The University of Manchester

Geography, Mobility and S&T Human Capital Formation of Collaborative Doctoral Graduates: The case of EngD in the UK

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Scientific Labour Markets and Innovation Systems – Key background ideas in this exploratory paper

- **Mobility** is seen as a key mechanism of knowledge diffusion within the innovation systems– across *sectors*, *firms* and *places*
- Economic geography literature focuses on mobility as structured by local characteristics and the labour market

(e.g. Lawton Smith and Water, 2011; Marinelli 2013; Iammarino and Marinelli, 2011; Faggian and McCann, 2006; 2009; Trippl, 2013)

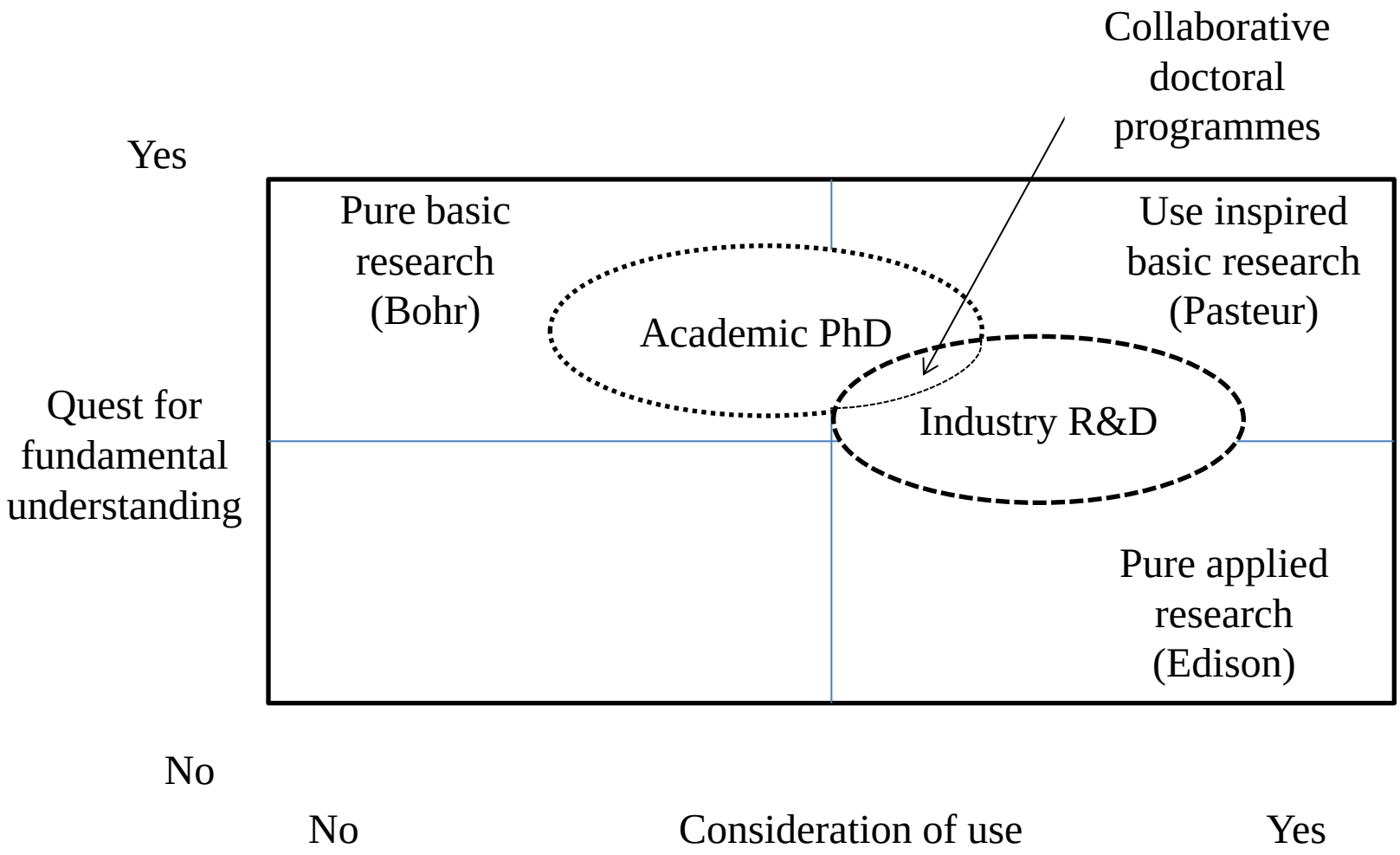
- **S&T human capital** (Bozeman and Corley, 2004) approach and recent R&D policy and funding assumptions (Rogers et al., 2012), including doctoral training
- Collaborative doctoral programmes - Doctoral students as "**bridging scientists**" going between two spheres of sciences – "hybrid spaces" (Lam, 2007); social capital and absorptive capacity of firms

Science and Technology (S&T) human capital –

"the sum of scientists' and engineers' scientific and technical knowledge, work relevant skills and social ties and resources"

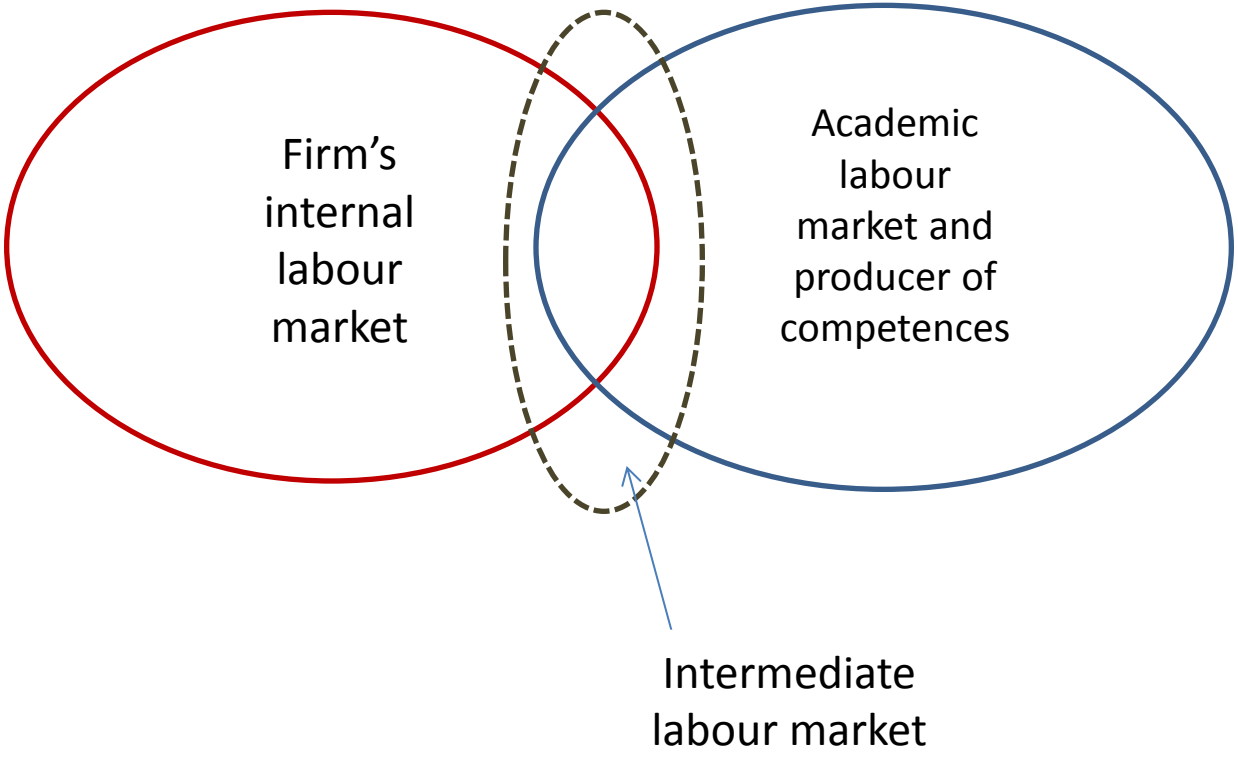
(Bozeman and Corley, 2004, p.604)

Conceptualising Collaborative doctoral programmes – Spheres of "Research spaces"



An intermediate labour market between academia and industry

(Lanciano-Morandat and Nohara, 2006)



Research questions

- In what ways are the collaborative doctoral training programmes between academia and industry organised as part of the scientific labour markets?

- How are the collaborative relationships evolved into different forms of *mobility*?

- How do we know the impact of such collaborative relationships within the innovation systems?

Objectives of the study

- Understanding of **micro-dynamics of relationship and capability building across organisational and spatial boundaries** is an imperative step in order to identify the factors and processes for innovation and skills/career development through doctoral training.

- Such micro-processes seem to be the critical element in order to understand **the dynamic nature of knowledge diffusion within the scientific labour market and the innovation systems** – yet understudied in the literature.

- This would lead to better understanding of **how different dimensions of mobility (geography, sectoral and organisational) work together**, the dynamics of knowledge flows, and **individual practices and social processes of innovation** within the changing institutional structures.

Policy and institutional contexts

- The UK government policy objectives to enhance closer links between academia and industry; and “people-based partnerships” (see Howells et al., 1998; Gertner et al., 2011)
- Collaborative doctoral schemes evolved over the last 20 years with public support e.g. Engineering doctorates (EngD) and CASE PhD (see Demerrit and Lees, 2005; Butcher and Jefferey, 2007; Kitagawa, 2014)
- International dimensions of collaborative doctoral schemes (e.g. European Industrial Doctorates; Australian Cooperative Research Centres; US NSF Industry/University Cooperative Research Centres; French CIFRE; Danish Industrial Doctorates) (see Borrell-Damian, 2009)
- Increasingly seen as Universities’ strategic institutional development “Boundary crossing organized research units” (ORUs) (Sa and Anatoly, 2011)

Two types of collaborative doctoral schemes funded by the EPSRC

- The Industrial CASE scheme provides funding for “industrially relevant PhD studentships that are jointly supervised by the academic and industrial partners” where “businesses take the lead in arranging projects with an academic partner of their choice” (EPSRC, 2013).
- The Industry CASE students need to spend at least 3 months of their 3.5 year project working in a non-academic setting with the collaborating organisation. Industrial CASE students are located in academic departments.

- The EngD programmes are “work-based alternative to traditional PhD” for those who want to work in industry; and are based in distinctive centres (EngD Centres/IDCs) and have more taught elements in the area of business administration.
- EngD students spend up to 75% of their time in industry (about 3 years).

- *These schemes were developed with different policy objectives, and technically not appropriate to compare. Here some data is shown to provide variety of contexts and differences.*

Methodology

- The study originates from an evaluative pilot study on the Impact of Engineering Doctorates (EngD) for the AEngD and EPSRC (conducted in 2013)
- Methodological exploration and pilot data collection
  - 35 semi-structured interviews with industry partners, and alumni of the EngD programmes; documentary analysis of 18 Industrial Doctorate Centres (IDCs);
  - HESA DLHE (2008/9- 2010/11) - 125 EngD graduates identified, 201 Industrial CASE PhD and broader PhD graduates (14400) data;
  - a bit of SNA
- An additional micro case study of one IDC with micro-career trajectories of 30 alumni; "Analytic integration of different qualitative methods" (Cronin et al., 2008)

Genealogy of the *EngD as the Scheme* and Evolution of *EngD Centres/IDCs as organisations*

- EngD established in 1992 as a "work-based alternative to traditional PhD" for those who want to work in industry
- 75% working in industry and 25% taught courses
- Discontinuity with continuity or Continuity within discontinuity (calls and renewals 1993, 1997, 2001, 2003, 2006, 2009)
- Recent evolution of CDTs since 2009, EngD Centres are now called Industrial Doctorate Centres (IDCs), around 1400 EngD graduates from the IDCs
- Under the 2013 call, the IDCs are integrated as part of the CDTs
- Six of the EngD Centres created in 1999 and 2001 still exits as IDCs
- Industry sponsors 600 over the years with several repeated ones

EngD - Lack of data and visibility

- HESA DLHE data – no distinction between EngD and PhD
- Some EngD Centres no longer exist
- High recognition from industry, but low recognition within academia;
- PhD getting closer to EngD - blurred identity
- Impact study – economic impact analysis; difficulty of capturing interactive/embedded nature
- Current funding issues

Outline of the exploratory analysis

- Geographical distribution of EngD, CASE PhD, wider PhD (2008/9-2010/11)
- Principal subject areas and employment sectors of EngD and CASE graduates
- How they found jobs
- EngD destinations and employment – geography and sectors
- Salary data
- Micro case study - 10 years review of EngD graduate destinations

Geographical distribution of EngD, CASE and Other STEM PhDs by number of graduates

(HESA DLHE 2008/9-2010/11)

	EngD %	EngD per 1 mil pop	EngD per 1 billion GVA	CASE %	CASE per 1 mil pop	CASE per 1 billion GVA	STEM PhD %	STEM PhD per 1 mil population	STEM PhD per 1 billion GVA
North East	1%	0.384615	0.02404	2%	1.538462	0.096158	4%	2.6	223.8462
North West	10%	1.690141	0.096841	13%	3.521127	0.201753	10%	7.1	201.9718
Yorkshire &Humber	0%			9%	3.396226	0.197707	7%	5.3	180
East Midlands	9%	2.391304	0.134835	8%	3.478261	0.196124	8%	4.6	260.8696
West Midlands	22%	4.821429	0.281714	6%	1.964286	0.114772	8%	5.6	204.2857
East of England	14%	3.050847	0.157733	17%	5.762712	0.29794	12%	5.9	283.8983
Greater London	11%	1.686747	0.049475	7%	1.566265	0.045941	14%	8.3	249.8795
South East	22%	3.103448	0.14037	16%	3.678161	0.166364	14%	8.7	231.7241
South West	2%	0.377358	0.019711	9%	3.207547	0.167545	8%	5.3	214.3396
Wales	8%	3.225806	0.211238	8%	4.83871	0.316857	4%	3.1	189.3548
Scotland	2%	0.566038	0.027753	7%	2.45283	0.120261	10%	5.3	270.1887
Northern Ireland	0%			1%	0.555556	0.033478	2%	1.8	121.6667
Total number	100% (125)			100% (199)			100% (14453)		

Two different Collaborative Doctoral Schemes – EngD and Industrial CASE

(HESA DLHE 2008/9-2010/11)

Principal subjects of the EngD graduates

General engineering	**16%**
Chemical, process & energy engineering	14%
Materials technology not otherwise specified	12%
Electronic & electrical engineering	11%
Mechanical engineering	10%
Civil engineering	8%

Principal subjects of the CASE PhD graduates

Chemistry	**29%**
Civil engineering	13%
Electronic & electrical engineering	8%
Physics	8%
Computer Science	6%
Aerospace engineering	6%

Employment Sectors of the EngD graduates

Manufacturing sector	32 %
Professional, scientific and technical activities	27 %
Education	15 %
Electricity, gas, steam and air conditioning supply	5 %
Construction	5 %
Public administration and defence; compulsory social security	2 %
Information and Communication	2 %

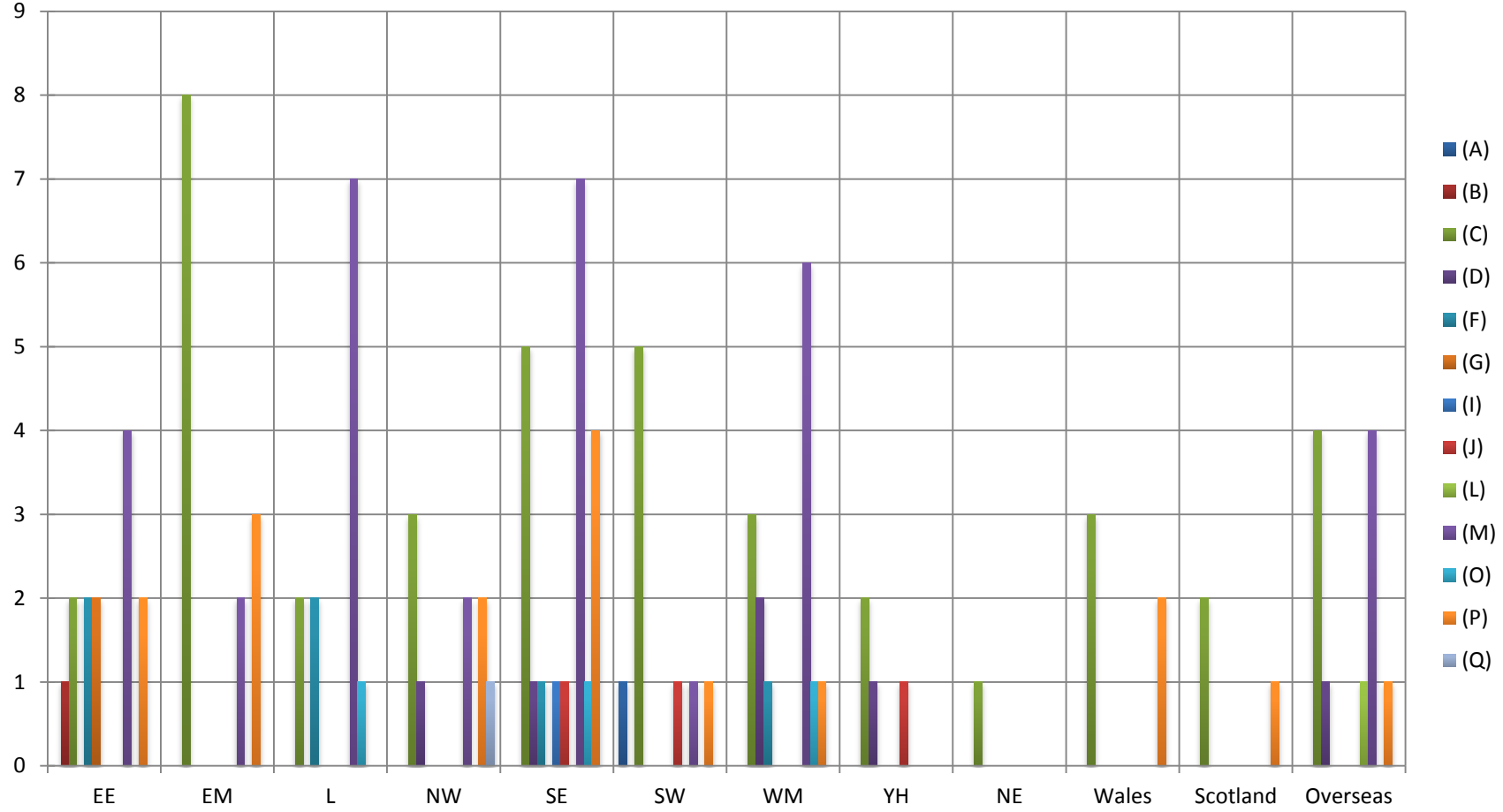
Employment Sectors of the Industrial Case graduates

Education	34 %
Professional, scientific and technical activities	19 %
Manufacturing	14 %
Information and Communication	7 %
Public administration and defence; compulsory social security	3 %

How did the doctoral graduates find their jobs?

	EngD	CASE	Other PhD
Own institution's Careers Service	6%	7%	3%
Newspaper/magazine advertisement	2%	2%	4%
Employer's web site	10%	13%	13%
Recruitment agency/website	9%	12%	9%
Personal contacts, including family and friends, networking	21%	22%	18%
Speculative application	-	4%	2%
Don't remember	1%	1%	2%
Other	10%	4%	8%
Already worked there	24%	10%	16%
Question not answered (default)	14%	10%	12%
Not applicable	5%	13%	12%
	100%	100%	100%

The EngD destinations and employment - Geography and Sectors



(A) Agriculture, forestry and fishing (B) Mining and quarrying (C) Manufacturing (D) Electricity, gas, steam and air conditioning supply

(F) Construction (G) Wholesale and retail trade; repair of motor vehicles and motorcycles (M) Professional, scientific and technical activities

(P) Education

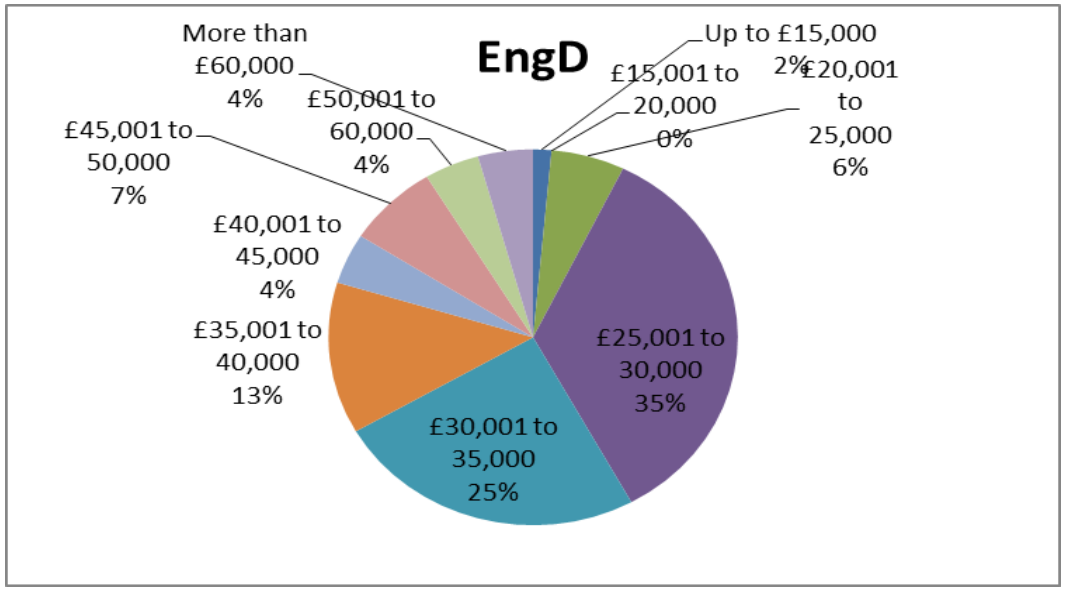
Employment of EngD graduates – Compares favourably with other doctoral graduates

- Six months after the completion of the programmes, 91.2 % of EngD graduates are in Full-time paid work (including self-employed). This compares favourably to Industrial CASE graduates (79.6%), Other PhD (all disciplines) (73.9%) and Other PhD (principal subjects A-K) (78.8%).

- In terms of how the graduates found their employment, 24% of the EngD graduates found a job as they "already worked" there (i.e. the sponsoring firm), higher than Industrial CASE graduates (10%) and Other PhD (all disciplines) (16%).

Employment of EngD graduates –

- Salary data in the DLHE is limited in terms of the size of the samples available. It is difficult to draw a general conclusion from the data presented here and careful interpretation is required when using the information. For those who are in full-time employment six months after graduation, 33.3% of the EngD graduates earn more than £35K per year. This compares favourably to Industrial CASE graduates (12.6%), Other PhD graduates (all disciplines) (29.8%) and Other PhD graduates (principal subjects A-K) (26.0%).



An exploratory case study of an IDC – Tracking Individual mobility

Organisational contexts and methodology:

- A former EngD Centre since 2001, became IDC in 2009
- Individual EngD graduates' names and theses titles are available in the public domain (the IDC annual report); tracked individuals through Linked In and publication/patent records; a few alumni and industry sponsors were interviewed as part of the pilot study
- 31 EngD graduates between 2005-2013;
- Average EngD lengths- 5 years – *before* and *after* EngD locations and job titles

Individual mobility patterns – Variety of S&T human capital trajectories?

- At least 10 of them had had industry experiences prior to the enrolment of the EngD programme, 7 of which carried out the EngD with their own employers.
- Five of them stayed with the same employers one year after the graduation; another five moved to other companies or to academia.
- One moved to another company during the EngD
- Two were from overseas (USA and South Africa sponsored by their employers); one became a professor in the UK after the EngD

- Of those who had no industry experiences prior to the EngD, and those whose pre-EngD experiences were unidentified (20 in total), 8 remained in the sponsoring companies after the EngD, and one moved back to the sponsoring company after a short spell working at a university.

Does geographical proximity matter in the EngD collaboration?

Industrial location of 35 sponsoring companies across the UK spread over 500 miles; half of them are around 50 miles ' radiator distance

"We are very keen for our local IDC to continue. Proximity is important. Students are co-located with us and, also, we tend to have close links and interact with the centre and academics. That is the direct value of the programme, being around and being networked. When another research opportunity comes up we want to be on their mind and be part of the research. When you do technology research it is very difficult to get funding.

It is great to have a university close by – I can take a half a day and work with the university. This is much more cost effective. We are very fortunate as the local universities are world class [in the research areas with which we work]." (*Manufacturing 1*)

c.f. Bishop et al (2011); Laursen et al (2010) ; Muscio (2012) D'Este and Iammarino (2010);

This may not be the common experience across the IDCs but in certain technology areas, the geographical clustering seems to be happening; the EngD/IDCs can be the core of R&D collaborative relationships.

Mobility types and Hybrid research spaces

EngD is a *hybrid research space* where

"bridging scientists" are trained; leading to ***Intermediate labour market***

Those with prior industry experiences – EngD gives further mobility within the scientific labour market

- ***Geographical mobility***

EngD graduates tend to stay in the sponsoring companies; some move internationally

- ***Sectoral/ organisational mobility***

- Between academia and industry, and back again
- From manufacturing to investment banking

EngD/IDCs as Open research, innovation and training spaces

- Through EngD/IDCs, industry co-sponsor projects to solve industry problems
- Identifying strategic directions
- Sharing of facilities, equipments
- Sctoral and cross-boundary pooling of human skills and resources
- REs as future research leaders;
- CPD for wider employees

The nature of the *impact* of the EngD

- *Generation of new knowledge*
- *Innovation* (product and process)
- *Knowledge networks and collaboration*
- *Human capital and skills development*.

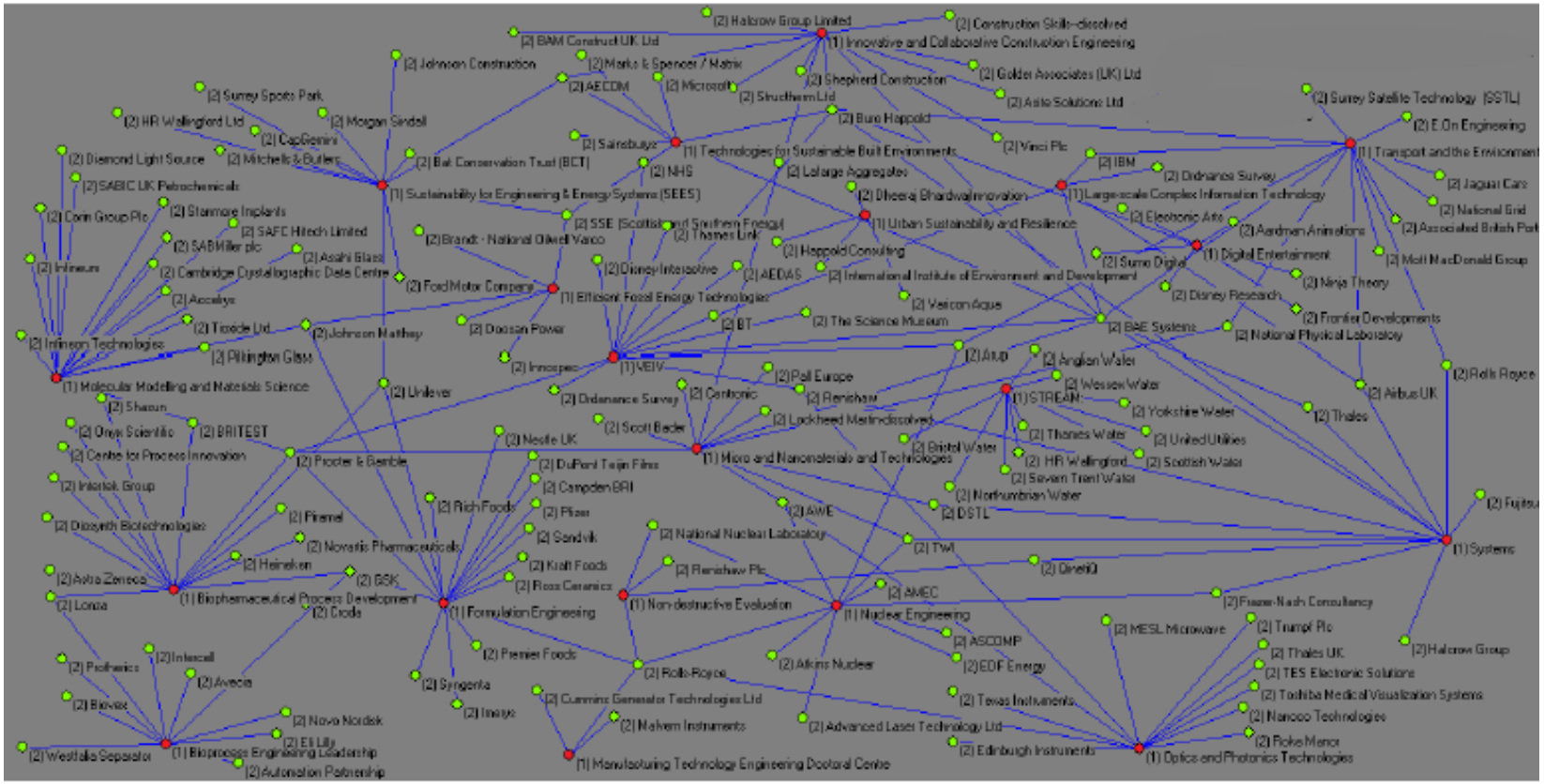
Forms of impacts from the IDCs

Appendix Table 9 Examples of Impacts at each of the IDCs (No company names)

Source: 18 IDC Mid-term review report (May 2011)

IDC	*Individual REs – Career paths and Impacts*	*EngD projects leading to impacts within existing Industry partners*	*Other Impact going beyond the sponsoring company and wider social impacts*
A (a former EngD Centre since 2006)	1) 3 REs were employed after completing EngD; one RE awarded a Knowledge Fellowship to continue her research; one got a job in nano-technology company and one recruited in Investment Banking. 2) REs receiving awards	1) Although projects focus on developing fundamental understanding of general principles, there are specific new products or techniques and benefits to time-to-market directly 2) New method leading to investment more than £500K; patent applied 3) Managerial experiences for early researchers as industry supervisors	1) Spin-out company won the 2011 Shell Springboard competition. 2) Royal Society Industry Fellows joined the IDC to work with industry partners 3) 3) Strategic alliance between the University and industry partner 4)Former research collaboration with international research organisations [US Pacific Northwest National Laboratories; collaborative research and training centre in Ghana]
B (a former EngD Centre since 2006)	1) 2 REs were part of the team that won a Chairman's Award for Innovation in 2008 2) 2 REs remain with their sponsors; one as a Higher Research Scientist, higher level than a normal PhD graduate in permanent employment; 3)one has been retained by his sponsoring SME, funded via KTP 4) 1 RE got a job with the British Transport Police by using his scientific skills 5) 1 RE awarded 1851 Industrial Fellowship	1) Enables advances in design and enhance UK-led collaborations with its US parent company 2) Advances in fundamental understanding of materials and enable to reduce product development cycle time 3) Increases its agility in responding to customer requirements 4) "significant input into improving our expertise that will benefit the aerospace and associated industries"	1) IDC brings about new collaborations in other research organisations, industry, business and society, including internationally industry, for EngD projects could provide new opportunities and improve interaction with the "community". 2) "This project delivers what industry wants, to their longer term needs, activities and ambitions. Moreover, it could change industry's thinking and ultimately their work practices." 3) Accredited course leading to CEng status 4) Influence networks via sponsors and KTNs

Preliminary visualisation of the network patters between the IDCs and the identified industry partners.



The IDCs are shown in red, and industry partners are presented in green. There are several industry sponsors acting as nodal points, linking different IDCs (e.g. Rolls Royce, Thalyse, TWI, Buro Happold, National Physical Laboratory, BAE Systems, Airbus, Johnson Matthey). Some IDCs have broad inter-sectoral linkages whilst others are one-sector specific IDCs.

Preliminary conclusion from the exploratory study

- Combined dynamics between dimensions of ***mobility*** in the scientific labour market – sectoral, organisational and spatial – need further investigation
- Collaborative doctoral centres – developed as national policy tool, which works as local as well as global ***hybrid research spaces***
- ***S&T human capital formation*** in the ***intermediate labour market*** - organisational R&D and HR strategies and individual career strategies and social practices

Policy and funding implications

- Collaborative doctoral programmes do have a role to play within the Innovation systems as providers and co-creator of S&T Human capital
- Could be used as policy tool for *smart specialisation*
- Joint investment from academia, industry and research council – open innovation/training
- The tricky issue is the balance for the university sector (and the research council) to hit the optimum mixture of research and training that respond to the needs of both academia and industry – with sustained funding and credibility with stakeholders

Thank you!