry during the 1990s in spite of rapidly rising labor costs (Saxenian 2006). Recent developments, however, have called into question the extent to which local agglomeration can adequately encapsulate the dynamics of Taiwan's information industry (Chen 2004). Second, innovation alliances have been organized as a means of spreading the R&D risk between firms and securing first mover advantages. Third, the scope of the government-sponsored Industrial Technology Research Institute (ITRI) has been expanded to serve as a channel for technology transfer within the private sector; the majority of the budget for National Science and Technology Projects (NSTPs) has also been allocated to ITRI in an effort to boost the institute's innovative capacity. Fourth, tax incentives have been made available to absorb some of the R&D costs of firms and to encourage them to engage in R&D activities. Finally, a venture capital (VC) industry has been established, with the growth of this sector having already helped to speed the overall development of the high-tech sector (Tsai and Wang 2005).

The Taiwanese government undertook a more direct role in the direction of the economy, taking steps to ensure that private entrepreneurs would invest in certain areas. The government helped establish industries, including plastics, textiles, fibers, steel, and electronics. For example, Wade (1990) provides an account of how Taiwan's plastics plant for polyvinyl chloride (PVC) was built under government supervision and handed over to a private entrepreneur upon completion in 1957. More generally, it was common for the state to establish new upstream industries and then either hand the factories over to selected private entrepreneurs (as happened in the case of glass, plastics, steel, and cement) or run them as public enterprises (Wade 1990).

On the other hand, a major distinction in policy regarding Taiwan's innovation development is in scale; Taiwanese production is marked by a large number of small

and medium-sized firms (Park 1990). In view of this, its capital market was at a very early stage of development little more than 10 years ago; i.e., there was an inherent phenomenon of market failure (Tsai and Wang 2005).

The advocacy for developing semiconductors in Taiwan started in the mid-1970s when several experts came back from the US to promote large-scale integration (Saxenian 2006). In 1974, the publicly owned Electronic Research and Service Organization (ERSO) was formed to bring in foreign technology and disseminate it to local firms. These and hundreds of other relatively unknown firms are also partners in the later success of the higher-profile companies like Taiwan Semiconductor Manufacturing Corporation (TSMC), Acer, and Quanta. These companies have developed their own capabilities by collaborating with customers and suppliers to develop new products or improve existing products (Saxenian 2006). The adaptive capacity of Taiwan's technology base derives from collaborations among local producers as well as from their long-distance partnerships. The fragmentation and localization of production in the Hsinchu region are keys to the flexibility, speed, and innovative learning-by-doing of its integrated circuit (IC) firms. Therefore, the growth and success of the semiconductor industry in Taiwan has been the result of the above (Saxenian 2006).

However, other strategies were not successful. For example, a 1970s push by the Taiwanese government into the automotive industry *via* its public enterprises failed. When new opportunities arise, market failure can constrain their fruitful exploitation and, at firm level, such failure is seen as an entry barrier. Such is also the case in segments of the semiconductor and consumer electronics industries (Mody 1991). Under such circumstances, government innovation policy measures can, to some extent, correct market failure problems and facilitate the pace of structural transformation. One example is the share of exports from the heavy chemical and technology-intensive industries, which was just 54.9% in 1986, but had grown to 80.6% by 2002. Such overall achievements demonstrate the effectiveness of the government's innovation policy measures (Tsai and Wang 2005). Recent years have also in fact witnessed a wave of establishments of R&D facilities in China by multinational enterprises (MNEs; Xue and Wang 2001; Chen, Shih, and Kao 2002; Walsh 2003), particularly in Beijing and Shanghai (Chen 2004). Through the wave of direct investment into China, Taiwan has built formal corporate network interconnecting with China as well as diffusing technology and management knowledge (Ernst 2008).

The basic philosophy underlying the Taiwanese government strategy is that an economy will undergo certain stages of development, and at each stage there are certain key industries (such as integrated steel mills, large shipyards, and petrochemical plants) that through various linkages will bring about development of the entire economy. This strategy also assumes that government officials know what those key industries are and what policy measures should be adopted to develop them (Hou 1988). According to Rodrik (1994), the available evidence strongly suggests that proactive government policy was directly responsible for the 'miracles' of the Asian Tiger economies of Korea and Taiwan as well as that of Singapore. The governments of these countries essentially solved a coordination problem that permitted their economies to take off. Context is important for understanding why government intervention was successful. It was the initial conditions of these countries that provided government policy with such a high payoff.

2.2. Ireland

With the fastest growth rate of GDP per capita in Organization for Economic Cooperation and Development (OECD) countries over the past decade, Ireland has largely caught up with leading countries in terms of productivity and, to a lesser extent, income levels (OECD 2005). The economy of Ireland has been traditionally agricultural. Since the mid-1950s, however, the country's industrial base has expanded, and now mining, manufacturing, construction, and public utilities account for approximately 37% of the GDP and agriculture for only about 12%. Private enterprise operates in most sectors of the economy (Bradley 2006). During the 1990s, service exports more than tripled and by 2002 reached 23.8 billion in value, with foreign-owned firms accounting for the majority of these service exports (Forfás 2005). Nowadays in Ireland, attention is often focused on the modern, high-technology sectors of computers, software, and pharmaceuticals; with the exception of the food processing sector, the remaining sectors are small and attract far less attention (Bradley 2006).

In Ireland, for various reasons, very little priority was given to the integration of scientific and technological research and industrial development until the 1980s. Yearly (1995) argues that, historically, this failure to integrate technology and industrial policy stems back to the pre-partition period. At this time, Yearly (1995) argues that scientific excellence in Ireland was 'cultivated for an international audience. The work of the foremost scientists showed few signs of being significantly Irish. It dealt in abstract, would-be universal propositions. In other words, science prior to partition was primarily practiced as a form of high culture' (Yearly 1995, 173). Following Irish partition in 1921 and the creation of the modern Irish state, this tendency was, if anything, exacerbated by the desire to distance the country from the British legacy and a concentration of public and academic resources on cultural and linguistic rather than scientific development (Lee 1989). One consequence of lack of applied scientific research in Ireland was a relatively low level of innovative activity among indigenous Irish companies that persisted into the 1970s.

By 1985, the nation faced inflation averaging 11% per year, unemployment of 15% and a vast national debt. Between 1981 and 1990, 200,000 people emigrated (Dorgan 2006) and, unlike previous waves of emigration, many of these were university graduates. In order to cope with the crisis, the government introduced a radical 3-year national recovery plan, government spending was slashed, and national partnership agreements were put into place between the government and employers and unions. These agreements restricted pay raises and introduced tax incentives. While government spending was reduced in many sectors, investment was made in telecommunications infrastructure in order to target the financial services and software sectors. Import substitution and tariffs were used to protect and develop Irish manufacturing. Ohmae (2005, 11) suggests that the previous industrial failure was at this point seen as a benefit: 'It meant that there was no rusting industrial plants and no unemployed workforce born and bred to heavy industry... Ireland could begin from scratch'.

Then, a reorientation of Irish industrial policy followed, toward a more balanced strategy involving the development of the export capacity of indigenous industry, alongside continued attempts to attract high-tech inward investment (National Board for Science and Technology 1983). Implicit in the policy shift was the recognition, perhaps for the first time, that the international competitiveness of

indigenous Irish industry depended on its technological development. The economy picked up, and by 1992 the concept of Ireland as the e-hub of Europe had been developed (BBC 2006). While the economy has continued to prosper and significant foreign direct investment (FDI) has been attracted, Ireland has become the European research base for a number of pharmaceutical companies; it is also the location of manufacturing plants for large international information and communication technology (ICT) companies such as Dell and IBM. In addition, its beautiful scenery and unique history has led to the development of a strong tourist industry (Ohmae 2005). However, large-scale inward investment has meant that 44.1% of manufacturing employment, 68.4% of net output, and 87.7% of manufacturing exports are now accounted for by foreign-owned enterprises (Ruane and Görg 1997). Moreover, only two Irish-owned firms appear in the list of Ireland's top 20 electronics companies (Roper and Frenkel 2000), and only 2% of patent applications made in Ireland are now made by Irish residents.

Even so, the bringing together of Irish industrial and technology policy with the aim of developing the competitiveness of indigenously owned firms has been strongly supported by the EU through both the Structural Funds and the Framework Programmes (see, for example, Massey, Quintas, and Weild 1992; Enterprise Panel 1996). Specifically, Ireland has benefited significantly from participation in EU Framework Programmes over the years. Framework offers valuable opportunities to Irish companies, research bodies and universities to participate in high-quality research in collaboration with their European counterparts. The Programmes have been a crucially important source of funding in supporting the growth of the Irish research base, and have helped to increase the knowledge and credibility of the Irish research community (McCall 2005). Besides, while the recent significant investment by the Irish state in R&D and in particular initiatives such as Science Foundation Ireland reveals a serious commitment to promoting a stronger endogenous technology sector in Ireland, policy-makers remain strongly committed toward exploiting the contribution of the foreign-owned sector for many years to come. The transition from the more basic 'branch plant' forms of investment that characterized earlier phases of Ireland's FDI model towards more knowledge-based activities involves major challenges to the state's ability to respond to significant demands in areas such as physical infrastructure and the supply of graduates in science and technology (Grimes 2006). As a result, state agencies acted to support emerging indigenous industry and to upgrade the national system of innovation in three major ways – defining the character of industrial strategies, implementing company development through grant aid, and creating an associational infrastructure for innovation (O'Riain 2006, 90). For instance, many Telematics Applications Programme (TAP)¹ projects involve the participation of national agencies from all member states and such agencies tend to be headquartered in Dublin (Grimes and Collins 2002).

We believe that these current efforts have corrected some criticism a while ago. Among these are the lack of embeddedness of foreign capital in the local economy (Andreosso-O'Callaghan 2000; O'Sullivan 2000); the generally low level in the value chain of activities located in Ireland; the significant vulnerability of activities such as software localization, logistics, and telemarketing as a result of rapid technological change; and the fact that the key competencies of software development and marketing have tended not to be located in Ireland (O'Riain 1999; O'Sullivan 2000).

3. Recent economic, innovation, and industrial profiles: Taiwan and Ireland

As noted, innovation policy cannot actually be separated from broader economic trends. It is then important to be aware of current economic, innovation, and industrial profiles or trends between the two countries.

3.1. Cluster strength

Furman, Porter, and Stern (2002) give Taiwan a Cluster Innovation Environment Subindex of 9.6, giving it a rank of 8 from a total of 60 in the economies surveyed. In the same survey, Ireland achieved 9.1 and a ranking of 17 from a total of 60.

Taiwan's experience might appear to be a classic case of the benefits of comparative advantage, with Taiwan specializing in IC and PC manufacturing and Silicon Valley leading in more advanced IC design and electronic system definition (Saxenian 2006). The most significant cluster in Taiwan is that centered on Hsinchu in the north of the country. This area focuses on computer/information technology; it has a strong geographic concentration in both the HSIP and in the coastal strip of land between Hsinchu and Taipei (the Hsinchu area being more IC and component oriented, and the area toward Taipei being more OED and consumer oriented). These regions and their industrial specializations continue to evolve as products engaged in joint innovation across geographically far-flung and protean supply chains (Saxenian 2006). The importance of this cluster to innovation cannot be underestimated since, according to Porter, the electronics cluster in Taiwan accounts for 80% of all USPTO patent filings (Porter 2001).

The Hsinchu industrial system, which successfully adapted to both competitive and technological changes in 1980s and 1990s, faced, however, its most severe challenge with the movement of manufacturing capabilities to the Chinese mainland as the decade drew to a close (Saxenian 2006).

Ireland has what Green (2000), Danson (2000), and the OECD (2006) describe as an ICT cluster. However, this broad definition realistically consists of three somewhat interrelated clusters:

- (1) A PC and hardware assembly cluster centered on Galway, with other plants in Cork, Limerick, and Shannon.
- (2) A software cluster based in Dublin.
- (3) A technical support cluster centered on Dublin but also in other nearby east coast towns.

Even so, factor conditions in Irish clusters remain weak, including technical education and research facilities (OECD 2006). Unlike clusters in Taiwan, cluster development of Ireland has been largely driven by the FDI rather than local ventures. However, this is beginning to change as local firms enter the software cluster (Green 2000). Among other things, the geography of Irish participation in TAP reveals a not very surprising concentration of projects in the larger urban centers of Dublin, Cork, and Limerick. In the Dublin metropolitan area, where more than one third of the Irish population is resident and which is characterized by a significant concentration of both public and private service sector activity, there were 110 of a total 190 participations (Grimes and Collins 2002).

Table 1. R&D expenditure indicators of Taiwan.

Item	Year				
	2001	2002	2003	2004	2005
Government-funded R&D expenditure as a percentage of GDP	2.08	2.08	2.35	2.44	2.52
Government-funded R&D expenditure by sector of performance					
Business enterprise sector (%)	63.6	62.2	62.8	64.7	67.0
Government sector (%)	23.3	24.8	24.7	23.2	21.0
Higher education sector (%)	12.5	12.3	11.9	11.5	11.4
Private nonprofit sector (%)	0.7	0.7	0.6	0.6	0.5

Source: National Science Council (2005).

3.2. R&D engagement

Major countries around the world are increasing their R&D expenditures as forward-looking investments (OECD 2005). Comparison of R&D expenditures in Taiwan and Ireland shows a difference with 2002 levels at 2.31% of Taiwanese GDP and 1.10% of Irish GDP (OECD, Factbook 2007) (also see Table 1).

More specifically, although grant support for R&D rose significantly in Ireland over the 1990s, the level of its R&D investment lagged considerably behind both the EU and OECD averages (European Commission 2003) (Figure 1).

On the other hand, according to Forfás (2005), for Ireland, the largest proportion of total R&D is performed by the business sector, especially MNEs. Similar situations occur in Taiwan, in particular association with government as well as higher-education sectors (Table 1). However, Ireland's direct support for enterprise R&D has tended to focus on near-market developments² and only in the recent years have greater resources been allocated to pre-competitive R&D³. In addition, the majority of financial support for R&D in Ireland over the period was made to manufacturing firms. Nevertheless, the contribution of support to the services sector increased in the 1990s; the services sector attracted some 33% of all grant payments made in 2001 *versus* 17% in 1991 (Figure 2) (Hewitt-Dundas and Lenihan 2002).

On the other hand, examination of productivity GDP per worker hour shows that worker productivity in Ireland has consistently been significantly higher than that in Taiwan, despite the indications of lower levels of innovation in Ireland. In fact, since 1993, the productivity ratio of Ireland to Taiwan has remained at about 1.7 (+/-0.05) (Groningen Growth and Development Centre 2006). In fact, as we can observe, high levels of productivity in Ireland is related to the predominantly high-technology profile of the FDI sector, which plays such a dominant role in the economy.

3.3. Industrial growth

Figure 3 shows that except during the year 2001, in which Taiwan had a negative growth rate of industrial production (-7.8%), both countries had similar trends in this sector from 2002 to 2006. Industrial production growth rates of Taiwan and

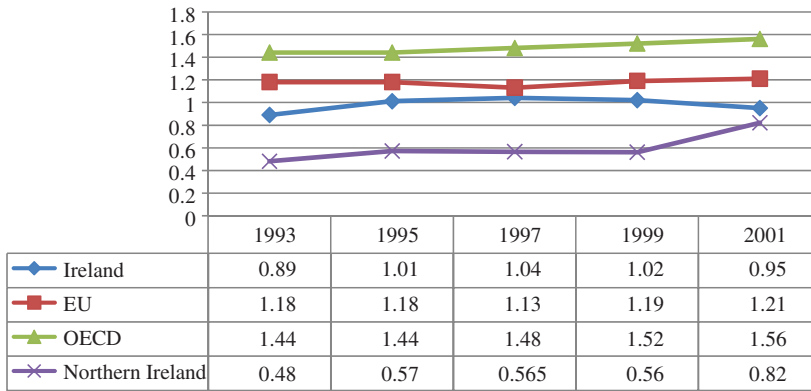


Figure 1. Business expenditure on R&D as percentage of GDP/GNP – Ireland, EU, and OECD, 1993–2001.

Source: European Commission (2003).

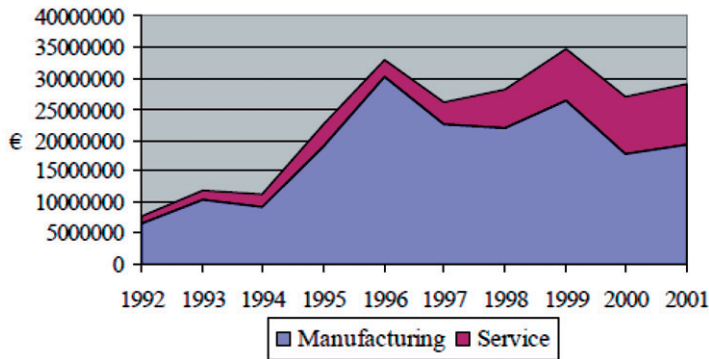


Figure 2. Grant payment by broad industrial sector, Ireland, 1992–2001.

Source: Hewitt-Dundas and Lenihan (2002).

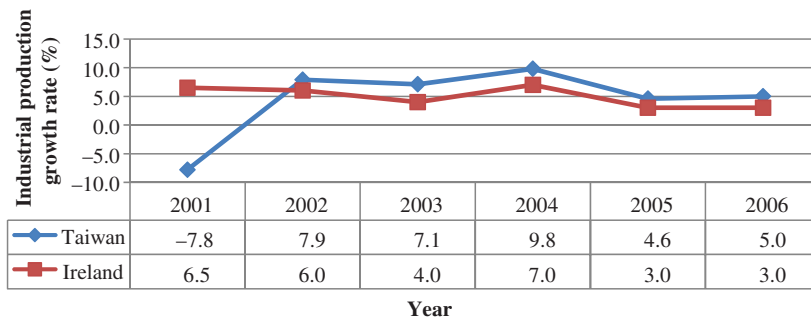


Figure 3. Industrial production growth rates of Taiwan and Ireland, 2001–2006.

Source: Central Intelligence Agency, World Factbook (2006).

Ireland both peaked in 2004, at 9.8% and 7.0%, respectively. However, in 2005, growth rates for the two countries dropped sharply to 4.6% for Taiwan and 3.0% for Ireland, less than half as much as the previous year. Overall, Taiwanese industries seemed to grow faster than Irish ones after the year 2002.

Part of the explanation of the above in Ireland's case is the ongoing offshoring of manufacturing activities to locations in Asia (China), while in the case of Taiwan, offshoring of electronics manufacturing to China has also been important, but remains under Taiwanese control.

More specifically, using the data from the 60-industry database (Groningen Growth and Development Centre 2005), industrial growth can be examined for both countries. The most recent information is from 2002; so we compare figures from Taiwan (which have been converted to Euros) at 2002 mid-year levels, and the Taiwanese numbers have then been scaled according to the population ratio with Ireland (0.173).

The results show that Ireland's industrial growth in 2002 primarily comes from chemical, computer, and related industries whereas Taiwan's growth comes mainly from high-technology industries, with lower-tech manufacturing and resources-based industries showing some growth.

On the other hand, evidence of strong service sector growth is shown in Ireland, particularly in the legal, advertising, and social work fields. Levels of service growth in Taiwan seem more modest, and the retail trade industry ranks highest.

3.4. Inward FDI

According to the OECD, strong FDI increases innovation as 'inward FDI is an important channel for knowledge diffusion, while outward FDI is a means of sourcing technologies and knowledge from elsewhere' (OECD 2006, 81). The most significant contribution to the development of the Irish economy has been its ability to attract FDI from overseas (Ohmae 2005), primarily from the US and Germany. FDI in Ireland has been consistently high in comparison with GDP. Since the year 2000, it has been the highest in Europe and one of the highest in the world (with the exception of tax havens and extremely impoverished countries). In comparison, Taiwan has attracted low levels of FDI, staying at only 6% of GDP during much of the 1990s and currently at 12% of GDP (against Ireland's 106%, OECD 2005) (Figure 4).

Ireland has very strong outward FDI too, which has risen from 26% in 1999 to 59% of GDP (OECD 2005). Both the OECD and Danson believe that the reason for this apparently high FDI is the return of dividends by MNEs (in part caused by the decline of the US dollar against the Euro) (Danson 2000). On the other hand, Irish companies employ almost as many people in the US as do US companies in Ireland. There has also been significant investment by Irish people in property in other markets such as the UK (Forfás 2008).

For the past 40 years, Ireland has implemented FDI-led regional development policies. Rural, low-value-added manufacturing once dominated Ireland's inward investment profile (O'Malley and de Paor 1994). Since the late 1950s, however, the Irish government has employed an industrial policy to attract inward investment based on the principle of 'industrialization by invitation'. The FDI was largely concentrated in ICT industry until the mid-1980s. Early inward investment certainly tended to locate in or near Dublin to take advantage of the labor market and logistic

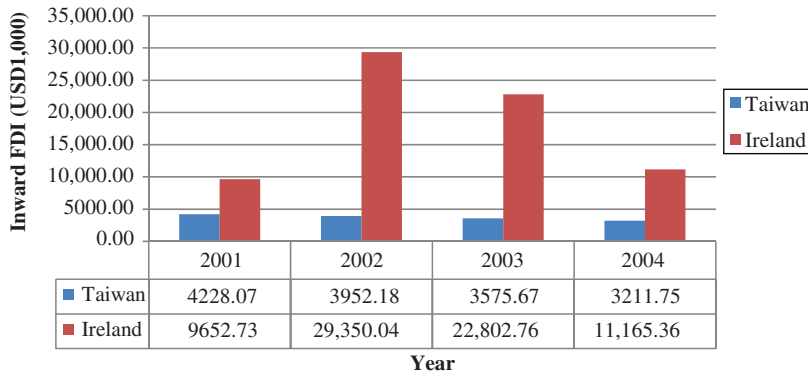


Figure 4. Inward FDI of Taiwan and Ireland, 2001–2004.
Source: OECD Factbook (2005).

advantages. From the beginning of mid-1980s, inward investment by high-tech manufacturing firms to Ireland has been accompanied by massive inward investment by US software companies, such as Microsoft, Oracle, and Lotus (Roper and Grimes 2005). Ireland’s policy successfully attracting FDI leads to its economic boom. Therefore, also, for the recent years, in Ireland, the shift to services is evident (Grimes 2003). Overall, this enhanced role places Irish affiliates in more advantageous positions from which to seek more extensive and sophisticated corporate mandates. As a result, Ireland remains better equipped to manage the changing demands of the world economy than during the period dominated by branch-plant manufacturing (Grimes and White 2005).

4. Assessing national innovation policy

Traditional innovation policy has often focused on promoting science and technological policies. These policy models have typically believed in the science push effect in the radical innovation process. The new innovation environment then sets new demands for regional innovation policies and strategies. Therefore, innovation cannot be seen as a property of science or technology-based firms; it is the basis of competitiveness in all types of economic activities (Pekkarinen and Harmaajorpi 2006). Besides, the nature of innovation varies significantly across sectors, and differences between countries in the sectoral composition of output and the position of domestic firms in international supply chains can lead to significant differences in national patterns of innovation (OECD 2005). In view of these, assessing national innovation in a comprehensive mode is essential for country competitiveness enhancement. The following portrays how national innovation policy can be evaluated by various approaches.

The National Innovation Systems (NIS) concept can be traced to the mid-1980s in the context of debates involved in the industrial policy in Europe. One of the notable advocates of the concept of NIS is Christopher Freeman. Since then, an international body of literature documents the growing influence of the NIS approach (Sharif 2006). Some international organizations, such as the OECD, the European Commission and the United Nations Conference on Trade and

Development (UNCTAD), have absorbed or are beginning to use the NIS concept as an integral part of their analytical perspective (Lundvall et al. 2002; Sharif 2006).

The concept of NIS can be perceived as a historically grown subsystem of the national economy in which various organizations and institutions interact with and influence one another in carrying out innovative activity and generating innovation performance. The NIS approach implies that innovative activity encompasses the processes of research and development efforts input by private sectors and public sectors as well as the determinants influencing national technological capabilities, for instance, learning processes, incentive mechanisms, or the availability of skilled labor (Nelson and Rosenberg 1993; Balzat and Hanusch 2004). Therefore, the NIS approach focuses on the analysis of nation-wide structures of innovation activities, their institutional determinants, and economic effects (Balzat and Pyka 2006).

Since the concept of NIS has emerged, an increasing number of studies adopt this approach to reveal the structure and the main actors involved in highly industrialized countries and some smaller emerging economies (Nelson 1993; Balzat and Hanusch 2004). Lundvall et al. (2002) indicate that the concept of NIS provides a new perspective to examine a country's innovation processes through different kinds of policies. A wide set of policies, including labor market policy, education policy, industrial policy, energy policy, environmental policy, and science and technology policy, affect a country's competence building. Moreover, a systematic analysis on comparative studies of different NIS helps to obtain a critical understanding of the limits and the benefits of specific national policy strategies (Edquist and Lundvall 1993; Lundvall et al. 2002).

System perspectives on innovation performance by many academics have examined the classification and role of innovation policies. One of the most comprehensive classification systems for innovation policy employment is that developed by Rothwell and Zegveld (1981), who grouped innovation policy tools into supply side, demand side, and environmental side. Supply side tools are those that provide the basic resources for innovation, such as educational institutions or universities, trained technicians, information networks, and technical advice. In addition, they include direct innovation by government-owned agencies and state industries and research directly supported by government funds such as research grants. Environmental side tools regulate the operating environment of firms and include means by which the government impacts the financial aspect of innovation. This classification also includes not only the legal environment in which firms operate but also the legal environment for innovation. Demand side tools have an effect on the stimulation of invention by the demand for new products and services created by public spending and public services. These also include the stimulation or suppression of innovation by regulation of demand from overseas and the ability of overseas competitors to operate in the national market.

In this research, we will make use mainly of these policy analysis denotations originally derived from Rothwell and Zegveld (1981) as a guideline facilitating a more insightful national innovation policy assessment. The reason we chose this framework as an analysis base is that this system rests on the premise that understanding the linkages among the policy actors involved in innovation is the key to improving technology performance (Shyu and Chiu 2002). Furthermore, it is more feasible and applicable than other indicator systems from the perspective of comparability and comprehensiveness.

However, on the other hand, based on what we have argued above, we find that the policy field of promoting network and entrepreneurship on the supply side may be a missing link in the innovation policy assessment framework first proposed by Rothwell and Zegveld (1981). Frenken (2000) contends that successful innovation depends on complementary competencies in networks of producers, users, and governmental bodies, and networks have become understood as an important organizational form for coordinating the efforts of heterogeneous actors without restricting their individual goals. More specifically, technological incubators have assumed a growing role in R&D research and innovation management, and their importance has not escaped the attention of the researchers (Lumpkin and Ireland 1988; Mian 1996). Science parks, like technology incubators, are property-based initiatives designed to provide a conducive environment in which high-tech businesses can be established and developed (Roper 2000). VC funds provide not only capital but also management assistance; once the enterprise has become a success, they sell-off their holding in the company to make a profit. Support of it is rather beneficial for entrepreneurship promotion (Tsai and Wang 2005). Importantly, inter-firm collaboration and interorganizational learning are central to the innovation process (Roper 2000).

Through the above discussions, to promote network and entrepreneurship, practice examples include establishing incubators and science parks, supporting start-ups, encouraging collaborations between firms, setting up VC associations, establishing grant-based measures to promote entrepreneurship, and so on. The revised innovation policy assessment model of general roles for each grouping is depicted in Table 2.

5. Supply sides of innovation policy: Taiwan and Ireland

There are some similarities and major differences between Taiwan and Ireland in supply side policies (Table 3). One common aspect is the creation of technical information networks that provide access to detailed technical information; this relatively low-cost service aids the research of companies and pools research knowledge (Advisory Science Council 2006). Another policy utilized by both is the offering of grants to universities to undertake research (Table 3). The Irish version of this policy is more specific in targeting advanced research, whereas the Taiwanese policy is more focused on application research.

The key difference in supply-side innovation policies between Taiwan and Ireland lies in the role that universities play in their association with industry in the process of innovation development. The Global Competitiveness Report 2006–2007 published by the WEF cites Taiwan's seventh-place world ranking in 'higher education and training pillar', with both quantity and quality of higher education reflecting the government's efforts to promote education and the development of elite personnel. On the other hand, while both systems try to improve links, the Irish system places a far greater emphasis on the role of universities and state research institutes in association with industry and this deeply involves its participating EU's Framework Programme. For instance, Ireland builds the connection between universities, state research centers, and their peripheral high-technology companies through participation in EU's Framework Programme such as TAP, and Advanced Communications Technologies (ACTs), which facilitate small-medium high-tech

Table 2. A more complete innovation policy analysis model.

Grouping	Policy tools	Examples
Supply side	Public enterprise	Innovation by publicly owned industries, setting up of new industries, pioneering use of new techniques by public corporations, participation in private enterprise
	Network and entrepreneurship	Supporting start-ups, establishing science parks and incubators, encouraging collaboration between firms and institutions, VC associations, measures to promote entrepreneurship
	Scientific and technical	Research laboratories, support for research associations, learned societies, professional associations, research grants
	Education	General education, universities, technical education, apprenticeship schemes, continuing and further education, retraining
	Information	Information networks and centers, libraries, advisory and consultancy services, databases, liaison services
Environmental side	Financial	Grants, loans, subsidies, financial sharing arrangements, provision of equipment, buildings, or services, loan guarantees, export credits, etc.
	Taxation	Company, personal, indirect and payroll taxation, allowances
	Legal and regulatory	Patents, environmental and health regulations, inspectorates, monopoly regulations
	Political	Planning, regional policies, honors or awards for innovation, encouragement of mergers or joint consortia, public consultation
Demand side	Procurement	Central or local government purchases and contracts, public corporations, R&D contracts, prototype purchases
	Public services	Purchases, maintenance, supervision and innovation in health services, public building, construction, transport, telecommunications
	Commercial Overseas agent	Trade agreements, tariffs, currency regulations Defense sales organizations

Source: Adapted from Rothwell and Zegveld (1981, 59).

spin-offs from university incubators and gradually form clusters in Dublin, Cork, Galway, and other cities in the recent years.

Another indicator of the Irish focus is the setting up of industry groups for research; this policy seems to be open to failure, since it requires competitors to cooperate for the good of the group and essentially to reveal their research activities to each other. In the Taiwanese policies, we can see that the role of government as a direct provider (as opposed to facilitator) is emphasized; for example, it establishes research institutes to directly conduct a range of research that then becomes available to local industry. These institutes, such as the ITRI, Technological Information

Table 3. Comparison of supply-side policies between Taiwan and Ireland.

	Ireland	Taiwan
Network and entrepreneurship	University/firm/graduate Knowledge transfer Industry led collaboration groups Support for start-ups Incubator networks	Innovation alliances Incubator establishment Setting up of VC associations
Scientific and technical	(a) Advanced technologies research grants (b) University/firm joint research	Industry and research conferences Support of university research Establishment of research institutes University research grants
Education		Government training Higher education development
Information	The provision of technical information and support	Development of innovation information research networks

Center, and National Science Council (NSC), conduct research on a large scale and undertake studies into the feasibility of industrializing new technology. Although it tries to link universities *via* conferences, in effect the Taiwanese government is focused on providing the tools of innovation, i.e., technically educated students, government funded research, training, and information. One criticism of the approach by Shyu (2006), however, is that the needs of industry are not always served by the supply policy system; this is the result of the separation of education, industry, and government and the political nature of such a government-focused system.

The Irish government is focused on linkage of existing tools, i.e., joining firms into research groups, taking trained students into firms, bringing firms into the university research lab to participate in subprograms of EU’s Framework Programme. For its success, this policy is dependent on the strength of existing tools and on the strength of the firms to which those tools are linked. This is of concern as the higher institutions that are integral to these supply policies have been criticized by the OECD for their low levels of funding, despite recent increases in funding (primarily through changes in government policy and EU funds). Unlike many universities in Taiwan (e.g., National Chiao Tung University, National Tsing Hua University), Irish universities (e.g., Trinity College Dublin, University College Dublin) have had a strong focus on the humanities (Pontikakis, McDonnell, and Geoghegan 2006), particularly Irish history and literature. This has resulted in a lack of experienced researchers in universities and limited research facilities. The situation is now improving; ‘after years of neglect universities have only recently had the resources to carry out high-quality research’ (OECD 2006, 13).

In addition, the governments of both Taiwan and Ireland have engaged in activities promoting collaboration and mutual learning between firms. In Taiwan, from the late 1980s through the early 1990s, in order to promote industrial upgrading, the government directed a considerable number of innovation alliances in the areas of notebook computers, high-definition televisions, fax and communications equipment, and so on, working through research institutions such as the ITRI.

The most successful of these was the Notebook PC Joint Development Alliance (Tsai and Wang 2005). In Ireland, national initiatives were in place to promote collaboration in pre-competitive or basic research between firms, universities, and other research bodies. For example, programs in advanced technologies (PATs), funded through Measure 2 of the EC Support Framework, had aimed to stimulate basic research in universities and technology transfer to companies in specific areas of new technology (Roper 2000). On the other hand, Taiwan's VC has made a considerable contribution to the growth of small- and medium-sized enterprises (SMEs), particularly those in the emerging industries, and the government has set up many VC associations and offered financial support to help investors (Tsai and Wang 2005). In addition, since 1996, the small and medium enterprise administration (SMEA) of Taiwan has continued to promote the establishment of incubators through the use of financial support available from the Small and Medium Enterprise Development Fund for office equipment, personnel, and related costs. After 5 years of continuous effort, the SMEA has promoted 63 incubators and attracted around 900 firms to move into these incubators (Tsai and Wang 2005). As for Ireland, new export-oriented businesses can receive employment grants and R&D grants (Roper 2000). However, in Ireland, the business incubator network is relatively limited, although most Irish universities have small innovation centers, and EU-sponsored networks of business innovation centers and innovation relay centers support the relatively sparse innovation centers in Ireland that provide incubator-type facilities (Roper 2000).

6. Environmental sides of innovation policy: Taiwan and Ireland

Strong similarities exist between the two countries with regard to the provision of grants and tax relief for R&D (Table 4). A number of these policies have specific aims rather than general ones:

- Patent Royalty Tax Exemption (Ireland): To increase levels of Irish patenting and patent licensing (Roper 2000).
- High Risk R&D Support Program (Ireland): To reduce the financial risks involved in undertaking high-risk research⁴ (Roper 2000).
- Tax Relief on Training (Taiwan): To encourage the further training of technical and managerial staff (Tsai and Wang 2005).

More specifically, in Taiwan, companies can be exempt from import duties on instruments and equipment for experiments in R&D. Equipment for R&D with a life of longer than 2 years can adopt 2-year accelerated depreciation. Expenditures in R&D of 15–20% can be business income tax deductible (Shyu and Chiu 2002). On the other hand, the Ministry of Economic Affairs also took action in promoting the technology capacity of the traditional industries with 'Rules of encouragement for the private sector's development of new products' and the 'Law governing development for directive new products' (Shyu and Chiu 2002). In addition, subsidy for R&D activities of high-tech companies located in the Science-based Industrial Park is offered by the Taiwanese government, which usually prepares an annual budget of relative expenses to support firms' research projects (Tsai and Wang 2005). In Ireland, R&D support is offered on a discretionary basis, with a maximum grant of 50% of the eligible *non-capital* element of R&D project costs. Similar levels of

Table 4. Comparison of environmental side policies between Taiwan and Ireland.

	Ireland	Taiwan
Financial	(a) Financial introduction services (b) Equipment/firm infrastructure grants (capital grant) (c) Commercialization fund (d) Grants for incubators	(a) Loan subsidies (b) Grants for incubators (c) Subsidies for firms located in science parks (d) Development fund (e) Research facilities
Taxation ⁶	(a) R&D expenditure tax credits/relief (b) Tax incentives for inward investment	(a) R&D equipment/expenditure tax alleviation (b) Tax relief for training (c) Tax incentives and EPZs for attracting FDI
Legal and regulatory	(a) Patent royalty tax exemption (b) Patent/copyright/trademark law (c) Strengthening of copyright	(a) Patent and copyright acts (b) Fair trade law focusing on preventing cartel and monopoly
Political	(a) EU support for R&D (b) EU membership (c) High risk R&D support program (d) Competition act focusing on FDI supervision	(a) Visa restrictions (negative effect) (b) Technology export restrictions (negative effect)

support are available for feasibility studies and licensing of new manufacturing technologies (Roper 2000). Tax relief is available in Ireland on all R&D expenditure, patenting costs, and costs of acquiring manufacturing licenses, etc., with expenditure being written off against profits in the year in which the expenditure is incurred. In addition, royalties and other income received from the use of patents are also exempt from income tax and corporation tax. The impact of EU support for R&D and innovation capability development has been important for Ireland. The Operational Program for Industrial Development, 1989–1993, for example, provided continuing funding for capability development, which in all probability could not otherwise have taken place given the state of public finances at the time (Hewitt-Dundas and Lenihan 2002).

Ireland’s policy to attract foreign FDI from the end of the 1950s was particularly successful. Initially, job maximization was a driver in attracting FDI, with large MNEs concentrated in traditional and labor-intensive sectors. By the late 1970s and 1980s, however, policy began to adopt a more selective approach to the FDI sought, focusing more on high-tech and higher-value-added firms. Over the same period, the motivation for MNEs to invest in Ireland shifted, from tax and grant incentives along with low-labor costs in the 1960s, to access to major markets in 1973 with accession to the EU, and access to a skilled labor force that the Irish government had actively tried to develop, particularly in the areas of computers and other electronic products, pharmaceuticals, medical and scientific instruments, and software (Hewitt-Dundas and Lenihan 2002). In Ireland, international firms have been attracted by the 10% corporation tax for all manufacturing companies that is due to continue until 2010 (Yuill et al. 1997). As for Taiwan, two main policy instruments were developed to attract FDI: direct taxation incentives and export processing zones (EPZs). To consolidate these incentives, between 1966 and 1971, a number of EPZs

were established that enjoyed the benefits of simplified official procedures and duty-free imports of machinery, equipment, raw materials, and finished goods (Chen and Sewell 1993). Currently, preferential tax measures, R&D assistance, and low-interest loans are being offered to encourage foreign investment, with the goal of further developing Taiwan as a hub of R&D and high-tech manufacturing. These measures, along with the establishment of modern science parks, have led to an increase in the amount of foreign investment dedicated to electronics and electrical appliances, a sector that now accounts for 33.45% of foreign investment (Department of Investment Services 2006).

In Ireland, as with R&D support, capital grant support is offered on a selective basis. Capital grant support has been ubiquitous, but higher maximum grant rates have been on offer in less developed western regions (Yuill et al. 1997). However, a number of studies have suggested that capital grant support is particularly prone to deadweight and may lead to substantial distortion in the type and extent of the firms' investments (Roper 2000).

In financial support for R&D another common policy is the setting up of incubators. In Ireland, implementation has been undertaken at a national level by Enterprise Ireland (OECD 2006) and all third-level institutes now have incubators; institutes have been in charge of establishing their own incubators and are supported by grants from the SMEA. While incubators in Taiwan have been successful at attracting firms, quality of support has varied, and firms coming out of the incubators have tended to be of a similar nature, with similar products and little to distinguish them in the marketplace (Tsai and Wang 2005). In Ireland, the more centralized policy has resulted in the development of incubators specializing in a number of target industries and more consistent support levels (Advisory Science Council 2006).

The role of the legal system in innovation is highlighted by the efforts taken by each country in addressing perceived weaknesses in their intellectual property rights (IPR) laws. For Ireland, this involves the strengthening of copyright rules regarding software and the Internet. However, many small companies believe that they do not own any intellectual property because they do not recognize it, but all companies have at least one trademark – their name – even if it is not registered as a trademark. It is very much in the interests of even the smallest company or individual innovator or entrepreneur to make the best use of their intangible assets by investigating the opportunities offered by the intellectual property system (Irish Patents Office 2007). In Taiwan's case the changes undertaken were of a more substantial nature, addressing the weaknesses in patent enforcement and prosecution (based on US government criticism). It is also interesting to note the integration of the Taiwan Intellectual Property Office into the NIS administration structure. The above Taiwanese laws and regulations include the Patent Act, Integrated Circuit Layout, Copyright Act, Trade Secrets Act, and so on. As for market competition law, Ireland has no limitation on FDI and relies on it to stimulate economic growth. However, most companies in Ireland are SMEs. Hence, to promote competition, Ireland's Competition Act also focuses on mergers and acquisitions from foreign investment as well as on supervision of cartel organizations and monopolies (The Competition Authority 2002). Although most of Taiwan's companies are SMEs as well, Taiwan's competition law, the Fair Trade Law, does not emphasize mergers and acquisitions. The Fair Trade Law focuses on preventing cartels, monopolies,

limited competition, and other behaviors hindering fair competition (Fair Trade Commission 2000).

The political situation with China has resulted in visa restrictions for mainland Chinese engineers and researchers. Although few visa restrictions are in place for other nationalities, the restrictions are of particular significance as the two countries share the same language (a significant number of research labs in Taiwan use Chinese as their main form of communication), China is a major recipient of Taiwanese FDI, and to some extent their cultures are similar (Wu and Huang 2003). This restriction contrasts with the liberal visa and immigration policy that Ireland offers as part of its EU membership and its growth strategy. In a similar vein, the use of technology export restrictions against China reflects the current situation of Taiwan. These rules prevent the export of advanced technology to China and Chinese subsidies even for research purposes, and like the visa policy reduce access of Taiwanese companies to Chinese engineers. However, there is some evidence that this restriction is being circumvented.

7. Demand sides of innovation policy: Taiwan and Ireland

To comply with the Agreement on Government Procurement of the World Trade Organization (WTO), Taiwan's government procurement law was legislated in 1999 and aims to clarify procurement information, complete procurement evaluation, and internationalize the procurement market (Public Construction Commission 1999). Since then, the most advantageous tendering method has been adopted as a major legitimate contract award mechanism instead of the lowest bid tendering method (Tzeng, Li, and Chang 2006). On the other hand, Taiwan uses government procurement as one of the most important sources of technological development, especially weapons systems procurement (Tien and Yang 2005), though it faces a predicament in weapons systems procurement. The Sixth National Science and Technology Conference, for instance, proposed a strategy to strive for industrial/military cooperation in opportunities for purchasing defense weapons systems from abroad and introducing key defensive technology (National Science Council 2001). Such an industrial cooperation policy is one of the main sources of key technologies.

In contrast to Taiwan's procurement with the objective of introducing key technologies, Ireland's public procurement law regime focuses on generating competition and promoting the free movement of goods, skills, and labor within Ireland and Europe. The regime applies to the procurement of works, services, and supplies by government departments, local authorities, and regional public sector bodies and entities financed in whole or in part by public funds and certain utilities (Arthur Cox and Davis Langdon PKS 2003), which enlarges the market to enterprises in Ireland and EU.

The main difference on the environmental side between Taiwan and Ireland is the policy tools adopted by the two countries facilitating public services. The Taiwanese and Irish governments mainly use build-operate-transfer (BOT) and public-private partnership (PPP), respectively, in this aspect. In Taiwan, BOT is applied to lower government expenditures, share risks with contractors, and introduce advanced technologies. The Taiwan High Speed Railroad, electronic toll collection on the two freeways, and construction of Kaohsiung Mass Rapid Transit are the major BOT examples in the recent years (Kang, Feng, and Lo 2007). On the other hand,

infrastructural investment projects in Ireland have been funded by the Exchequer or EU transfers. However, since the successful transition of the Irish economy to the standards of the core EU economies, EU transfers are unlikely to play an important role in the future financing of Irish infrastructure (Scally 2004). PPPs are partnerships between public sector organizations and private sector investors and businesses for designing, planning, financing, constructing, and operating of infrastructure projects. PPPs are being used increasingly in Ireland to deliver both major and minor infrastructural projects in the transport, environment, education, and health sectors that have been essential to support its economic growth and population changes (Scally 2004).

Regarding trade policies, both countries are striving to join international or regional trade organizations for improving their industries' competitiveness and now have become members of important economic integration organizations. Taiwan accessed the WTO at the end of 2001 after 12 years of effort (Cho 2004). To comply with the regulations of WTO, Taiwan has to reduce tariff duties on agricultural and industrial products, remove import quotas, reduce exporting subsidies, and so on. In compliance with Taiwan's accession commitments to the WTO, there will be positive and negative influences on different industries (Huang et al. 2003; Hsu and Chang 2004; Weng, Chen, and Kuo 2005; Dent and Chuang 2005). In addition to WTO, Taiwan also joined a multilateral regional trade organization, Asia-Pacific Economic Cooperation (APEC), in 1991 together with China and Hong Kong (Chou 1999). Experts believe that enlisting a free trade area of Asia-Pacific would be a hope for Taiwan to surmount its trade barrier.

Ireland relied on trade protection to stimulate industrial development after independence in 1937. The Irish government opened up its market for free trade instead of a 'block policy' at the end of the 1950s. Because of its small domestic market, export promotion is Ireland's basic trade policy. In contrast to Taiwan's difficult trade position, Ireland not only is a member of WTO and EU, but also signed an Anglo-Irish Free Trade Agreement in 1965 and comprehensive double taxation agreements with 44 countries. Ireland's close trade relationship with other EU members has led to a high growth rate in medicine and information industries.

Concerning foreign exchange controls, Ireland's policy is less stringent than that of Taiwan. Multinational corporations are permitted outward remittance without timing or amount limitations in Ireland, enabling the country to successfully attract FDI (Industrial Development and Investment Center 2004). In contrast, companies in Taiwan have to report to the Central Bank when they have to make outward currency exchanges worth more than US\$1 million (Yu 2003). Table 5 summarizes the above dynamics.

8. Conclusions: Policy implications

International variation in innovation policy presents an opportunity to examine various influences on the pace of technological change. Understanding international differences in the intensity of innovation also informs public policy. While most studies of innovation are set in a given public policy environment (Griliches 1995), policy analysis requires an evaluation of variations in innovation with country-level policy differences.

Table 5. Comparison of demand-side policies between Ireland and Taiwan.

	Ireland	Taiwan
Procurement	(a) National, regional, and local government procurement (b) Public-private partnership	(a) Government procurement and industrial cooperation (b) Build-operate-transfer
Commercial Overseas agent	Lessen foreign exchange controls (a) Access multilateral trade organizations such as WTO (b) Participate in regional trade organizations such as EU (c) Sign the FTA with England and comprehensive double taxation agreements with 44 countries	Intensify foreign exchange controls (a) Access multilateral trade organization such as WTO (b) Participate in regional trade organization such as APEC (c) Sign the FTA with Panama and Guatemala

This article sought to compare innovation policy in two small island countries that have experienced rapid growth in similar areas of their economies. We review and synthesize the main findings of the study in an effort to identify the key policy messages and to make recommendations that could inform further policy developments in Taiwan and Ireland.

As a ‘higher education and training pillar’, Taiwan’s higher education reflects the government’s efforts to promote education and the development of elite personnel. Taiwanese innovation policy emphasizes the development of innovation by research institutes and through universities. The most important direct subsidies in Taiwan are in the form of tax incentives. Among other things, the maximum business income tax paid by enterprises has been reduced and tax holidays on new investments have been increased as time has gone by. Generally speaking, the Taiwanese government takes a more active role in innovation/R&D and focuses policies on specific industries. Particularly, one of the clear differences exhibited in clustering policy in Taiwan is the importance attached to policies targeting specific industries and providing financial, research, and informational support to these industries. The results of this are seen in the specializations of science parks and strong cluster formations. This contrasts Irish cluster policy with early FDI-led approaches taken by the Irish government, which provide incentives to attract high-tech inward investment in or near Dublin to take advantage of the forces of labor and logistics. Also, Irish participation in EU’s Programmes obtaining various research funds also helps facilitate high-tech spin-offs from university incubators and gradually form clusters in Dublin, Cork, Galway, and other cities in recent years.

Furthermore, Taiwan’s economic gains achieved from specialization and trade are limited compared to the far more dynamic process of cross-regional collaboration and upgradation (Saxenian 2006). The Taiwanese policy accords with the nationalist history of planned economic development and state-owned industries, which has been successful in transforming Taiwan from an agricultural to heavy manufacturing to high-tech economy. However, on the other hand, heavy dependence on the government to control the direction of Taiwanese innovation creates a number of risks:

- Political factors may affect direct investment and policies.

- The government may incorrectly judge changes in technology and market developments.
- Significant support may be perceived as dumping, subsidization, or other unfair business practices to competing countries which then seek restitution or institute punitive tariffs (as happened to the Taiwanese DRAM industry in the late 1990s).

The Irish government prefers not to be involved directly in R&D or in controlling the type of innovation that firms undertake. Irish innovation policy emphasizes innovation at the firm level and the interaction between firms and universities. Funding for universities is low, as is the level of government research. In particular, public support for R&D and innovation in Ireland accounts for a lower proportion of costs. Being minimized in Ireland, levels of R&D grant support are typically lower and public assistance is given on a more selective basis. Lower grant rates also mean, however, that a higher proportion of the risk of any R&D will be borne by the private sector. Thus, the need to provide up-front evidence of the commercial validity of R&D or innovation projects to satisfy selection criteria, and the unwillingness of the Irish government to support near-market developments, is likely to reduce the contribution of Irish innovation policy to diversity. On the other hand, the fact that Ireland's policy to attract inward FDI is quite successful also implies a high level of R&D globalization for the country, helping to gain more international mobility of R&D and innovative activities. In international terms, substantial inward FDI in Ireland for the last three decades has created the potential for substantial learning by indigenously owned enterprises (Roper 2000). However, one criticism leveled at Irish innovation is that too much focus on FDI policies results in failure to address some of the weaknesses in the indigenous technology sectors (Walker 1993; Hewitt-Dundas and Lenihan 2002). To engage this challenge, in the more recent years, Irish government has begun to foster the R&D capability of indigenous technology sectors through national initiatives such as the establishment of Science Foundation Ireland (Grimes 2006).

The Taiwanese government emphasized the use of government procurement and industrial cooperation policies in the past to acquire advanced technologies such as aerospace technology, military technology, transportation technology, etc., establishing the foundation of the high-tech industry in Taiwan (Industrial Technology Research Institute 2005). Along with introducing key technologies by use of policy tools, the Taiwanese government also takes a role in linking customers to manufacturers by holding trade shows. However, the Irish government intends to establish an environment to attract more foreign investments. Table 6 summarizes the main innovation policy contrasts between Taiwan and Ireland on the supply, environmental, and demand sides.

9. Recommendations for Taiwan's and Ireland's innovation policies

In the future, the innovation performance of a country is likely to be even more crucial to its economic and social progress (OECD 2005). This research concludes some recommendations for Taiwan and Ireland, respectively, as given below.

Table 6. Summary of major innovation policy differences between Taiwan and Ireland.

	Ireland		Taiwan
Supply side policies: Both provide technical and research information	Emphasis on knowledge transfer between universities and firms, role of industry highlighted. (Weak university funding)		Emphasis on research institutes, university development, and university research
Environmental side policies: Both have many financial incentives for firms to conduct research and incubators	Mostly focused on the provision of finances including program to make access to private finances easier		Very strong role for science parks. Research facilities are provided and the government directly funds key companies (Restrictions because of China situation)
Demand side policies: Both have undertaken deregulation but more efforts need to be made	Limited marketing initiatives		Government procurement is important. Trade shows link customers to manufactures
General policy observations	General development polices benefit all industries Bottom-up approach to innovation	<i>Versus</i>	Targeted development of innovation in chosen industries <i>Versus</i> Top-down approach to innovation

9.1. Taiwan

9.1.1. Supply side

9.1.1.1. *Fundamental research, long-term economics, and technology developments should be coordinated with each other.* Taiwan’s innovation performance in recent years, as mentioned in the previous parts, has already become very competitive worldwide. However, why can’t economic growth catch up with the speed of technology development? We suggest that fundamental research projects should be coordinated with long-term economics and technologies. Technology forecast may be one of the feasible strategies for the Taiwanese government, given the limited R&D resources. Moreover, the focal domain of development with technology forecast should still be complemented with industrial demands so as to contribute to the entire economic environment in the future. For instance, if technological demands brought on by industries cannot be realized, product quality can hardly be improved, and in the end firms remain without market competitiveness. Under such circumstances, there will be negative effects on national economic growth in the long run. Therefore, the government should inspect the demands of technology in the context of the market itself instead of distributing resources based simply on technology. Furthermore, it is advisable for the government to establish institutions such as technological trade centers where technologies can be more efficiently exchanged and extended into the market to benefit national economic growth.

9.1.1.2. *Integrating production network in China.* As mentioned before, Taiwan's economic growth performance is associated with its steady relationship with China's government in terms of politics, economics, and diplomacy. Because of increasing investments in China over the years, leveraging mainland China's technology resources and market should be a key point enabling the Taiwanese government to strengthen technological and economic developments in the future. Particularly, if Taiwan-based firms undertake offshore R&D associated with production network of China such as Shanghai or Shenzhen, the similarities in language and culture between Taiwan and China may facilitate knowledge communication and absorption between the two parties (Chen 2004). The participants in this on-going dialogue can also include industrial planning agencies, state-owned development banks, and private VC firms (Saxenian 2006). This also suggests that collaboration as well as global networking plays a more and more important role for Taiwan in its cluster development stages.

9.1.1.3. *Improving distributions of R&D human resource and managerial performance.* As the previous observation indicates, Taiwan puts heavy emphasis on training of high-tech elites such as electronic information; however it is not enough. Besides enhancing relationships between universities and conventional industries, the government should strengthen human resource training and evaluate the quality of the workers in conventional industries. The other important issue is distribution of human resources. Hsinchu Science Park is just like a black hole, attracting elites from all over. This should be viewed as a severe warning to other industries. The managerial problem is another challenge when developing human resources. Therefore, training and retaining policy elites (or technological policy research elites) in organizations is also a human resource management difficulty that needs to be seriously confronted.

9.1.2. *Environmental side*

9.1.2.1. *New aspects of intellectual property impetus.* In section 6, we have demonstrated that intellectual property protection is an important innovation policy for the Taiwanese government in the recent years. However, in practice, more emphasis can be put on intellectual property in the world of the Internet as well as on setting up a series of standards for uses of Internet compilation. On the other hand, implementing regulations such as the IC Circuit Layout Protection Law not only represents technological advancement in Taiwan but also has some impacts on domestic industries. This is what Taiwan is facing as it becomes internationalized.

9.1.2.2. *Diffusing research results and technologies.* As noted before, technological case projects are often administrated by public or private research institutions in Taiwan. As a result of the high flow rate of research elites in these institutions, technology accumulation is difficult. As a matter of fact, to accelerate information circulations, it is advisable to release intellectual properties to industries after a certain period of time. Moreover, government should establish derived companies through the technical transformation of several research projects, transferring elites to industries step by step in order to accelerate the process of diffusing techniques and strengthening the R&D power of civil firms. Finally, extending Taiwanese R&D

and intellectual property activities to institutions other than research ones is the ultimate aim.

9.1.2.3. *Improving investment environments.* As said before, Taiwan attracts lower levels of FDI than Ireland. Compared with that of Ireland, Taiwan's inward FDI is not as good as it appears. This indicates that Taiwan perhaps needs to improve its investment environment. We suggest that the primary remedies would be to provide a sound capital market, loosen foreign exchange controls, and then stabilize the political situation. As far as Taiwan's situation is concerned easing the monetary policy and remaining in the same condition, and also having a low interest rate should be the right policy trends for the government to stimulate business investments.

9.1.3. *Demand side*

9.1.3.1. *Advancing BOT mechanism.* In section 7, we have mentioned that Taiwan has applied BOT to create a market for advanced technologies in the recent years; however, some cases suffered from scandals benefiting specific contractors, reflecting the fact that Taiwan's BOT mechanism is immature. To prevent a financial predicament for contractors caused by over-optimistic financial prediction, the government may adopt the least-present-value-of-revenue auction proposed by the World Bank (Engel, Fischer, and Galetovic 1998). This way, the crucial market provided by the government for innovation can be more sound.

9.2. *Ireland*

9.2.1. *Supply side*

9.2.1.1. *Developing R&D capability in indigenous firms.* According to the earlier emphases, Ireland's FDI policy has been successful; however, the government should try to create domestic conditions that gain as much as is lost from international mobility of R&D and innovative activities. For Ireland, a key challenge is not only to encourage foreign-owned MNEs to increase their investment in R&D undertaken in Ireland, but also to ensure that the social benefits arising from this are maximized. This could be accomplished through greater partnerships and collaboration between universities and the MNEs as well as through vertical supply links with local suppliers. This will develop R&D capability in indigenous firms and increase the likelihood that they will subsequently undertake R&D.

9.2.1.2. *Upgrading higher education system.* As mentioned before, Irish universities used to focus chiefly on the humanities fields. This has resulted in a lack of researchers in technology and engineering sectors and limited research facilities. This problem with higher education in the innovation system needs to be addressed, either by significant investment and reorientation of the educational system or by depending less on the education system as an input. Given the importance of higher education in innovation, the former would likely be most beneficial. The Irish government may also wish to consider whether a more focused approach to innovation policy would be better suited to a country with such a small population.⁵

Targeting the creation of industrial clusters that complement the existing MNEs based clusters would both provide ready customers for those new clusters and aid in retaining MNEs within Ireland.

9.2.1.3. *Facilitating cluster development to foster competence of indigenous industry.* As emphasized in the previous parts, the Irish economy has benefited from the successful FDI-led development policy and the high level of dependence on inward investment. However, imported technology leaves Ireland easily exposed to influences of global downturn. On the other hand, Ireland has successfully experienced networking based on formal inter-organizational collaboration between research centers, universities, and private sectors through participation in, as noted before, EU's Framework Programme, which provides a foundation to facilitate cluster development. Therefore, Irish government could commercialize research results to enhance competence of indigenous industry by the existing linkage between state research centers, universities, and indigenous high-technology companies.

9.2.2. *Environmental side*

9.2.2.1. *Encouraging non-R&D active firms to invest in R&D.* As mentioned before, in Ireland, efforts have been made to bridge links between industry and science. However, a large proportion of firms receiving grant support are in sectors where R&D is established in the organizational ethos of the industry, and many of these firms are large, foreign-owned plants with well-developed R&D capability. One explanation for this is that firms are unable to participate in huge R&D programs if the underlying capability to undertake R&D does not exist. Therefore, a continued focus on encouraging non-R&D active firms to invest in R&D is to be encouraged for Ireland. However, this aim will be achieved only where a holistic approach to business support and development is adopted in building R&D capability along with the provision of R&D support. In particular, the lack of intermediate technology transfer institutions should be leveraged.

9.2.3. *Demand side*

9.2.3.1. *Public procurement.* As analyzed in prior sections, Irish government uses public procurement in terms of PPP to create market for emerging technologies. As we have known, large firms have more sufficient capability to participate in government's important procurements. However, high-tech SMEs occupy a large proportion in Irish industry market. Accordingly, in Ireland, Start-up SMEs should be given full and fair opportunities to bid for public R&D contracts or contracts to buy technology-based products, The US Small Business Innovation Research (SBIR) program is one possible way of achieving this objective.

9.3. *Small summary*

Both countries have been significantly affected by developments and innovation in Silicon Valley. Saxenian (2006) shows how Taiwanese entrepreneurs developed important network connections with Silicon Valley, while many SV companies have been key investors in Ireland. As we have observed, a major incentive for US

technology companies investing in Ireland has been the EU's single market, while in the case of Taiwan, China has provided an important offshore development location or Taiwanese companies, while also being an important market for such companies. For the two countries, therefore, it is important to keep sustainable collaboration with EU and China to get themselves deeply involved in the global production networks.

10. Future research

Additional researches can be conducted to evaluate the differences between the two nations in the production of visible innovative output and to investigate how variations in innovation policy matter to performance in small countries such as Taiwan and Ireland. Another focus of future studies should also be to explore how innovation performance directs policy as feedback. Consequently, more efficient policy implications and suggestions can be drawn from further findings.

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Notes

1. Like all other areas of the European Framework Programme, TAP was focused on the construction of networks involved in the sharing of information, knowledge, and expertise, and bringing together service providers and users in different areas of activity such as health and education (Grimes and Collins 2002).
2. *Near-market R&D support* schemes to support the development of specific products and or processes with an immediate and clearly identified market application.
3. *Pre-competitive R&D support* schemes to fund applied research which has commercial potential but which is not linked to any specific product or process development. This type of R&D may be conducted within a company, university, or through a collaborative arrangement.
4. High-risk research is often associated with radical innovation.
5. Ireland's population was estimated in July 2007 at 4.1 million (CIA, The World Factbook 2007).
6. The corporate tax rate in Taiwan is 25% as opposed to 12.5% in Ireland (KMPG 2008).

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