CREATING ADVANTAGE IN PERIPHERAL REGIONS:
THE ROLE OF PUBLICLY FUNDED R&D CENTRES

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Creating Advantage in Peripheral Regions: The Role of Publicly Funded R&D Centres

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Abstract:
Regional investment in R&D, technological development and innovation is perceived as being strongly associated with productivity, growth and sustained international competitiveness. One policy instrument by which policy makers have attempted to create regional advantage has been the establishment of publicly funded research centres (PRCs). In this paper we develop a logic model for this type of regional intervention and examine the outputs and longer-term outcomes from a group of (18) publicly funded R&D centres. Our results suggest some positive regional impacts but also identify significant differences in terms of innovation, additionality and sustainability between university-based and company-based PRCs. University-based PRCs have higher levels of short-term additionality, demonstrate higher levels of organisational innovation but prove less sustainable. Company-based PRCs demonstrate more partial additionality in the short-term but ultimately prove more sustainable.

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Key words: Publicly funded, R&D, R&D Centre, Northern Ireland
Creating Advantage in Peripheral Regions: The Role of Publicly Funded R&D Centres

1. Introduction
The capability of a region to generate advanced technology, information and ultimately knowledge is regarded as the ‘single most important force driving the secular process of economic growth’ (Bresnahan and Trajtenberg 1992, p. 1). In particular, regional investment in R&D, technological development and innovation is perceived as being strongly associated with constructing regional advantage (Cooke and Leydesdorff 2006) through productivity, growth and sustained international competitiveness (Malecki 1981; Romer 1990; Eaton and Kortum 1995; Koo and Kim 2009). Moreover, Audretsch (1998, p. 26) argues that as ‘knowledge spillovers tend to be spatially restricted… The increased importance of innovative activity in the leading developed countries has triggered resurgence in the importance of local regions as a key source of comparative advantage’. This emphasises the importance of regional policy in ‘creating advantage’ and, in particular, the role of public policy and public investment decisions in shaping the innovation system within which firms’ operate (Leydesdorff and Etkowitz 1998).

One way in which regional policy-makers have recognised the importance of these linkages has been through the establishment of publicly funded research centres (PRCs) with the objective of stimulating industry-university links and localised economic benefits (Debackere and Veugelers 2005). Feller (2004), for example, examines the importance of public research universities to economic development in the US, while Graversen et al. (2005) emphasise the role of Centres of Excellence in achieving EU objectives relating to the European Research Area. Recent evidence, however, suggests that the productivity benefits from PRCs engaging in different types of technology transfer activity, and operating in different organisational and economic contexts, may differ significantly (Graversen, Schmidt, and Langberg 2005). Bilbao-Osorio and Rodriguez-Pose (2004), for example, argue that publicly funded R&D may compensate for business R&D in more peripheral regions, while

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1 Feller (2004) also focuses on the need for universities to maintain a high quality and well resourced research environment to attract and retain high quality research staff, with the result that ‘states which are either unable or unwilling to provide the financial support necessary to maintain competitive higher education systems are likely to fall behind in longer term efforts to develop nationally competitive knowledge-based economies’ (p.141).
Fernandez et al. (1996) suggest that publicly funded applied R&D (as opposed to basic R&D) may be of greater value in peripheral regions due to firms’ more limited absorptive capacity (Zahra and George 2002; Roper and Love 2006). Other studies, while stressing the strong benefits of university research (Anselin, Varga, and Acs 1997, 2000; Fischer and Varga 2003; Verspagen 1999) also stress the differential strength of these localised effects from R&D in different sectors and disciplines.

Our objective here is to examine whether public investment in R&D centres can generate longer-term economic outcomes in a peripheral region given the limited absorptive capacity of firms in such regions (Roper, Hewitt-Dundas, and Love 2003) and uncertainties around the longer-term sustainability of public R&D investments. In particular we consider how different organisational contexts, i.e. R&D centres in Universities as compared to private sector businesses, may influence the short-term outputs and longer-term outcomes from these centres. Our starting point is a logic model or programme theory linking public investments in R&D to short-term impacts and longer-term regional outcomes. Our empirical study is based on a longitudinal analysis of a new policy initiative conducted in Northern Ireland over the 2002 to 2005 period in which a group of eighteen new publicly funded R&D centres were established. These Centres were then followed-up in 2009 to assess their sustainability and longer-term outcomes. Our results suggest some positive impacts, but also identify clear differences between the profiles of additionality and outcomes of publicly funded university-based and company-based R&D centres.

The remainder of the paper is organised as follows. Section 2 outlines the logic model underlying the public investment in this group of R&D centres, focussing particularly on the mechanisms through which private and regional outputs and outcomes might occur. In Section 3 we then outline the data and methods that we adopt in both the longitudinal element of the study and the subsequent follow-up. Our main empirical findings are included in Sections 4, 5 and 6 relating separately to private outputs, regional outputs and outcomes. Section 7 concludes by considering some of the key findings and implications of the research for the development and implementation of science and innovation policies in similar regions.

2. PRCs and regional development – logic model
The programme theory or logic model for any public policy intervention provides a unifying framework – ideally developed ex ante – which links the justification for public intervention to the objectives of the intervention, its inputs, process model, outputs and outcomes (Donaldson and Gooler 2003). The aim of developing a logic model is to provide a comprehensive framework against which the validity and success of an intervention can be judged as well as identifying any contingent factors which may influence longer-term outcomes. For the PRCs considered here the implicit programme theory, based on discussions with the intervention sponsors, is depicted in Figure 1. The starting point in the logic model is the justification for intervention (Donaldson and Gooler, 2003). In the case of the PRCs we consider here this related to longstanding concerns about low levels of R&D and innovation in the region (Roper 1998; Hewitt-Dundas et al. 2002) and evidence that increasing R&D and innovation can have positive effects on firm-level and economy-wide growth and productivity (Crepon et al. 1998; Parisi, Schiantarelli, and Sembenelli 2006; Guellec and van Pottelsbergh 2004). One assessment at the time concluded that Northern Ireland’s regional innovation system was: ‘dominated by relatively few large firms, with predominantly national and global rather than local and regional linkages, and supported by relatively low levels of regional private and public R&D’. The result was that ‘business innovation [was] too low in Northern Ireland and the linkages in the innovation system [were] inadequately developed. Both the level of innovation (capabilities) and of interaction in the innovation process (networks) need to be increased’ (Cooke, Roper, and Wylie 2001).

In this context the Centres of Excellence programme was launched in 2002 to ‘support the establishment of R&D centres to stimulate leading edge, industrially exploitable and commercially focused research which will demonstrably improve the competitiveness of Northern Ireland industry’ (INI 2003). The intervention was launched with two competitive calls for proposals. Twenty-eight applications for

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2 In 2005, for example, business R&D in Northern Ireland was equivalent to 0.6 per cent of regional value added (GVA), around half of the UK average of 1.2 per cent. In part, low levels of business R&D in Northern Ireland are a result of the preponderance of smaller businesses in the region. Also, employment in medium and high-tech manufacturing activity in Northern Ireland, accounting for around 4.5 per cent of manufacturing employment, is well below the OECD average of 7.4 per cent, although comparable to the UK average (4.5 per cent). Source: Regional Competitiveness and State of the Regions, DTI, April 2005.
funding were received, and eighteen publicly-funded research centres (PRCs) were approved for funding over three years. Host organisations then undertook to ‘sustain’ activity in the PRC for three further years after the grant funded period. Of the eighteen funded PRCs, ten were based in private companies and eight were university-based (Table 1). Inputs to the scheme in terms of public funding for the eighteen PRCs amounted to £34.0m (30.0 per cent) with this matched by an additional £79.4m from the PRCs’ host organisations over three years (Figure 1). The ten company-based PRCs accounted for 40.3 per cent of total programme investment and received 31.5 per cent of public funding. The eight university centres, on the other hand, received 68.5 per cent of programme funding and made up 59.7 per cent of total spending. The difference between the composition of total programme investment and public funding is due to the larger average size of the university centres and the higher proportion of public support they received.

Although the absolute value of the public and private inputs to the eighteen PRCs is small in a UK or international context, Northern Ireland is a relatively small region with a population of around 1.7m. In a regional context, the investment in the PRCs was therefore larger, increasing higher education R&D in the region by around a fifth and business R&D by a tenth (see DETI, 2005). This step-change in levels of R&D investment would, it was hoped, lead to both positive private and regional outputs within the funded period (Figure 1). The most obvious private outputs result from the impact of the PRC on the host organisation’s stock of knowledge, and hence to commercial applications or the sale of licences to other technology users (Figure 1). Other private benefits may also be evident, however, in terms of improvements in the host organisation’s R&D capability and its ability to absorb R&D results or knowledge from elsewhere (Griffith, Redding, and Van Reenan 2003; Cassiman and Veugelers 2002). Reputational or ‘halo’ effects may also stem from having an in-

3 Finance for this initiative came from the European Union Programme for Peace and Reconciliation in Northern Ireland and the Border Region of Ireland (PEACE II) managed by the Special EU Programmes Body in partnership with the Northern Ireland Department for Employment and Learning.

4 The average university-based PRC represented an investment of £8.5m compared to £4.6m in the company-based PRCs and the higher grant rate (50 per cent as opposed to 20-25 percent).

5 In 2002, total higher education spending on R&D (HERD) in Northern Ireland amounted to £105.8m. The proposed investment by the university-based Centres at this time was £68.29m, equivalent to 64.5 per cent of HERD. Similarly for company-based Centres, the proposed investment in 2002 of £46.15m was equivalent to 29.5 per cent of total business expenditure on R&D in Northern Ireland (£156.6m). Over three years these amount to around a 20 per cent increase in higher education R&D and a 10 per cent increase in business R&D.
house PRC as potential employees or alliance partners may be attracted by an organisation’s research or innovation capacity.

The regional outputs of PRCs are normally identified as developing through three main mechanisms (Figure 1). First, supply-chain or rent-based effects may occur where a PRC generates gains to other organisations through the supply chain or through other forms of market transaction (Figure 1). These effects may include both new supply contracts – either forwards or backwards along the supply-chain - and also rent spillovers ‘which arise when quality improvements by a supplier are not fully translated into higher prices for the buyer(s). Productivity gains are then recorded in a different firm or industry than the one that generated the productivity gains in the first place’ (Beugelsdijck and Cornet 2001). The extent of these regional supply chain outputs will depend crucially on market interactions between the PRCs and other regional organisations. The stronger are local supply chains and other market interactions (e.g. licensing agreements), the stronger will be the outputs.

Second, PRCs may generate positive regional outputs through the labour market where a PRC helps either to create or attract a pool of research-trained labour (Figure 1). This can help to reduce the potential for crowding out of the type envisaged in David and Hall (2000), may reduce the upward pressure on regional wage levels for research workers (Golsbee 1998), or may contribute to organisations’ absorptive capacity (Roper and Love 2006). The extent of any regional labour market outputs will depend on the quality and extent of training within the PRCs, the extent of labour turnover from the PRCs, and crucially the retention of PRC-leavers within the region. Finally, positive regional outputs may occur through pure knowledge spillovers where information from a PRC flows to others in the local area through social contacts or other ‘un-priced’ interactions ‘either unintentionally, as it happens when inventions are imitated, or intentionally, as it may happen when scientists divulge the results of their research’ (Breschi and Lissoni 2001, p. 975). Such spillovers do not require any type of ‘market’ interaction but depend instead on the openness of the PRC in sharing knowledge and the effectiveness of its absorption and adoption by other local

It should be noted however that R&D may also have negative regional effects for example where new technology replaces labour or where R&D leads to a reduction in cost then this will have a ‘knock-on’ effect on the price of substitute products.
organisations (Figure 1). As Narula (2004) emphasises, however, a region’s ability to benefit from pure knowledge spillovers will reflect both the absorptive capacity (ACAP) of individual enterprises, the capability of knowledge intermediaries in the region, and the extent of association between regional organisations (Cooke and Morgan 1998).

Longer-term, the likelihood of positive outputs becoming positive outcomes in terms of sustained increases in regional R&D activity or growth depends strongly on other contingent factors (Figure 1). Organisational approaches to IP management, for example, might shape the extent to which knowledge generated by the PRCs is either regarded as proprietary or widely diffused (Young, Hewitt-Dundas, and Roper 2008). Similarly, host organisations’ ability or attitude to sustaining activity within a PRC beyond the funding period will be important in the longer term. Equally important perhaps are the characteristics of the wider business environment in the region which may either enhance or restrict the transition from positive outputs to outcomes. In either situation, the logic model in Figure 1 suggests that we would hope to observe positive longer-term outcomes at both the private and regional levels.

3. Evaluating the logic model - Data
The data we use to evaluate the logic model developed in Figure 1 comes from two main sources. First, to profile and assess project outputs we use detailed data derived from longitudinal monitoring of the PRCs undertaken over the 3 year funding period (i.e. 2002-2005). Second, to assess longer-term project outcomes we conducted a series of follow-up interviews around the end of the ‘sustain’ period (i.e. 2009).

During the funding period, our longitudinal monitoring of the PRCs involved an initial review of the case for support written by the PRCs as part of the application process for public support. This provided background on the host organisations and the aims and objectives of the proposed PRCs. We also asked each PRC to complete a detailed postal questionnaire every four months. This provided regular quantitative data on the level and type of R&D activity conducted by each PRC, its links to external partners and its commercialisation activities. An overall response rate of 75 per cent was achieved. In addition, we conducted periodic unstructured and semi-structured interviews with the PRCs over the funded period to verify aspects of the
survey data and explore specific issues (e.g. human resources, intellectual property management). Finally, in mid-2006 we conducted a focussed series of (17) semi-structured interviews with the PRCs themselves and with a range (36) of their private and public sector contacts within Northern Ireland. These focussed specifically on the relationships between the PRCs and their local contacts to help assess regional outputs.

To assess longer-term outcomes, face-to-face, interviews were undertaken with the PRCs in late 2009. For most of the PRCs these coincided with the end of the three-year period over which host organisations had undertaken to sustain PRC activity. By this point one of the firms hosting a PRC had closed (PRC-10 in Table 1). Of the remainder, interviews were conducted with senior staff who had been based in twelve of the PRCs (71 per cent) focussing on the development of the PRC over the funded and sustained period, and the scale and nature of outcomes. Wherever possible, interview data was supported by publicly available information to provide as complete a picture of potential outcomes as possible.

4. Evaluating the logic model – Private Outputs

The private outputs derived by any PRC - including scale effects of the R&D investment, creation of patents or licenses, spin-out or spin-in activity, contribution to sales and the recruitment of staff - will clearly depend on the type of R&D the PRC is conducting (Kirchhoff et al. 2007). Across the PRCs significant differences were observed between the profile of research activity in the university-based and company-based centres. For example, reflecting the commercial pressures on the organisation and the lower level of public support they received, company-based centres were more likely to be engaged in experimental R&D activities, while university-based centres concentrated on basic and applied R&D (Table 1). Both the university and company-based PRCs, however, reported significant scale effects from the PRC funding both in terms of its direct effect on R&D volume but also its indirect effect on the PRCs ability to attract external R&D resources. Overall, the university-based PRCs generated 36.1 per cent of their income from external sources compared to 24.3 per cent for company-based PRCs. One university-based PRC commented:
“We have a growing confidence in our ability to get competitive research money and to work closely with industry, which again we didn’t have before. To be involved in a £2 million government contract would have been absolutely impossible for us to dream about four years ago.”

Other private outputs related to the downstream benefits of this R&D which led to 38 patent applications by the PRCs over the funded period: 22 by the university-based centres and 16 by the company-based centres. On a per PRC basis this suggests that university-based PRCs were more likely to make patent applications than the company centres (2.75 per university-based centre compared to 1.6 per company-based centre). If patent applications are measured relative to R&D investment, however, then this distinction disappears with each type of centre being equally as effective in translating R&D investment into patent applications, i.e. £3.04m investment in R&D per patent application in company centres and £3.08m per patent application in university centres. Alongside these patent applications and awards a number of product trials (273) were also reported over the funded period primarily by the company-based PRCs. Over the funded period outputs in terms of licensing activity by the PRCs was limited, with only five being reported. Three of these were granted by two of the University-based centres with the remaining two licenses being issued by one company-based centre. One other element of commercialisation activity that differed significantly between the company and university centres related to spin-in and spin-out activity. In one of the University centres, four spin-in companies were reported while in two other University centres, three spin-out firms were established. No spin-out or spin-in activity was reported by the company-based PRCs. Our evidence therefore points to significant differences in the profile of technological outputs of the company-based and university-based PRCs. This reflects earlier studies which have emphasised the importance of licensing and spin-outs as exploitation mechanisms for university-based R&D (Siegel et al. 2003; Lee and Win 2004).

For the company-based PRCs, much more important than either outputs in terms of spin-outs or licensing were new sales contracts attracted over the period. For these PRCs, total R&D investment amounted to £48.6m with £32.4m being reported during the period in new contracts, equivalent to 66.6 per cent of total R&D investment.

7 Indeed, one centre in the food processing sector was responsible for 77.3 per cent of these trials. This suggests that project/product trials is strongly biased by the sectoral representation of centres in the sample.
Among the university-based centres on the other hand, total R&D investment was £67.6m with new contracts reported over the funded period of only £4.2m, equivalent to 6.2 per cent of total R&D investment.

The scale of these new sales contracts in the company-based PRCs suggests that PRCs’ investment in knowledge creation was being commercially exploited generating significant private outputs in a relatively short period of time. These short-term sales benefits were also markedly larger for the company-based PRCs, a result linked no doubt to their greater focus on near-market R&D. By contrast, the more applied focus of University-based research may have been reducing the scope for commercial exploitation particularly in the short-term. One university-based PRC commented:

‘The idea was to use Centre funding to push forward a selected number of projects, which we had the technical capacity to do, that we hoped would … result in some commercial applications… The idea behind the centre was not to do projects which would be immediately commercially viable, but to do projects which, if they work, would give you the basis of a project which would be commercially viable.’

One other benefit of the public funding received by the PRCs was their ability to recruit additional research and administrative support. Over the funded period 320 new jobs were created in the PRCs of which around two-thirds were new research posts (66.6 percent) with a quarter (26.9 per cent) being technical support posts and 6.5 per cent administrative or other staff. In general, the recruitment of research staff was more problematic for the company-based PRCs with one company-based PRC commenting:

“Finding people with the necessary skills is a problem at times… What we do is very niche therefore they don’t often come in with the necessary skills. We are employing people on their ability to learn. Then of course in Northern Ireland your base is less. If you were in the South of England you would probably have more, but then of course you would have to pay more.”

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8 Compared to the composition of R&D employment in NI, the PRCs demonstrated a higher proportion of research and technical posts and a lower proportion of admin or other staff (DETI, 2005a).
Recruitment of suitably qualified researchers was less of a problem for the university-based PRCs, largely due to their ability to attract human capital into the region from elsewhere; 21.9 per cent of all new posts in the university-based PRCs were filled by staff from outside the region, compared to only 4.8 per cent of those in the company-based PRCs. In general, the university-based PRCs suggested that public sector funding had been important in attracting highly skilled people from all over the world. Indeed, at one stage, one of the university-based PRCs had staff from 26 different countries involved in the centre. At the same time, just under half of the ‘new’ posts in both company-based and university-based PRCs were filled by employees recruited from within the host organisation.

As envisaged in the logic model in Figure 1 our evidence suggests that the PRCs generated relatively substantial private outputs over the funded period both in technological and commercial terms. The nature of the research activities in which the company and university-based PRCs were engaged and their exploitation strategies varied significantly, however, suggesting the potential for marked differences in the type of regional benefits generated by each type of organisation.

5. Evaluating the logic model – Regional outputs

Over the funded period, our monitoring data suggests that both the university and company-based PRCs generated significant new connectivity which might provide the basis for regional outputs: university-based PRCs developed 277 new connections (34.6 per PRC); while the company-based PRCs developed 107 new connections (10.7 per PRC). Around 18 per cent of the new relationships developed by the university-based PRCs and 47 per cent of those developed by the company-based PRCs related to supply chain outputs, i.e. new market mediated relationships. In total these new commercial contracts were worth £28.8m during the funded period, and although almost half of these contracts (45.9 per cent) were with other Northern Ireland based companies, the total value of the Northern Ireland contracts was relatively small (£1.41m or 4.9 per cent). One possibility is that this reflects

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9 This result contrasts somewhat with (Palmberg 2008) in their study of nano-technology in Finland. Their results suggested that ‘company respondents report more frequent interactions by all the different modes when compared with their university counterparts’ (p. 639). This contrast may relate to the contrast between the intensity of interaction rather than the extent of individuals’ contact networks.
absorptive capacity, or the limited size and productive potential and range of the Northern Ireland economy (Crone and Roper 2001; Hewitt-Dundas et al. 2002). However, a company-based PRC indicated that even though the establishment of the PRC did not lead to the development of new supplier relationships it increased the volume of work with the firm’s pre-existing suppliers:

‘I don’t think that … we have started working with any new suppliers. The volume of work has increased with existing suppliers. One of the companies we are working with… have got a lot of new business out of this project. We have a large supply base. We tend to supply things in Northern Ireland if it is possible and the volume has increased dramatically with a lot of the Northern Irish suppliers.’

Evidence from our discussions with the local partners of the PRCs (2006) also suggested positive regional output effects with around a half indicating that their relationship to the PRC had had a discernable impact on their turnover. One company remarked that:

‘Without [the PRC] we couldn’t have grown as well as we have. They are our most important customer and a major contributor to our revenue’.

In other instances, the impact on turnover was less substantial yet other benefits arose from supplying the PRC. Examples of this included a broadening of business activities and the development of further collaborative research partnerships:

‘It’s one of those things: the amount of money brought in for us directly because of them is not enormous but it facilitates further revenue. Most of our revenue comes from manufacturing, but the ability to supply analytical packages also helps us to stay competitive and can be very lucrative’.

Another organisation commented that:

‘We were a supplier to [the PRC]. Since that, we have also done some collaborative work with them which has been highly beneficial to our business, so we’re technology partners to a certain extent also.’

Working with the PRCs had also allowed other firms to improve other aspects of their competitive position. Some supply-chain partners, for example, noted improvements in costs:
‘The increased efficiency in processes which comes with … should reduce costs significantly.’

And,

‘Due to the increased turnover that [the PRC] has brought, the percentage of cost in relation to turnover has probably gone down. Because we are producing more, costs have fallen slightly in terms of percentage’.

Other firms benefitted from their relationships to the PRCs in terms of increased product range, quality and technical capability. One local firm remarked that their product range:

‘has widened greatly. We have been able to go into areas which would have been otherwise inaccessible. It has allowed us to develop new-to-the-world products as well as new-to-the firm’.

Similarly,

‘…. are a leading edge company and being their supplier has led us to try and keep up with them by investing and acquiring new skills. So they helped us to be a leader too and this has helped us with other companies’.

However, in some cases the relationship led to increased costs that were not offset by an increase in revenue. One local firm remarked:

‘There’s one thing that happened with [company-based PRC] last year, when we embarked on production for a series of parts for them and it caused a lot of ill feeling between ourselves and them because we incurred a tremendous amount of costs and they refused to pay for them. I’m sure we’ve lost money; we’ve sold them stuff, but our costs haven’t been covered.’

On balance our evidence suggests therefore both that the PRCs had developed significant new networks of contacts over the funded period and that for some of these contacts at least there had been significant output effects. Other regional outputs may arise through less clear mechanisms, however, with both the company and university-based PRCs engaging with a number of networks which might provide the basis for socially-mediated knowledge spillovers (Beugelsdijk and Cornet, 2001). Overall, 12-15 per cent of the new relationships established by the PRCs during the funded period were network memberships, although the proportion of these relationships which were intra-regional differed markedly between the university-based PRCs (19 per
cent) and the company-based PRCs (70 per cent). One of the university-based PRCs commented:

‘Our collaborations have been more with English universities and American and Indian and hopefully very shortly Japanese universities, more than local universities. That has been part of the whole outreach agenda. I think there is going to be a lot more of that before we completely interlink with each other, but in saying that there are examples of some activity that is joint [between the two local universities].’

Another of the university-based PRCs commented on the wider benefits of the networks established:

‘When we met the software companies, one of the things that they wanted from the university was for the university to be linked with blue chip partners, so that they can, through the university, access people from those companies. I would regard that as a spillover effect …. If we have suddenly found that Rolls Royce, British Aerospace, Airbus and others, are becoming part of contracts that involve [the PRC], then in the event that an engineering company wants a contact with Rolls Royce, we have a facility to make those contacts. The network is built up. The network is one based on the solid foundation of research.’

Regional output effects might also occur through other forms of relationship such as R&D collaborations or consultancy or service provision contracts. This type of relationship accounted for around two-thirds of the new connections established by the university-based PRCs and around 40 per cent of those established by the company based PRCs over the funded period. Here, however, the majority of new relationships for both the university-based PRCs (75 per cent) and company-based PRCs (57 per cent) were outside the region perhaps reflecting issues around local absorptive capacity and the nature of the industrial base in Northern Ireland (Fernandez 1996; Oughton, Landabaso, and Morgan 2002).

The issue of potential barriers to local connectivity was not simply the consequence of limited absorptive capacity on the side of Northern Ireland firms, however. A number of the company-based PRCs had had mixed experiences trying to form technology partnerships with universities (Palmberg 2008). One of the company-based PRCs recalled positive links to both regional and national universities:
‘We have established formal links as a result of having a Centre.... we’ve got a graduate placement underway [with a local university]. That has been going for about a year, year two will start fairly soon. The second one... is with [English university name] where we will be sponsoring a post graduate student.’

Other PRCs identified issues with developing links with local universities in terms of a lack of engagement:

‘We would also have hoped to tap more into the post-grad world, but so far we have failed to find anyway to engage in R&D within the local universities. They seem to have as much money as they can spend to do the kinds of things that interest them. My attempts to suggest projects that we might in someway support have had literally no interest at all in taking me up on the offer.’

And, a difference in perceived timescales:

‘We had a lot of viable projects but most of them had a deadline, which made that sort of partnership prohibitive... Whenever we talked to various people at [a local university] we realised that they would not be able have a result in a twelve month period... In the end we did not do a research project with them but it certainly helped with the communication.’

The final route through which regional outputs can occur is through the labour market due to the availability of new or improved research skills, via training in the PRCs, or through research-trained staff acting as localised carriers of knowledge (Roper et. al. 2006). As indicated earlier, the PRCs particularly the university-based PRCs, did recruit new staff. They also invested relatively heavily in training, with staff in company and university-based PRCs undertaking broadly similar levels and types of training. Training undertaken by PRC employees over the funded period accounted for over 2,500 man-days and included: technical courses; equipment training; soft skills training; coaching and mentoring; on-the-job training; self learning; and conference and seminar attendance. Generating regional benefits from these new and upgraded skills, however, also requires the retention of job-movers within the region. In fact of the 120 staff which left the PRCs over the monitoring period, three quarters (76.8 percent) were retained within the region, one fifth (19.6 per cent) left Northern
Ireland, and 1.2 per cent retired. This suggests a relatively positive picture in terms of the potential for regional labour market outputs, however, there was a tendency for staff recruited from outside the region by the university-based PRCs to also find subsequent employment outside Northern Ireland. This again raises issues about the absorptive capacity of the region and the availability of attractive local opportunities for internationally mobile R&D workers.

6. Evaluating the logic model – Outcomes

Our longitudinal monitoring of the PRCs during the funding period suggested a relatively positive picture in terms of both private and regional outputs: scale effects on R&D had been achieved, with some positive re-configuration of existing activity and the development of some new regional R&D competencies; new linkages had been established and there was evidence of positive regional supply-chain and knowledge spillover effects. Maintaining these effects to achieve the outcomes envisaged in the logic model required the sustainability of the PRCs and depended on contingent factors (Figure 1). Two main types of contingent factors are specified in the logic model relating to economic conditions and PRCs’ organisational context. In terms of the broader economic context, UK economic conditions during the funded period (2002-05) and sustained period (2006-08) were relatively benign with the UK economy experiencing steady growth underpinned by investment in innovation (Haskel et al. 2009). For the university-based PRCs at least, the broad organisational climate was also relatively positive over this period, with UK universities being encouraged and funded to prioritise industrially-relevant research and technology transfer activities.

Follow-up interviews to assess PRC outcomes were undertaken in late 2009. By this time five of the eight university-based PRCs (71 per cent) had essentially ceased operating; two had achieved a position of sustainability and had maintained their levels of R&D activity since the initial funding period (14 per cent); and one was

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10 We were unable to determine the destination of 2.4 per cent of the staff leaving the PRCs over the period 2002 to 2005.
11 See, for example, the discussion of the Higher Education Innovation Fund at www.hefce.ac.uk/econsoc/buscom/heif.
continuing to expand. Of the five university-based PRCs which had closed, all were new PRCs which had been set-up in 2002 as a response to the funding opportunity presented by the scheme. Conversely, both of the PRCs which had achieved a sustainable position in 2009 pre-dated the 2002 funding scheme and both either had, or had developed, synergies with other elements of the regional economy. In one case, these synergies, in the form of pre-existing R&D collaborations, provided the basis on which the PRC application was made, and continued collaboration helped the PRC to achieve sustainability. In the other case, although again the R&D centre predated the PRC funding the development trajectory was rather different. In this case, the PRC suggested that at the time of initiation (2002) there was ‘no-one to talk to’ in the region. However, during the funding period, local entrepreneurship, strongly supported by targeted public investment in parallel to that in the PRC, led to a ‘co-evolution’ of regional R&D and industrial capacity, and the development of balanced local technology innovation system embodying both R&D and innovation capabilities. The final university-based PRC is perhaps the scheme's most obvious success, at least in terms of the scale and maintenance of a leading edge research profile. Continued support from the university, and much greater inter-disciplinary collaboration than was evident in the other university-based PRCs have provided the basis for success in acquiring a number of significant research grants. These have supported significant changes in the research agenda of this PRC, moving from mobile IT applications to secure IT systems. Industry collaboration in this agenda – particularly from within the region – however remains limited reducing the potential for both regional supply-chain and pure knowledge spillovers. Instead, where commercialisation has taken place tended to follow spin-out route. In the follow-up interviews (2009) staff in this PRC commented that there was ‘still room for improvement’ in terms of local collaboration and reflected the comments of one of the other university-based PRCs:

‘… because of the highly technical nature of what we do there isn’t a huge industry within Northern Ireland so we are very much an international Centre. We really do need to get out and about. In California, Germany or Taiwan, they have a massive industry on the doorstep, which we don’t have in Northern Ireland.’
Adopting a longer-term perspective on the group of university-based PRCs and their regional outcomes therefore suggests a rather different impression to that gained from any assessment made on the basis of the funding period alone. Of the eight university-based PRCs, five involved organisational innovations in terms of new R&D collaborations. This suggested a relatively high level of additionality in the short-term, i.e. these PRCs would not have existed without the scheme. However, in the longer-term it was these new PRCs which ultimately proved unsustainable beyond the funded period due to a lack of regional demand for services, difficulties with operationalising knowledge transfer, or personnel moves and changes. One of the university-based PRCs commented:

‘Local companies just aren’t necessarily geared up or ready for the type of technology that we are developing. There is also a global issue pertaining to how you take [the technology] that we can do in the laboratory and apply it to an industrial situation and an industrial product.’

The issue was clearly not all on the demand side, however, as one PRC commented:

“None of us in the Centre have any background in marketing or selling and I think that is where we are sadly deficient. It is becoming more and more important to us as we get to the point were we have more services to offer. A lot of the selling has been down to fumbling around as a couple of mad academics, rather than a very slick, well oiled sales machine.”

One factor common to those university-based PRCs which proved less sustainable was a marked disconnect between the funder’s view of the objectives of the PRC and the view taken by the university. Senior staff in one PRC commented:

“Everyone has different expectations of a Centre like ours. As far as the universities are concerned it’s a source of funding: to provide equipment and staff and potentially bring in more grants. Invest NI and government look on it as a vehicle to help generate economic activity, spin out companies and support local industry. Industry’s idea of it is perhaps to generate ideas for new products for them, or to provide training ad educated staff to work in their companies. So you have got all these partners with different expectation of what a Centre like this is supposed to be all about.”

This difference of view of their objectives led to operational difficulties for some of the PRCs. In terms of leadership, for example, one PRC commented:

“There was not a disagreement, but a difference of opinion in terms of what the role of our centre would be when he was put in post. Was his role to
promote Northern Ireland, promote the research we have here, promote the international links with industry and academia and put us on the map? Or was his job to write grant and research proposals that bring in more money. What was his job supposed to be?”

Similar issues were also reflected in comments by the university-based PRCs about a lack of organisational support, issues around the allocation of overheads, universities’ willingness to invest in administrative and support staff and their recognition of technology transfer activity in promotion processes. Senior staff in one PRC commented: “Does the university even know we exist? I ask myself”. For the university-based PRCs therefore goal ambiguity, ambivalence on the part of their host organisations and in some cases a lack of regional synergies combined to reduce sustainability and therefore their ability to generate sustainable private or regional outcomes despite high levels of project additionality. For the company-based PRCs, developments tended to be more incremental reflecting lower levels of grant support and more partial additionality. One firm commented for example:

“We didn’t twist ourselves to do this. We were doing this before anyway. What this does is help us do it quicker. If I give you twenty percent more funding it allows you to do twenty percent more. That is the bottom line. You can talk about additionality and everything else, but it allows you to do twenty percent more or twenty percent faster whatever way you look at it. Being to the market twenty percent sooner can be a real benefit and that has certainly happened…”

Staff in another of the company-based PRCs commented on the centrality of the project to the firm’s activities

“It (the Centre) is well embedded both in the physical structure and also in the operational structure of where we sit now as a business.”

In the longer-term, and beyond the funding period, the more incremental nature of the company-based PRCs contributed to greater sustainability than that of the university-based PRCs. By 2009 of the original ten company-based PRCs, nine were still operating either in a similar form to that envisaged in the initial proposal or with relatively minor changes. The tenth company-based PRC closed when the host firm closed its Northern Ireland operation in 2008 and moved its R&D and manufacturing operation to Malaysia. The closure of this PRC clearly limits the potential for it to
generate supply-chain or pure knowledge outcomes. It did, however, create the potential for labour market spillovers as research staff from the PRC seek other employment. In fact, four members of the leadership team from the PRC moved to Malaysia to lead the new R&D facility, with most other (c. 30) members of staff getting jobs in the firm’s other NI plant12.

Over the funded and sustained period (2002-2008) the majority of the other company-based PRCs expanded and became significant assets to their host businesses generating positive private outcomes. One PRC said:

“… you have got ten percent of the company’s people that generate forty percent of the company’s revenue and they are doing that at half the cost of the equivalent number of resources in the US. It is a fairly powerful equation overall.”

Senior staff in other company-based PRCs stressed the organisational outcomes both in terms of the efficiency of the local operation but also the position of the Northern Ireland operation within the wider group:

“There have been two benefits: one is internal, having your development co-located with your manufacturing ensures that you have got a very smooth transition from development into production, product development and manufacturing; the second is that by having development our position with the food chain and our level of expertise as perceived within other divisions and departments within …… has increased. So we have got more technical exposure as well as more technical credibility.”

From our 2009 interviews, however, evidence of regional outcomes was more limited and depended strongly on synergies between the host company and other firms in the local supplier base. For example, contrast this quote from the senior management of one of the PRCs based in a food company:

“I think it has been a benefit to the Northern Ireland industry. Not simply the people here have got jobs, but there is three-thousand dairy producers out there and their families that rely on us to bring products to market … sustaining their livelihood.”

12 Source: Interview conducted in late 2009 with a senior manager from the PRC which had closed.
And that of the senior managers of a PRC hosted in a defence company:

“There really isn’t any other defence contractor in Northern Ireland except for the lower level of some machining. Our machine shop here is set up to cope with our production contracts. If we are going into some R&D work generally, we might subcontract that into the local community, but there is no real design capability, and all the complicated and high cost equipment we would order from a variety of sub-sources.”

As in the case of the university-based PRCs, supply-chain – and potentially also knowledge outcomes – therefore seemed greatest where there existed synergies between the host company of the PRC and other regional firms. Where no such synergies existed linkages tended to be extra-regional with fewer local contacts.

7. Conclusion
Public investment in R&D centres has the potential to create both private and regional benefits in both the short and longer-term. This profile of potential benefits can be captured in the form of a logic model emphasising the short-term outputs which might occur during the funded period (here 2002-05) and the outcomes which might occur after the funded period (here 2006-2009). Here, we describe the profile of outputs and outcomes arising from a regional investment initiative to develop a new group of PRCs (Fu, 2008). A number of key findings emerge from our study relating to the contrasting regional benefits of university and company-based R&D centres, findings which might guide the design of similar policy initiatives elsewhere.

First, our evidence suggests that over the funded period (2002-05) public support had clear additionality effects on the profile and volume of R&D activity being undertaken by the PRCs. Some new – and wholly additional – university-based centres were established, while company-based PRCs tended to exhibit more partial additionality with developments being either accelerated or expanded. Significant private outputs were also evident in the funding period in terms of both technology and commercial gains through licensing, spin-out and new product innovation. The profile of commercialisation activity, however, was strongly dependent on the type of R&D being undertaken and the character of the PRC’s host organisation (Palmberg 2008). Exploitation approaches also differed markedly between the university and
company-based PRCs, with the university-based centres adopting more of an ‘open-science’ approach supported by spin-outs, licensing and the seeking of research grants while the company-based PRCs focussed on attracting new commercial contracts (EU, 2004).

In terms of regional outputs we also find positive evidence of supply-chain and knowledge spillovers within the funding period, although again the regional profile of these benefits differs substantially between the company-based and university-based PRCs. During the three-year funded period, university-based centres developed more new linkages than the company-based PRCs but with a much stronger extra-regional focus. As such the university-based PRCs strengthened the ‘global pipeline’ in bringing technology, finance and skills into the region although the regional knowledge and network benefits were constrained in some cases by the weak absorptive capacity of Northern Ireland firms (Fernandez et al., 1996; Oughton et al., 2002), and in other cases by the lack of any ‘relatedness’ between the technological focus of the PRCs and local businesses (Benneworth and Hospers 2007). Other regional outputs mediated through supply-chains were largely restricted to the company-based PRCs with these PRCs – or at least their host firms – developing a number of new supply contracts related to their R&D activity. These new contracts also contributed to improved products, processes and profile in other local companies, although again there were indications that the scale of these effects was limited by the nature of the local supplier base – although 45.9 per cent of new contracts were with regional firms, these contracts only accounted for 4.9 per cent of the total value of new contracts.

Beyond the funded period (i.e. over the 2006 to 2009 period) we find significant differences in the sustainability of the university-based and company-based PRCs. Of the original eight university-based centres, five (71 per cent) had ceased to function in their original form by 2009 with the remaining three either stable or growing. All except one of the ten company-based PRCs, however, remained in existence. Higher levels of pure additionality in the university-based PRCs seems to have translated into greater long-term vulnerability and dependency on public funding, with the more partially additional company-based PRCs proving more sustainable. Comments from the university-based PRCs stress issues around ambiguity of goals, leadership, support
from their host organisations and in some cases a lack of synergy with local firms. Comments from the company-based PRCs provide a rather different impression suggesting their centrality to firms’ strategic development. For both types of centre, however, sustainability and the potential for regional outcomes was greater where either pre-existing or co-evolving synergies existed with regional companies (Frenken, Van Oort, and Verburg 2007; Koo and Kim 2009).

The contrasting pattern of sustainability between the company and university-based PRCs suggests very different patterns of longer-term regional outcomes: limited from the remaining university-based PRCs but potentially more extensive from the company-based PRCs. However, firms’ focus on commercial exploitation, was serving to restrict any positive ‘pure knowledge’ externalities arising from knowledge transfer (e.g. Beugelsdijck and Cornet, 2001). At the same time, private outcomes to the company-based PRCs were substantial and, as a result of supply chain links to other businesses in the economy, the potential for rent-based regional benefits was significant particularly where there was some regional clustering (Koo and Kim 2009).

The contrasts between the university-based and company-based PRCs in terms of additionality, openness and sustainability suggest the alternative outputs and outcomes which might stem from public funding of each type of PRC (Nikulainen and Palmberg). In the short-term, additionality and regional knowledge outputs are likely to be greatest from university-based PRCs; in the longer-term their greater sustainability suggests that company-based PRCs are likely to generate more substantial private outcomes and rent based regional outcomes. Irrespective of the mechanism through which these outputs or outcomes occur, however, the potential to capture these regional outcomes within the region depends strongly on the extent to which the PRC and host organisation is embedded in the region and the absorptive capacity of local businesses and other organisations.

From a policy perspective the contrasting profile of additionality and sustainability of the university and company-based PRCs emphasises the difficulty of R&D programme design. Adopting a reactive approach, such as that in the Centres of Excellence programme considered here, tended to encourage innovative responses from the universities which ultimately proved unsustainable in the longer-term.
Firms’ responses were more incremental reinforcing existing technological capabilities rather than the development of new technological trajectories within the region. Public investments in both types of centres therefore involved tradeoffs between the extent of innovation – and the potential for establishing new regional R&D capabilities - and longer-term sustainability. For policy makers considering this type of R&D initiative therefore our results suggest the importance of resource allocation decisions between university and company-based centres, decisions which might reflect the trade-off between additionality and sustainability and their impact on policy outcomes.

Targeting support at individual PRCs as in the scheme considered here may also have been limiting the scope for local knowledge sharing and collaborative innovation. More recent policy initiatives which have supported formal, long-term university-industry R&D collaboration may help to overcome any additionality/sustainability trade-off by promoting both technological novelty and sustainability. For example, the NSF Centres in the US and Competence Research Centres in the EU both involve long-term collaborative relationships between university-based research teams and networks of industrial partners (Adams, Chiang, and Starkey 2001; Gray and Walters 1998). Finally, it is worth considering the adequacy of the timescale over which public funding is committed to PRCs. In the case of the Northern Ireland PRCs considered here funding was provided for three years for both the university and company-based PRCs. Where, as in the university-based PRCs, this funding was supporting more basic or applied research a three-year period was clearly insufficient to enable centres to achieve sustainability with some of the university-based PRCs reported exploitation horizons of 10-15 years. Maximising the regional outcomes from such university-based research is therefore likely to require relatively long-term funding commitments.

Extending over seven years after the foundation of the PRCs allows us to take what we feel is a realistic view of the additionality/sustainability trade-off and the potential implications of resource allocation decisions made at the outset of the scheme. An important limitation of our analysis, however, is its focus on a single scheme and region. It would be interesting to compare our results here with those of other similar regional initiatives where both company and university-based PRCs have been funded.
in a similar context over a similar time period. Other developments are also possible including a potential follow-up of the technological outputs (i.e. patents) from the PRCs and a geographical analysis of their longer-term benefits. Following the key individuals from the PRCs would also be of potential interest given the evidence from elsewhere on the importance of ‘stars’ as carriers of knowledge (Zucker, Darby, and Bewer 1998).
Open call for proposals
Funding to support R&D centres over three years (20-50 per cent)
Host commitment to ‘sustain’ Centres for three years

Increased R&D and sales
Training and managerial benefits
Patents, Licenses

Supply-chain spillovers
Labour market spillovers
Pure-knowledge spillovers

Sustained increases in R&D capacity
Patents, Licensing etc.
Improved productivity, growth or exports

Sustained upgrade to regional R&D capacity
Improved knowledge diffusion/collaboration
Increased regional productivity/growth

Support will increase R&D activity and drive regional economic growth
Contingency factors which may influence outputs becoming outcomes

Justification for Intervention
Low level of business and higher education R&D spending
Weak regional R&D capability in ‘key’ areas
Desire to boost regional economic growth

INPUTS

OUTPUTS

PRIVATE
REGIONAL

OUTCOMES – MEDIUM/LONG

PRIVATE
REGIONAL

Organisational/Institutional
Contingency factors which may influence outputs becoming outcomes

Environment
Contingency factors which may influence outputs becoming outcomes

Assumptions
Support will increase R&D activity and drive regional economic growth

Figure 1: Logic Model for PRC support, outputs and outcomes
Table 1: Profile of PRCs

<table>
<thead>
<tr>
<th>PRC</th>
<th>Budget £m</th>
<th>Employ. in 2005</th>
<th>Subject Focus</th>
<th>Host Organisation</th>
<th>Types of R&amp;D Undertaken:</th>
<th>Basic R&amp;D</th>
<th>Applied R&amp;D</th>
<th>Experimental Development</th>
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<tr>
<td>PRCl</td>
<td>37.76</td>
<td>110</td>
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<td>●</td>
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<tr>
<td>PRC-2</td>
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<td>4</td>
<td>Medical Polymers</td>
<td>University</td>
<td>○</td>
<td></td>
<td>●</td>
<td>○</td>
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<td></td>
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<td>7</td>
<td>Functional Genomics</td>
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<td>●</td>
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<td>PRC-7</td>
<td>0.95</td>
<td>6</td>
<td>Technology Start-up &amp; Incubation</td>
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<td></td>
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<tr>
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