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Author post-print (accepted) deposited in CURVE March 2015

Original citation & hyperlink:
de Freitas, S. , Mayer, I. , Arnab, S. and Marshall, I. (2014) Industrial and academic collaboration: hybrid models for research and innovation diffusion. Journal of Higher Education Policy and Management, volume 36 (1): 2-14.
http://dx.doi.org/10.1080/1360080X.2013.825413

Publisher statement: This is an electronic version of an article published in Journal of Higher Education Policy and Management, 36 (1), pp. 2-14. The Journal of Higher Education Policy and Management is available online at: http://www.tandfonline.com/doi/abs/10.1080/1360080X.2013.825413.

Industrial and academic collaboration: Hybrid models for research and innovation diffusion

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Abstract

In the light of global economic downturn and rising student populations, higher education funding is being squeezed, internationally. The squeeze on finances is affecting research funding in terms of core research and for maintaining and extending research infrastructure, as a result new academic-industrial 'hybrid' models for research collaboration are emerging as potential methods for preserving and extending existing available infrastructure and development funds. This paper therefore considers how new ways of attracting industrial funding into higher education can help offset the available research funding sources, as well as provide greater opportunities for encouraging innovation transfer between the sectors in order to accelerate productization and promote Intellectual Property (IP) generation. To facilitate these academic-industrial collaborations, the paper introduces the Innovation Diffusion Model (IDM) which promotes innovation diffusion by bringing academic and industrial experts into close proximity, supporting new models of technology and knowledge transfer by using Living Labs, exchange programmes, networks of interest, industrial placements, attachments and spin outs for increasing IP generation in high growth technology clusters.

The paper explores two case studies in relation to the IDM and promotion of the new Serious Games (SG) sector: (1) The UK Coventry University's Serious Games Institute – a hybrid model of applied research and business, which is a pilot for the innovation diffusion model, and for providing a unique European model for business engagement as part of a

regionally promoted technology cluster in the West Midlands in the UK. (2) The Netherlands based TU-Delft University Serious Game Center – a networked model of semi-commercial funding and public-private co-operation between industry, public sector and research partners.

The paper suggests that while there are difficulties with bringing academic and industrial communities together, overall the benefits include sustained IP development and publication opportunities for academics, employment creation, accelerated development and real commercial benefits for industrial partners.

Background

Higher education is commonly funded by a combination of state subsidies (first-stream income), student fees (second-stream income) and funding from other sources (third stream income). Common to higher education institutions (HEIs) around the world, reliance on state subsidies has not been a sustainable business model. Furthermore, during a time of reducing national budgets for higher education due to economic downturn and pressures on available research infrastructure due to rising student populations, different models for funding universities are emerging in European countries (e.g. Frølich et al., 2010; Sursock & Smidt, 2010) and internationally (e.g. Chapman, 1997). The resultant trend away from wholly public-funded tertiary education is affecting how universities all over the world are funded and will be funded in the future, and has a significant impact upon how universities are changing in response to the attendant challenges of 'knowledge economy' (e.g. Checchi, 2006; Usher & Medow, 2010).

For example, in the United Kingdom (UK) higher education is following the United States of America (US) model, moving from a wholly state-funded model of education funding with three streams of funding to a purely student fees funded model (Albrecht & Ziderman, 1993; Dearden et al., 2008). The UK Russell Group of Universities (Conway et al., 2010) emphasises in their submission for the Browne (2010) report that in response to severe and ongoing financial pressures on the higher education sector in the UK, an increase in graduate tuition contributions from full-time Home and European Union (EU) undergraduates should be part of the solution for sustaining the quality of education and research in leading universities. This policy change in the UK context mirrors changes in higher education funding models globally, where economic downturn and a growing student body are putting a strain on existing state funded university infrastructure. Ultimately, this in turn is putting pressure on existing research funding, and while research funders such as the European Commission are responding to the global economic downturn with increased research budgets, much research funding is static or reducing in real terms (UK: Department of Business, Innovation and Skills, 2010). In the face of this situation, other methods and models for supporting research funding are required to ensure advances in scientific knowledge are maintained.

One response to the reduction in traditional funding is to seek alternative sources, such as industrial or commercial sponsorship, consultancy and private-public co-funding of academic research. Academic-Industrial collaboration perhaps reached its zenith in the US in the Second World War period, after which significant research funding and industrial sponsorship became an established and successful model, leading to the post-war growth and dominance of the US as an 'military-industrial complex' superpower. For example, from 1900 to 1933 seven Nobel Prizes were given to scientists in the US, while 77 were given in the years 1933-1970 (Hobsbawn, 1994). But looking more deeply at the model of collaboration, internationally this approach and model have supported post-war growth for over 60 years, until by the late 1980s 'the number of scientists and engineers…in research and experimental development in the world was estimated at about five millions, of whom almost one million were in the USA' (Hobsbawn, 1994, p. 523).

The model of linking research expenditure with industrial development and growth, established by Vannevar Bush and others at the end of the Second World War, have in many ways continued the pattern of growth of funding into research and universities (Bush, 1945) from the 1940s to the 1980s. Since then, the patterns of university funding set up at the end of the First World War have undergone significant transformation, in the UK for example successive conservative governments have reduced budgets to research, and at the same time the block grant (which pays for infrastructure) has not kept pace with increasing costs. In addition, since the 1980s two trends have put added strain upon university funding: the increasing numbers of students going into universities, around 40 per cent of females and 30 per cent of males in the UK as against 80 per cent of university students in Finland (according to OECD measures, reported in Coughlan, 2010) and reduced funding of research and the block grant (Browne, 2010).

Another important revenue stream in the UK for research funding is 'third stream' from business and industry. In the UK, industry spent £259 million on research in UK in 2000/1.

As income from the existing students' fees has not kept up with inflation, the third-stream income has been more attractive to universities in order to fund their operations. The 'third stream funding', is aimed at promoting knowledge transfer from university departments into business and wider industrial communities. In the UK, this is administered by the Higher Education Innovation Fund (HEIF). This funding has been used to finance business liaison and technology transfer offices, as well as to support spin outs and other business ventures. The Government planned to increase the size of this fund to £90 million in 2005/6. The Lambert Review published in 2003 proposed the introduction of a new stream of business-relevant research funding, potentially in the region of £100 - £200 million per year (Lambert, 2003).

Like the UK, universities in the Netherlands are financed through a combination of first, second and third stream funding. The first money stream (ar.60 per cent of the total budget) is the regular funding from the National Government budget for academic research and academic education (Rijksbijdrage voor onderzoek en onderwijs). Based upon certain endogenous and exogenous factors, the national budget is divided among the thirteen universities. An internal university model then divides the resources over the different university institutions, e.g. departments, faculties, institutions, centres. Especially in the light of the economic-financial crisis, the national budget for science and education has been under pressure for decades. It is now 1.73 per cent of the GNP (2009) – approximately the same as the UK and less than the European average – and it has been decreasing steadily in the last decade (source: VSNU). Furthermore, a steadily decreasing part of it within universities is being used for core-activities: fundamental research, educational curricula; on the other hand budgets for institutional facilities, overhead, critical events, such as fires or financial losses prove difficult to get under control, despite efficiency programmes.

The second stream funding (25 per cent) is the funding from institutions like the Netherlands' National Science Foundation (NWO), the National Academy of Science (KNAW) and affiliated institutions like STW. By and large, researchers at various stages in their career can apply for small or large research funds in a broad range of funding programmes. In the last decade, national government has also set up several long-term programmes to stimulate innovation in selected areas of the economy and society, like education, water, infrastructures, safety and security. Worth mentioning here are the so-called

FES-Bsik-gelden that have tried to feedback the benefits from the Netherlands' natural gas resources back into the socio-economic system.

The third stream funding (25 per cent) is a broad and diverse range of research and development activities that could be labelled as pre- or semi-commercial applied research, development and dissemination activities. This type of funding is highly decentralized and uncoordinated. It can take the form of direct contracting of individual researchers to temporarily perform certain academic research-related activities or it can involve an intricate and more sustainable network of public and private institutions often with a blend of first, second and third stream funding. The boundary between second and third stream funding is ill-defined, especially in case of EU-funding which can be regarded as serving fundamental or applied research. In most cases, EU funding requires co-financing or industry partnering. By and large and as compared to other countries, it seems Dutch universities fall behind in terms of acquiring its share in EU-funding. Overall, the importance of the third money stream varies greatly among departments, institutions and universities, from being a very substantial part of funding, e.g. for research groups in engineering, to being non-existent for a research group in the Humanities.

But in both the UK and the Netherlands, the role of third stream funding is becoming more important for funding research and research infrastructure, and this reflects a trend of how universities, once seen as an engine of the economy, are now being regarded as a *service*, as part of the wider socio-economic trend towards greater service-orientated provision where universities provide a service to industry, not just in terms of employment but also for adding valuable commercial advantage to industry. This approach however requires new infrastructural requirements both for supporting enriched student experiences, including flexible and technology enhanced learning provision, opportunities for industrial placements and importantly for supporting the new skills required for the 'knowledge economy' (e.g. de Freitas & Oliver, 2005; Kemp, 2011); but also for providing quality applied research capabilities and a reliable and reputable brand to support the changing research needs of industry. Together these academic-industrial partnerships have gains for both sides: IP generation and exploitation for industrial competitiveness, enhanced research capabilities and updated research infrastructure for the universities and innovation diffusion that fosters links between the sectors.

The Innovation Diffusion Model (IDM)

To address the importance of how academic and industrial collaboration can facilitate and support innovation diffusion between the sectors, the authors have developed and iterated the IDM as a successful model for promoting innovation diffusion across the sectors. The model has been deployed initially in the Serious Games Institute (SGI) at Coventry University and through the EU-funded GALA network of excellence in Serious Games across 31 European universities and companies.

While the model has been deployed, new methods for how to evaluate its efficacy are inevitably difficult to define and determine, as innovation measures are difficult to accurately measure. However, at SGI, we have used specified measures such as: number of spin outs, new IP arising, technologies transferred to industry and evidence of knowledge transfer including joint PhD supervisions with industry, joint publications and proposals submitted and jobs protected and created, as per our funding requirements. By these metrics, the IDM has been successful, as we have already supported 3 spin outs, 161 scientific publications, 2 industrial funded PhDs and 1 technology transferred from the US to two European companies.

The basis of the model includes a three-step flow model (RAM – Research to Application to Market) as a primary driver. This includes the traditional idea of research leading directly to applications and on to market as products and services, which although slightly transformed in the light of digital delivery and platforms, and more access to global markets, still is a major route for pathways for innovation today. The main blockages to this flow have been often institutional barriers between organisations, including IP provisions, legal entities, copyright specifications, non-disclosure and preventions of publication or open access to project outcomes.

To overcome these barriers between sectors and organisations approaches to open source, open IP and open innovation, models have emerged with more layered levels of IP (e.g. creative commons licensing) and opportunities for exploitation. The IDM supports this more open approach ensuring maximum join-up between leading edge research outputs and applications of these advances into the market, promoting the use of wrap around and added value services (servitisation), such as training.

The (IDM) aims to bring together open innovation models of product development (Chesborough, 2003), crowd wisdom (Surowiecki, 2004) or collective intelligence and distributed development to accelerate innovation between sectors. Together, this approach facilitates accelerated uptake of innovation (see **Figure 1**), across the academic and industrial partners. In this way, the IDM aims to accelerate the processes of open innovation through the proximity of academia and industry, closer interworking and partnering in more varied practices and processes (see Chesborough, 2003, Digital Agenda for Europe (COM(2010)); Foray et al., 2012).

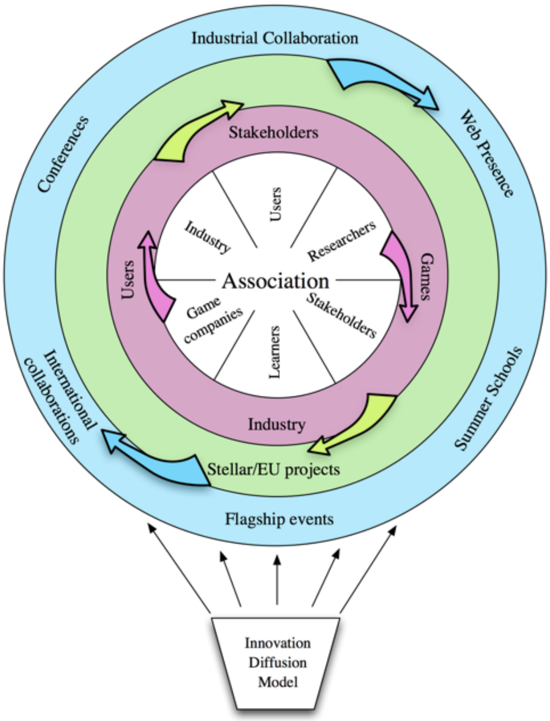

Figure 1: Innovation Diffusion Model pushing up the three step approach

The serious games sector is a relatively new segment high growth sector of the e-learning, digital media and games sectors, and produces an interesting example of how innovation diffusion can provide academic, industrial and socio-economic benefits. With estimated growth figures of 47% 2010-2015 (I-DATE report), the segment adopts existing games technologies used so successfully in entertainment games in new non-entertainment markets (e.g. Knight et al., 2010). Serious (or educational) games are being used for problem-solving in manufacturing, health, education and the environment. By exploiting games technologies, engagement and motivation can be encouraged and sustained, and at the same time greater personalization of services can be supported, which include servitization or product-service systems which can increase profit margins significantly by moving towards a service-based approach to manufacturing (Lightfoot et al., 2012).

In the serious games sector, however growth and development has often been piecemeal and disjointed which has prevented more rapid growth. To overcome this, we have implemented the IDM to bring the sectors together. For instance, at the SGI, we are developing a cluster of industrial companies that has increased from five to around 30 companies, over the last five years. The proximity of the two sectors together allows for greater opportunities for knowledge and technology transfer, building communities and shared development and proposal writing. Innovation diffusion therefore is supported by the more traditional clustering, community building, knowledge transfer approaches and importantly through the more innovative participatory models of co-creation between user and development communities. The model also supports significant interworking, through shared development tools and approaches, seminar series, conferences and workshops, as well as knowledge exchange support by case studies and practice examples. To summarise this, the IDM then has several main indicators:

- Proximity (e.g. closeness of academic and industrial partners),
- Generation of IP (e.g. spin outs and start ups, inward investment, patents and new IP),
- Open innovation models (e.g. co-creation of products within user communities)
- Technology and knowledge transfer (e.g. introducing BCI technologies to companies)
- Developing social and user communities (e.g. community building)

These elements will be considered in the case studies with respect to the SGI and TU Delft activities in the area of Serious Games. This approach has been extending from the SGI as an information and services hub for the field onto an international research network context: the GALA network of excellence in Serious Games which includes 31 partners. The model which has effectively generated IP and three spin outs in the SGI context. At the international level, the IDM has supported interworking between sectors through an Association model which aims to develop further and wider innovation and shared co-evolving practices.

While these examples have initially focused upon a combination of a traditional high technology cluster of facilities with an innovation of co-development and participatory joint research and development, the model may be used for supporting all kinds of academic and industrial collaborations in the future. The following section outlines in greater detail the case study of the SGI as one of a set of new ‘hybrid’ models that foster and evolve more formalised industrial-academic collaborations, by supporting open innovation processes and modelling.

Case study: Modelling academic and industrial partnerships in the Serious Games Institute

The Serious Games Institute (see: www.seriousgamesinstitute.co.uk) was founded in 2007 as a regional development funded project worth £7 million in capital funding (from the former Advantage West Midland Regional Development Agency). The SGI was set up to become a hub for international excellence in serious games research, business engagement and study, and is based on the Coventry University Technology Park, and includes companies in the sector, an applied research group and a business development group within the same building.

The SGI’s model and was first conceptualised as extension of the “Research Hotel” model in which industrial and academic units undertook research and consultancy projects in bookable shared space (e.g. Marsh, 2002). The Research Hotel model is normally based on the premise that the industrial partner join can book access to space and resources of the academic partner when needed. Literally, as with a normal hotel, this could be on a day by day basis but more usually it is for a predefined period of time associated with a piece of consultancy or a research project. The original promoters of the SGI had been involved in Research Hotels where the more casual relationship between academic and industrial partner had evolved in to permanent cohabitation which mutual advantages for both parties. This original idea has over time evolved into what we term here a ‘hybrid model’. It is ‘hybrid’ in the sense that it brings together business and academic partners, for example offering business incubator and services with research lab facilities, teaching communities and development of educational games and mobile applications. The Institute incorporates industrial engagement, business community outreach and services (such as Mobile Apps Lab and Serious Games Studio) with an applied academic research capability, innovation transfer and teaching for postgraduates.

The SGI is part of Coventry University Enterprises Ltd which is the University's vehicle for commercial activity. CUE Ltd undertakes business focused funded programmes, applied research projects, services and consultancies and provides office accommodation to a cluster of companies on the University's Technology Park. The Institute model is set up to provide income streams for the university, and our recent Serious Games International spin out has attracted £2 million in inward investment to support spin out activities, including developing new IP, and to support larger and purely commercial projects. The company has 17 new employees and has produced a range of apps and services including the Shakespeare Eye App, now deployed by the Shakespeare Trust.

The Innovation Diffusion Model has been applied to the SGI since its founding in 2007, and the Research Hotel model itself has elements of the IDM, most notably the proximity of industry and academia in one building. The idea of proximity between different sectors is not a new one – but the SGI provides a living model of how this proximity can facilitate interworking and faster models of innovation and IP generation. Technology Parks themselves are good examples of this element of the IDM.

The Institute provides a potential model for how industrial and academic collaborations can be used to create sustainable research income for universities to invest into improving the increasingly under-funded research infrastructure. The strength of this 'hybrid model' is that diverse funding streams are opened with greater potential for encouraging industrial investments and funding. The proximity of industrial business with applied research knowledge and intellectual property has benefits for all partners in the collaboration, such as: knowledge transfer, technology transfer, exchanges, employment opportunities between the sectors, employment opportunities for interns and students and better opportunities for retention and access to staff across the business and academic groups. The latter is particularly troublesome in high-tech areas where new and specialised skills are needed. Importantly, through these mechanisms the model allows for building new capacities and capabilities in wider sectoral areas of business and research, and supports innovation diffusion across sectors.

What was interesting over the first five years was not the success of academic-industrial collaboration, but the diversity of ways and models for collaboration that emerged. Some of the examples of these have included: industrial sponsorships of PhD students, collaboration on funding proposals, co-branding services, consultancies with academic and business partners, trade missions, collaboration on overseas branches including attracting funding for start-ups abroad, co-attendance of conferences and workshops, co-organisation of virtual conferences, sharing overseas facilities, reciprocal use of overseas networks and facilities. The main industrial-academic collaborations have centred around business creation and jobs created and protected within the industrial sectors, additionally technology and knowledge transfer has notably supported high value competitive advantage of businesses in the cluster, as well as supporting new opportunities with partnering with new companies and organisations.

One example of this has been the introduction of the NeuroSky Mindset brain computer interface headsets in the UK and into the business cluster. This resulted in one company, the London-based Roll7 company developing several games for NeuroSky which are now bundled with all headsets sold. The applied research group tested the headset in advance of introducing it to partners to ensure that it could be used effectively for games developers and had notable benefits for users (e.g. Rebolledo-Mendez et al., 2009; Rebolledo-Mendez et al., 2010). This is an example of how technology transfer and academic evaluation and review can impact upon profit margins and allow small SMEs to build extra capacity, whilst innovating products and broadening markets.

Alongside these kinds of models of business engagement, the SGI has been developing university wide systems for supporting open innovation models that integrate businesses and academic research expertise. In OpEx, a Joint Information System Committee (JISC)-funded project, university wide human processes that model and shape open innovation models between industry and the academy are being mapped into digital systems, that can be used for scaling up innovation across wider business communities, though initially deployed at Coventry University.

The main learning points from the case study are: the effectiveness of the IDM centres heavily upon proximity and IP generation, where these are supported in the system, then the user communities, open innovation and technology and knowledge transfer seem to take place quite organically, with partnerships evolving over time based on communities of interest around thematic areas which can be technological, but more often are based upon quite commercial factors such as access to communities, benefits from services such as evaluations. However, the perception of quality is a significant aspect to the success of the model and while a successful and high quality offering is perceived, then profile remains high and many more industrial contacts are gained. While academic goals and metrics are generally more centred upon student numbers and high quality research outputs, it is notable that for industrial partners just in time information is a major requirement. However, most industries do value the high quality research findings, especially where they can be clearly and easily defined in terms such as return on investment, market drivers and broadening market share for products and services.

Through the IDM initiative, the SGI is able to bring together open innovation models of product development, crowd sourcing and distributed development to accelerate innovation between sectors. This case study has highlighted a common practice of the SGI, where the proximity of the industrial and applied research sectors together allows for greater opportunities for knowledge transfer, building communities and shared development and proposal writing. Clustering, community building, knowledge transfer and participatory models of co-creation between users and developers therefore support innovation diffusion. The model also supports significant interworking through shared development tools and approaches, events and workshops, and knowledge exchange support by case studies and practice examples. But crucially the approach opens up access to public and private funding that can sustain and support research infrastructure to replace the gaps in funding.

Case study: Public-private partnerships in funding serious game research in the Netherlands

The TU-Delft Centre for Serious Gaming was founded in 2004 as an internal faculty initiative of a number of researchers from various disciplines who were getting more and more involved in the use of game-technology and concepts for issues on policy, organisation and management. The centre has gone through several stages of development, with different academic partners, but has functioned as a network of academics who shared knowledge and facilities using expertise for external promotion and funding of projects.

The field of serious games which focuses upon using games technologies has been a matter of interest in the Netherlands, where the field has been given a major boost nationally by government subsidies. For example, in 2004 and 2007 respectively, two large research projects were granted Fes-Bsik subsidies that significantly stimulated and institutionalised the co-operation between academics, private and public institutions in the field of serious gaming: the GATE programme (€19 million) and the NGI programme (€40 millon).

The GATE programme (Game Research for Training and Education, 2007-2012) was a consortium of academic, private and public institutions in the field of game-research. The consortium was primarily led by Utrecht University, the Utrecht School of Arts (HKU) and the Dutch applied research organisation (TNO) but also included a range of Small to Medium Sized Enterprises (SMEs) and other Dutch universities, e.g. TU-Delft, as partners in the consortium. The GATE programme produced a series of 19 PhD theses in the field of gaming, some of the earliest PhDs in the field in the world. The programme organisers also organised and hosted many national and international events in the area of gaming, enhanced and stimulated several commercial activities especially in or around the city of Utrecht. It should be noted that GATE was about all kinds of digital gaming - entertainment and serious - and very much focused upon the more fundamental computer science or artistic aspects of game design. At the end of the programme, in 2012, however, no privately funded research centres in the field of SG were established. Research funding of SG in the Netherlands was continued in the so-called Top Sector policy programme (2012, see below) with different rules of the financing game.

The second programme was the Next Generation Infrastructure program (NGI) funded from 2004–2013. The NGI is huge consortium of national and international academic, public and private partners in the area of infrastructure design and research. NGI is an independent foundation, but its board and management reside within Delft University of Technology, the Netherlands. With reference to its interest in complexity and system theory for infrastructures, the exploration, use and research of simulation-gaming and serious gaming (SG) for infrastructures was incorporated in the research programme from the beginning. Overall, the NGI program has dedicated several million euros for SG-research, development and diffusion. It has directly funded 7 PhD researchers in this area and co-funded a series of SG development and application projects.

To align the many emerging activities in the field of SG, a TU-Delft Centre for Serious Gaming was established in 2004. In contrast to the GATE program, the research within NGI/TU-Delft Center for SG was much more focused on social and engineering sciences, in particular the decision sciences (policy analysis, systems engineering). The TU-Delft centre’s niche of SG application is infrastructures and complex, socio-technical systems.

Since 2004, TU-Delft has formed the so-called TU-Delft Valorisation Centre. Its task is to stimulate and co-ordinate the co-operation between industry/society and TU-Delft, in particular in relation to private funding and dissemination of R&D. The Valorisation Centre manages two TU-Delft holdings: TU-Delft services (for TU-Delft commercial daughters) and TU-Delft enterprises (for commercial spin-offs where TU-Delft still has some IP or financial involvement). In contrast to the SGI institute in Coventry, the TU-Delft Centre for Serious Gaming was never put under TU-Delft services or TU-Delft enterprises, which would have established as an independent, privately funded-research institute. It remained a faculty research group. However, the turn-over increased steadily to over 1 million each year. The NGI foundation has been very active in bringing the use of SG to the attention of its partner network, e.g. organisations like the Netherlands' railway network manager ProRail. This resulted in subsidiary forms of co-operation and funding. In 2010, for instance, a four-year collaboration contract was settled between the Center and Prorail with funding for two additional PhDs in Railway Serious Gaming and a series of SG development projects to increase the performance of the organisation. In a similar fashion, we have been working with and for many SMEs - energy companies, port and logistical companies, societal organisations and public agencies - either at the SG-development side or the SG user side. The result is that around 81 per cent of the research and development budget (excluding facilities, overheads) between 2008 and 2012 for SG could be labelled as private funding or third money stream.

Over the years, and in collaboration with private and public partners, the TU-Delft Center for SG has been successful in a broad range of projects and activities. These outputs include: dedicated courses in serious game design and serious game production for Masters and post-academics, development of five spin off companies, the largest now having 20+ full time employees. As well as participation in two European Commission funded serious game projects and the GALA Network of Excellence. The group have developed a self-sustainable, internal SG production lab (with 12 full time employees) run by TU-Delft graduates with help of interns and students of all faculties. With the development of around five serious games per year for high profiled clients in the world of infrastructures (e.g. *SimPort MV2* for Port of Rotterdam; *Hazard Recognition* for Shell; *Levee Patroller* for Water boards; several games for ProRail). The group is operating as a Lab but with a broader remit for development and research engagement. Here as with the SGI model, the benefits of public-private funding have net results upon the research infrastructure of the university, while supporting the high-growth technology area of SG, providing a sustainable model for future applied research clusters.

Discussion and Conclusions

While serious games is a distinct high-technology sector area, this IDM model can be used and adapted to different sectors, and the main learning points clearly point to the success of the model for establishing clear importance around *proximity* of industrial and academic sectors and *IP generation* as primary drivers that can then have other linked benefits of evolving user communities, technology and knowledge transfer and open innovation models and processes.

This study presents the IDM model and its primary elements as a basis for testing and evaluating other models for industrial and academic engagement, open innovation and communities for stimulating growth in particular regions and areas internationally. While proximity is an important aspect of supporting open innovation, the proximity of ideas and key expert communities clearly has an impact upon industrial innovation in products and services.

While both Coventry and Delft are in high-technology corridors, the supply of skilled workers and specialised facilities has a draw for new companies and can be a magnet for growth, many lessons remain for how academic and industrial communities can interwork and co-relate best practices. In particular, these approaches can be heavily reliant upon start up public funding, and issues around IPR can present impediments to real engagement of the communities with one another.

However the main facilitator of high growth areas is clearly shared interest and objectives, and it is here that more work is required. Events and communities emerge and die away, questions remain around how to sustain interest in these communities and how to keep partners engaged in initiatives and promoting innovation.

These early exemplars in the field of serious games offer a ‘fourth’ way of plugging the gaps in funding for research infrastructure faced by universities. Industrial collaboration, either in return for development services offered, in the case of game development, or through reciprocal exchanges of facilities and services provides a mechanism for generating extra funding that can be invested into research infrastructure. Collaborative projects involving participation from industrial and academic partners show social impact and benefits can be provided, for example in using games for supporting levee training in TU Delft.

However, the case studies also show how the ongoing evolution of these models will be vulnerable to changes in public funding, due to its reliance upon public funding to pay for the full costs of research and development, including infrastructure. Since the late 1980s we have been struggling for a new model for paying for public services, and in global economic downturn and with rising students, universities are feeling the pressures on their budgets. Yet the decision as to whether to cut research budgets in the future will not be a financial argument, but a matter of politics, if we do not maintain our research in real terms the result will be a proliferation of privately funded labs and companies that pay for unique IP as and when needed, rather than state funded labs and institutes that serve a wider good. At the heart of these debates is a wider question not just about industry and academia, but upon public services. If we do not choose to invest adequately in them, we will lose them. In the case of universities and research funding in particular this is all bound up in service culture, if research and teaching are disconnected for example any argument for continuing research funding may be weakened, on the other hand if all research is industry driven and applied what will happen to areas of the disciplinary tradition where no outputs can be produced?

In the modern environment where utility and output, impact and financial gain are writ large, will research culture and infrastructure be able to be maintained on levels that support quality, rigour and validation? The challenge for the future of research funding is considerable, but as Vannevar Bush before us identified, the importance of science and research is that it has considerable cross benefits that sustain and support industry and productivity, and therefore cannot be separated. With this in mind, the two case studies provide modern illustration for how applied research and university facilities can support and motor industry. However for this to be a viable and sustainable project, the critical features include: ongoing shared interest and utility, inward public investment and the support of interested specialised and skilled communities.

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