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Vorsprung durch Technium: Towards a System of Innovation in South West Wales

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ABSTRACT

Begun in 2001, Technium is a Welsh university-business interface project presently consisting of ten facilities. Seven of these are jointly managed by the Welsh Development Agency and Swansea University. Taken together with other, linked developments at the University, Technium is helping to generate a distinct sub-regional innovation system incorporating many features that researchers have identified as critical to successful localised collective learning and innovation. A provisional evaluation of costs and benefits suggests that recent criticism of the project is unfounded. With its initial dependence on EU Structural Funds, the Technium model incorporates which may be appropriate to other relatively deprived regions of the EU.

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INTRODUCTION

In their recent survey of the literature on innovation policy, TODTLING and TRIPPL (2005) argue that policies that have evolved in the context of high-performing metropolitan regions may not be wholly applicable to regions that are peripheral or facing the consequences of decline in once-dominant traditional industries. The descriptors 'peripheral' and 'old industrial' both apply to Wales and the restructuring of the economy has proved particularly challenging. The collapse of coal and steelmaking employment in the 1980s was addressed by a massive effort on the part of the Welsh Development Agency (WDA) to attract inward investment in manufacturing. While initially successful in meeting the need for jobs, it was a strategy that became increasingly unsustainable in the face of rapid globalisation (MAINWARING, 1995). A shift in emphasis became apparent in 1994 when Wales was selected as one of the regions to pilot the EU's Regional Technology Plan (RTP) and, since the establishment of the devolved National Assembly for Wales (NAW) in 1999, the Welsh Assembly Government (WAG) has adopted – in principle, at least – the aim of developing Wales as a 'knowledge economy'. The Technium project, which emerged in south west Wales as an attempt to strengthen the interface between higher education and business, has become a key component in the new strategy.

In this paper, we argue that Technium provides a valuable case study and potentially replicable innovation model (or component of such a model) for relatively disadvantaged regions. The project has been subject to criticism (COOKE and CLIFTON, 2005) but we believe that in key respects the critics have projected an

unjustifiably negative picture. Technium is presented here as part of a set of complementary developments, including the establishment of an Institute of Life Sciences and an Institute of Advanced Telecommunications, which have occurred at a sub-regional (i.e., sub-Wales) level and which may be characterised as signalling the emergence of a local or sub-regional innovation system (IS). The next section provides a brief overview of the literature on territorial innovation systems and the policy insights it has generated. The following sections put matters in a more localised context with a sketch of the recent evolution of policy-making in Wales and a description of the pre-Technium research base in south west Wales. We then explain what Technium is and describe the architecture of the system of which it is part. That is followed by a provisional (and necessarily partial) assessment of the costs and benefits. We consider the extent to which these developments constitute a distinct approach to creating a local IS, before concluding.

TERRITORIAL INNOVATION SYSTEMS

The notion that the innovation process in the modern economy is best understood in systemic terms seems to have originated with FREEMAN (1987) and was developed through the 1990s by LUNDVALL (1992), NELSON (1993), CARLSSON (1995) and FREEMAN (1995) himself, among others. It marked a shift away from the idea that innovation is an act occurring within a firm or other agent in isolation from the broader cultural and institutional context. Innovation was believed to be more effective where there is a rich mix of formal institutions (firms, universities, technical colleges, training

agencies, government advisory agencies, etc.), operating within a supportive legal and policy framework, plus a rich mix of informal institutions, from close personal relationships involving trust (MASKELL and MALMBERG, 1999), through industry clusters promoting Marshallian external economies (PORTER, 1990; BAPTISTA and SWANN, 1998), to localised networks and broad innovation-conducive milieu (CAMAGNI, 1991).

The IS concept was initially thought out in terms of nation states and, in that respect, is territorially constrained despite the obvious trend towards globalization. It has survived this trend because globalization and localization are now broadly accepted as complementary processes (CANTWELL, 1995; CARLSSON, 2006), the diversity of local systems allowing each to find a niche in the global economy and for multinational firms to tap into local expertise. The concept is not, however, spatially defined of necessity and some have argued for its applicability to technologies (CARLSSON, 1994) and sectors (MALERBA, 2002). It is probably best to think of the spatial, technological and sectoral dimensions as interacting in complex ways and, in relation to Technium, we shall see that, while the spatial aspect is dominant, the others are also relevant.

Because there may be sub-national differences in the mix of institutions and economic structures it follows that ISs could be identifiable at smaller territorial levels. Indeed, one might imagine a series of systems of increasing locality nested one within the other. What are likely to give the more localised versions their identity are the informal institutions: trust-based relationships, for example, tend to be promoted by proximity (MASKELL and MALMBERG, 1999; MORGAN, 2004); networks function more effectively when people meet regularly; labour mobility and idea spillovers occur in

clusters (industrial districts) which are, necessarily geographically concentrated. These notions were brought together by STORPER (1995) in his characterization of the regional economy as a 'nexus of untraded interdependencies'.

If one seeks the distinctive components of an IS in a set of formal and informal institutions then, clearly, the degree of institutional development, or 'institutional thickness' (AMIN and THRIFT, 1995), has a role to play in the system's success. But while institutional development is generally regarded as a positive sign, institutional ossification, or lock-in, can have a stultifying effect, something which appears to be more problematic in old industrial areas (GRABHER, 1993; HUDSON, 1994; MORGAN and NAUWELAERS, 2002). Within the Welsh context, for example, HENDERSON (2000) concluded that the RTP may not have filled early hopes because of 'well-entrenched interests and responsibilities'.

All this implies that IS designs that are appropriate for one region may not be for another. There may be best-practice regions but not necessarily best-practice systems (HUDSON *et al*., 1997; NEUWELAERS and WINTJES, 2003; TODTLING and TRIPPL, 2005). Even so, a number of positive features appear to be common to a wide set of regions displaying successful collective learning (KEEBLE and WILKINSON, 1999, for an editorial summary of case studies in the special issue of *Regional Studies*). A checklist of desirable characteristics suggested by these case studies include:

- the creation of strong local knowledge networks, proximity being important for such desirable traits as 'imitation, emulation and reverse engineering'
- the exploitation of the multi-disciplinary culture of a university

- the avoidance of path-dependent overspecialisation in increasingly obsolete areas of technology
- SMEs in different technological areas having their own interactive networks (effectively, therefore, separate technological ISs interacting with the spatial IS)
- large corporations seeking to externalise part of their R&D functions to SMEs that can act as intermediaries with universities
- the importance of developing extra-regional links
- the importance of producing highly qualified workers to support the labour market.

To these, one might add:

- the avoidance of top-down modes of intervention in favour of an interactive and facilitative role on the part of government and its agencies (NEUWELAERS and MORGAN, 1999)
- the avoidance of entrenched cultural attitudes (GRABHER, 1993)

In the context of old industrial areas, TODTLING and TRIPPL (2005) see the key issues as: strengthening higher-education institutions (HEIs) and their links to business; embedding foreign firms in order to acquire complementary knowledge and compensate for the low knowledge-absorption capacity of the region; and overcoming locked-in behaviour.

Wales appears to have been fertile ground for IS analysts and advocates and provided an early example of its application at a regional level (REES and MORGAN, 1991; COOKE, 1992). This is attributable to its distinctive political culture and

autonomy relative to the English regions (long pre-dating formal devolution). Of course, the existence of an identifiable system is one thing, its effectiveness quite another.

ECONOMIC POLICY DEVELOPMENT IN WALES

Throughout the 1990s, the WDA gradually shifted emphasis away from the 'advance factory - subsidy' approach to attracting investment and towards a more collaborative business-support regime encompassing indigenous SMEs. Considerable effort was put into embedding foreign multinationals into supply chains into which domestic companies were insinuated. The quality disciplines and, in many instances, the Japanese-style industrial practices, imposed on these firms were seen by the Agency as the way to create a domestic innovation culture. The most successful and multi-tiered supply chains developed in the automotive parts industry, which has become a well recognised cluster, and, to a lesser extent, in the more diffuse electronics sector (COOKE, 2004). According to MORGAN (1997), these strong public-private collaborative arrangements were instrumental in Wales' invitation to participate in the RTP. That programme, itself, represented a switch in the EU's innovation policy away from a technology-driven model to one emphasising the social, institutional and commercial aspects of innovation (i.e., a recognition of the systemic nature of innovation). Despite the policy adaptations within Wales, as late as 1998, the Welsh Affairs Committee of the House of Commons (WAC, 1998) voiced concern about the slow rate of change in WDA philosophy away from its preoccupation with inward investment. This was a clear suggestion that the Agency, or some parts of it, remained locked into the old 'build it and fill it' mentality.

This, in effect, represented the immediate policy legacy of the new Assembly Government. In terms of the actual state of the economy, what it inherited was per capita GDP at around 80 per cent of the UK average – the consequence of a low employment rate (primarily low activity rather than unemployment) and an unfavourable occupational composition, i.e., too few highly-paid jobs. Moreover, the sector in which the best-paid jobs were to be found, manufacturing, appeared to be in rapid decline, partly as a result of foreign firms severing their links with Wales (COOKE, 2004).

Given that inheritance, the significance of the Government's first economic strategy document, *A Winning Wales* (NAW, 2002), lies in its recognition that the sustainable growth of welfare is dependent on the successful commercialisation of knowledge. Addressing the GDP deficit was no longer seen as a simple matter of job creation but more particularly of: increasing the rate of home-grown, knowledge-intensive start-ups; putting greater effort into attracting high-quality inward investment (i.e., closer to the start of the product cycle); and promoting private-sector professional services, in which Wales appeared to be lagging the rest of the UK. The primary means by which these objectives were to be attained were by encouraging innovation, entrepreneurship and skill acquisition and by improving the communications infrastructure and business support services. In each respect, links between businesses and HEIs were seen as critical and, in relation to the incubation of home-grown ideas, Swansea University's Technium project was considered an examplar.

Although *A Winning Wales* appears to mark a departure from the old job-creation formula, COOKE and CLIFTON (2005) have been notably pessimistic about actual progress. They argue that, since devolution, Wales has, compared to Scotland, pursued a

less 'visionary' and less robust approach to system building. In part, this is attributed to the weaker nature of the devolutionary settlement in Wales, but they see also a problem in the very culture and institutions that have made Wales distinctive. Among the latter is the WDA which, in their view, is still excessively wedded to its traditional agenda – though more now in the form of advanced offices than advanced factories. WAG's promise (since fulfilled) to take the WDA (a quango) into government, as part of the civil service,[1] is not seen by them as part of the solution but as a reinforcement of WAG's top-down and more 'precautionary' attitude to economic development. As for Technium, COOKE and CLIFTON describe the project as flawed and overambitious, charges which are considered later in this paper.

Perhaps as a result of its institutional development (and the politics of national identity), Wales has been particularly successful in accessing EU Structural Funds. Since 1999, 'West Wales and the Valleys' (which incorporates south west Wales) has qualified for Objective 1 funding (directed at regions having less than 75 per cent of the EU average GDP per capita). The same area has also qualified for the successor Convergence Fund, which runs from 2006 until 2012. (For earlier regional funding comparisons, see COOKE, 1992). *A Winning Wales* recognised the opportunities presented by the receipt of EU Structural Funds, especially Objective-1 funding, but did not specifically link these to its strategic objectives. The successor document, *Wales: A Vibrant Economy (WAVE)* (NAW, 2005), however, states quite explicitly that 'any post-2006 EU funds should, … , reflect the Lisbon [summit] reform agenda of promoting jobs and growth – particularly in innovative knowledge-intensive sectors' (p. 18). Not surprisingly, innovation is again ranked first among the key drivers for business growth

and not only is Technium cited as a flagship project in this respect (pp.15 and 51) but it and related developments such as the Institute of Life Sciences are seen as enabling Wales to 'draw away from the "branch factory" economy' (p.42). This is a clear statement that WAG regards the old inward-investment strategy as history.

WAVE was drawn up in the light of the Wales Spatial Plan (NAW, 2004) and, as a consequence, the spatial aspect of economic strategy is more fully articulated than it is in the 2002 document. The Spatial Plan itself is a formalization and acceptance of the de facto nature of regional governance, particularly among the former quangos involved in education, training and economic strategy. Indeed, GOODWIN, JONES and JONES (2005) assert that south west Wales has become one of the (four) key spaces in the economic geography of Wales since devolution and that this 'demonstrates a spatial rather than a sector-based approach to the delivery of economic development'. However, south west Wales is a far from homogeneous space, being highly urbanised in the east (around Swansea Bay) and rural to the west (Carmarthenshire and Pembrokeshire) and these differences are respected in the Spatial Plan. In particular, the HEI-based innovation approach is not only constrained by the existing distribution of HEIs but is initially more appropriate for areas of higher urban density and, therefore, of knowledge-absorbing potential (and which in Wales as a whole means Cardiff, Swansea and north east Wales). Taken together with eligibility for Objective-1 funding, this leaves Swansea as the obvious location to experiment in and nurture an innovation system that can subsequently reach out to the more rural areas to the west and to other parts of Wales.

THE INHERITED RESEARCH BASE

Shortly after devolution, the National Assembly's Economic Development Committee commissioned a report on the state of R&D in the economy (JONES-EVANS, 2002). This basically established that the research base in Wales provided inadequate foundations for the knowledge-economy aspirations implicit in the Assembly government's economic plan. Calculations in BEALE and MAINWARING (2006) bear this out. From the 2001 Research Assessment Exercise (RAE) for UK HEIs, it is possible to estimate the numbers of academic staff resident in departments that made a submission to the Exercise. In 27 (of 68) subjects that, broadly, qualify as science and technology (S&T), Wales had 932 staff, as compared with Scotland's 3,146. In per capita terms, Wales's research base, on this measure, was about half of Scotland's (and similar to Northern Ireland's).

The total S&T staff count for Swansea University was 138. This compares with 557 at Cardiff (the combined University and College of Medicine). Even ignoring its elite universities, Scotland's other 'old' institutions - Aberdeen, Dundee, Heriot-Watt and Strathclyde - all had more than double Swansea's researcher numbers. Given the weak HE base, it is not surprising that interactions with business have been muted. To take one example (BEALE and MAINWARING, 2006), between 1983 and 2005, Swansea University was granted 0.04 European and US patent grants per S&T researcher (on the basis of the 2001 RAE count), compared to 0.12 for Aberdeen, 0.15 for Dundee, 0.17 for Cardiff and 0.41 for Strathclyde. While these comparisons have to be qualified by

recognizing that other avenues for commercialization exist, apart form patent registration by the institution itself, they probably do fairly indicate a general performance ranking.

Apart from Swansea University (and the neighbouring Swansea Institute of HE, which has very limited research strengths), there is no other public civil research base in the area, unless one interprets the 'south west' more broadly to include the Institute of Grasslands and Environmental Research at Aberystwyth. Nor is there a military research establishment or much in the way of defence-related R&D (BISHOP and WISEMAN, 1999). As is well known, commercial R&D in Wales is low in comparison to other UK regions and (given the dominance of the Cardiff area) that almost certainly applies *a fortiori* to south west Wales. Large firms here tend to be inward investors who, hitherto, have shown little interest in devolving fundamental R&D functions to their branch plants.[2] An exception was the steelmaker Corus which had a substantial materials research centre at its Port Talbot plant, near Swansea, but this closed in 2001. (The facilities remain available for hire to private companies.) Meanwhile indigenous SMEs have failed, up till recently, to develop a strong research ethos or research capacity.[3]

Given this historical legacy, the Technium project was designed to do five things: improve the knowledge flow from the University into the private sector; help spin out a local population of SMEs with a strong research ethos; use the potential for University links to attract (spin in) non-local research-driven young firms; promote the retention of graduates in the area; and encourage large, established firms to devolve part of their R&D functions to Technium and so develop fruitful links to the University and to Technium-based SMEs. As is obvious from our description of the inherited research base, an ambitious programme of this nature would be unsupportable without a significant

expansion of that base. It should, therefore, be considered as one of a number of parallel initiatives.

These other initiatives include the new (2001) Swansea Medical School whose researchers will come together in a £50 million facility, known as the Institute of Life Sciences (ILS). The Institute, which will house IBM's 'Blue C' computer, one of the largest and fastest in the world, will add over 200 academics to the existing S&T numbers. In addition, the recently announced £30 million Institute of Advanced Telecommunications (IAT) will employ 40 new academics and around 100 other research-related staff, some employed in Agilent Technologies' test and measurement laboratory, an integral part of IAT. (Other collaborating multinationals include BT, Cisco, Ericsson, Motorola, O_2 and the construction company Laing O'Rourke.) These initiatives will have the effect of nearly tripling the academic S&T research base in south west Wales from around 140 in 2001 to something like 380 in 2008, as well as substantially adding to the number of non-academic researchers. On the commercial side, IP Wales, a business-support initiative designed to promote awareness and uptake of intellectual property among SMEs in the Objective-1 area, has been set up in the University's Law School.

WHAT IS TECHNIUM?

The Technium project began as a partnership between Swansea University and the WDA and has, so far, had its greatest impact in south west Wales – what might, in HE terms, be thought of as the natural hinterland of Swansea University.[4] It is also within this region

that the initial partnership arrangements have been sustained and Technium has remained most faithful to its original philosophy. It would be wrong to think of Technium as solely an incubator programme (though that is an important part), or to evaluate it independently of the other projects which are occurring at the same time and with which it is intimately linked. Insofar as Technium was initiated by an academic bidding for EU Structural funds,[5] it could be described as a bottom-up initiative, but it is also true to say that the bid could not have succeeded without the involvement of an established and centralised agency (the WDA).

In its physical manifestation, Technium is a set of high-quality buildings providing homes for small business units – which may be small firms or devolved units of larger firms. By the end of 2006, there will be seven of these in south west Wales (eight if a satellite building is counted separately) (see Fig.1). Elsewhere, there are three completed and two at an early stage of planning. The seven in the south west are managed as partnerships between Swansea University and the WDA. Of the three others, one is managed as a partnership between the WDA and the University of Wales Aberystwyth and the others (at Bangor and St Asaph in north Wales) by private agencies on behalf of the WDA. Whilst the entry criteria are meant to be the same for all Techniums, the active and close involvement of Swansea University in the south west group and their incorporation in broader systemic developments, sets these seven apart. They will be the focus of the remaining discussion.

[Figure 1 about here]

The idea of the project was to build on the WDA's existing CETIC initiative (Centres of Excellence for Technology and Industrial Collaboration) which arose out of the RTP and which aims to link businesses with the leading science and technology research groups in Welsh universities. The Swansea-based CETICs, which would provide the initial research links for the Techniums, were: power electronics design, computation and simulation, communications and software technology, materials engineering, and complex fluids processing. Firms wishing to enter the programme had (and still have) to satisfy basic criteria. Apart from demonstrating commercial potential and managerial capability, applicants are required to be: operating in a high-technology or knowledge-based sector; exploiting intellectual property, either their own or via licensing; engaged in R&D; and have or wish to develop links to university researchers. The latter are facilitated by but not limited to the CETICs. Costs of setting up collaborative links with the University can be partially defrayed through grants from the Swansea Bay Partnership (of local authorities). Help and advice in respect of intellectual property is facilitated by IP Wales, and Technium firms appear to be among the most active in exploiting this resource.

The first Technium (now known as Technium 1 – abbreviated here as T-1) was built on a brownfield site in Swansea's dockland and opened in 2001. (Swansea's docks have seen better days and a vast area of land has become available for a 'waterfront' redevelopment. As we shall explain below, Technium has been instrumental in bringing forward this programme of urban renewal.) Because of pent-up demand, the 14 units filled up quickly and the pressing need then was to get firms out rather than in. The objective has been an initial incubation stage of two-three years for university spin-outs

and other start-ups. Whilst this is essential to maintain a constant flow through the system, it was recognised that young firms would still need support through their next growth stage. This led to a 'grow-on' Technium (T-2) adjacent to the first.

While T-1 provided firms with academic support and opportunities, and general business support and advice from the WDA, T-2 additionally attracted involvement from private sector business-support firms Morgan Cole (solicitors), PriceWaterhouseCoopers (accountants) and Urquart-Dykes & Lord (patent attorneys), and the first of these set up new offices close to the Techniums. T-2 opened in mid-2005 and its occupants have collectively funded their own private grow-on space next door. There are thus the beginnings of a mixed public-private knowledge-based cluster at this waterfront location.

Techniums 1 and 2 are also host to the International Business Incubator which is designed to encourage spin-in firms from foreign universities seeking links with Swansea University departments. A partnership arrangement with Fudan University in Shanghai has brought in two firms, one seeking nanotechnology collaboration and the other co-operation in the field of telecommunications and medical devices.

The first two Techniums were not intended to have any particular sectoral or technological emphasis, but subsequent facilities have been designed with particular sectors or technologies in mind and have a wider geographical spread (see Fig. 1 and Table 1). First was T-Digital, located on the University campus with a satellite at Sony's Pencoed operation. Firms at the latter can make use of Sony's R&D laboratories and manufacturing and conference facilities. This enables Sony to spread overheads and use up excess space. Apart from Sony, T-Digital has received co-funding from Agilent Technologies and it will, in future, provide a destination for spin-outs from the new IAT.

T-Digital builds on the existing local cluster in the electronics sector. Next comes T-ST (sustainable technologies) at Baglan Energy Park, initially in partnership with Neath-Port Talbot unitary authority, BP and General Electric, later to be joined by 3M which is looking to replicate the Sony model at its Swansea plant. Part of the justification for this particular sectoral emphasis is to support the WAG's statutory commitment to pursue sustainable development.

[Table 1 about here]

Further along the pipeline are T-PE (performance engineering) at Llanelli, which aims to reinforce the automotive parts cluster, and Technium Pembrokeshire (T-Pembs) at Pembroke Dock. Both of these involve partnerships with the local authorities and with IBM and (along with T-Digital) will have direct access to IBM's product life-cycle management (PLM) software.[6] T-Pembs will be focused on energy technologies, taking advantage of its location on Milford Haven with its existing oil terminals and refineries, and two LNG terminals and associated power plants presently under construction. The south Wales coast, with its high tidal range, is also an ideal location for the development and testing of wave and tidal power generators. There also appears to be potential here for a link-up with Institute of Grassland and Environmental Research (IGER) to commercialise new technologies for developing bio-fuels. The remaining sub-regional Technium has had a chequered history. T-LS (life sciences) was conceived as a 'BioTechnium' at the National Botanical Gardens of Wales, a Millennium Fund project that subsequently got into financial difficulties. As a result the Technium was put on hold. Now that the Gardens have been put on a sound financial footing, the Technium is apparently back on the agenda.[7]

The intention of the sectoral and technological configuration of the later Techniums is to combine the advantages of spatial clustering (within a spatially defined IS) with the desire among practitioners to form and exploit their own discipline-based networks (DE BERNADY, 1999). Collective learning is facilitated by proximity, but proximity can be defined in technical and commercial as well as geographical terms. In this way embryonic sectoral and technological ISs are woven into the fabric of the territorial IS.

T-1 remains the hub of the Technium network, housing the IT infrastructure that connects to the University and, from there into the UK HEI 'SuperJanet' network. However, each individual facility also has on-site business support. All Technium tenants will be able to use PLM software (though not all with on-site access). Fig. 2 is a schematic representation of the broader system of which Technium is part. The key players are the University, the WDA, the local authorities and private companies.

[Figure 2 about here]

The Technium philosophy is that new firms should be able to stand on their own feet after two-three years of intensive incubation support. During that time they not only have favourable access to knowledge and technology networks and business support, but they also have the opportunity of sharing information with each other and thus establishing informal networks that can continue when they move on. It is too early to assess the extent to which such self-supporting behaviour has developed, but the fact that T-2 tenants are co-funding their own grow-on space is a positive sign. Even when they have left, these firms (and any others that satisfy the criteria) have the opportunity to be

Technium associates: an annual subscription allowing access to the Technium virtual network.

COSTS AND BENEFITS

Raising the capital costs of these developments has been facilitated by the operation of EU Structural Funds. To access these funds, project proposers have had to generate £-for-£ match funding. This has come from University overheads and staff time, land (from the WDA, local authorities and the University) and public-sector grants. Over a quarter of the funding has come from the private sector. For the first six Techniums (1, 2, Digital, PE, ST and Pembs), the public/private capital/revenue breakdown is shown in Table 2. The long-term sustainability of the project depends on rental incomes, service charges and associate membership subscriptions. The rentals are levied at commercial rates, commensurate with the quality of the buildings, and will sustain the project (i.e., pay for maintenance and depreciation) provided that the occupancy rates are adequate.

[Table 2 about here]

Success in maintaining high occupancy is therefore critical to long-term viability. This has been seized on by COOKE and CLIFTON (2005) who, citing the view of JONES-EVANS (2002) that the research base in Wales cannot support the planned number of incubator spaces (based on average European rates of university spin out), describe the project as 'overambitious'. Several observations are relevant here. The first is that COOKE and CLIFTON quote figures for the number of Techniums (20), the

number of incubator spaces (400) and the project cost (£260 million) which bear little resemblance to reality. It is true that they are considering the whole of Wales rather than just south west Wales; but even in the all-Wales context each of these figures should be halved to approximate the actual state of affairs. (The two additional Techniums planned for the Cardiff area, using private funds, will still bring the total only as far as twelve.) For the Swansea-based Techniums, the respective figures are: eight; 121; and £52 million, of which £39 million is public. The second is that, within south west Wales, as we have noted, the research base will have almost tripled by the time that the project has reached maturity. The third is that Technium aims to encourage spin-ins as well as spin-outs. The fourth is that Welsh universities as a whole have a spin-out record that exceeds the UK average: in 2001/02 Wales accounted for 10 per cent of UK HEI spin-outs, twice its per capita share (HEFCE, 2003). And the final point is that the new Swansea on-campus developments, the ILS and IAT, are focused on those areas of S&T which are particularly productive of spin-out ventures.[8]

One explanation for COOKE and CLIFTON's scepticism is their apparent belief, echoed by some media commentators,[9] that the Techniums represent a return to what they call the WDA's 'field of dreams' approach of building facilities (formerly advanced factories) in the hope that someone will occupy them. Elsewhere, COOKE (2004) claims explicitly that 'true to WDA traditions, they are properties for leasing space [and] thus they are not in themselves innovative.' The implication here is that the entry criteria for SMEs is some sort of fig-leaf. Given the dangers of locked-in behaviour by entrenched interests (in this case the WDA), this is an understandable concern. The transformation of Technium facilities into mere commercial office space is at greatest risk where

effective control is vested in a single agency and the physical assets have potential value apart from their role in promoting innovation. In the case of the Swansea Techniums, management is shared with the University whose only conceivable interest in the buildings is as means of strengthening the two-way relationship between business and academic research and graduate skills. The University has a strong interest in maintaining the initial philosophy and would undoubtedly suffer were the buildings to become mere property assets within a WDA/WAG portfolio.

COOKE and CLIFTON's final criticism, that Technium has failed to provide adequate managerial assistance relating to finance, legal matters and accountancy, is also unsubstantiated. All Technium SMEs have direct access to WDA support services, support on intellectual property from IP Wales, and access to product life-cycle software, and they can apply for financial backing via the WDA's Smart Cymru programme. There is also the direct involvement by private-sector service suppliers already noted.

What if Technium were to fail? What would be the impact on public funds? It can be seen from Table 2 that public-sector capital and revenue expenditure has been £38.9 million. Of this, half has come from EU structural funds. A proper evaluation of the project would require comparison with other projects which competed for equivalent funds but failed to get them. If Technium was not at the expense of any demonstrably superior project, it cannot be said (from the perspective of WAG) that these funds were poorly invested. Unfortunately, we do not have information on which to make that judgement. The remaining public contribution, in the form of university overheads and development land, arguably also has an opportunity cost below its nominal value (overheads, in principle, having zero marginal cost). Even if these considerations are

dismissed, a failed project will leave behind capital assets of considerable value. The precise value of the residual capital assets will, of course, depend on prevailing conditions in the commercial property market.

High-quality commercial property is at a premium in Swansea according to a report of the property advisers, Lambert Smith Hampton, *Turning the Corner,* reported in the *Western Mail*, 8 June, 2005. According to the newspaper, the Swansea waterfront re-development 'has attracted a great deal of private sector interest following public sector investment'. The public-sector investment referred to here is T-1 and T-2. It appears that these Technium projects have created the conditions for a healthy commercial property market, from which they will benefit themselves. Of course, it remains to be seen whether something similar will happen to the other off-campus buildings. In the absence of any clear knowledge of the residual capital values, it seems sensible to use building cost as a proxy. Assuming the public-sector share of the residual capital is equal to its share of the capital cost, then that implies subtracting £32.3 million from the total public investment to yield an estimate of public sunk cost, i.e., the £6.6 million public revenue expenditure.

The public investment has, in turn, helped lever £13.1 million from the private sector. Of course the systemic costs, involving the ILS and the IAT are greater. But although these are important constituents of the system architecture, they are independently conceived on the basis of their own projected internal returns. The system is more than the sum of its parts and the system returns, mostly in the form of dynamic externalities over a long period, will be greater than the returns to any one component. Thus, even assuming that the public contribution to Technium has an opportunity cost

equal to its nominal value, the modest sunk costs of £6.6 million are buying a critical piece of a large jigsaw.

This may be a relatively small sum to risk on a project that could transform the local economy, but are there any signs that Technium will actually succeed? Any evaluation is necessarily provisional since the programme is still being rolled out. The established facilities, at the time of writing T-1, T-2, T-Digital and T-Digital at Sony, are 77 per cent occupied and are host to around 300 jobs, nearly all graduates; see Table 1.[10] (A degree of spare capacity is actually desirable to accommodate the turnover of occupants.) T-SS was the latest to open and is presently home to two tenants; the projection is for full occupancy over three years. In one respect, perhaps not anticipated, the project has already had a visible impact - on the Swansea waterfront redevelopment. This was scheduled to occur anyway, but there seems little doubt that the Technium developments have been instrumental in bringing the scheme forward by several years.

The waterfront example illustrates the fact that the benefits of a system component accrue to the whole system and are, therefore, to a substantial extent external to the component itself. An evaluation of Technium benefits based solely on jobs created, or of value added by businesses located there, or by the value of Technium assets, will inevitably miss a large part of the gains to the local economy. These will take the form of network externalities that will reach into the economy once firms graduate from the project, knowledge spillovers operating within supply chains of which Technium firms are part, higher land values, and the multiplier effects associated with greater local value added. It was noted earlier that low Welsh GDP is at least partly a consequence of an employment structure skewed towards low-paid jobs, and this has

been reinforced by a tendency for locally-produced graduates to seek opportunities elsewhere. Technium has the potential to host 700 jobs in south west Wales and for these numbers to cumulate throughout the economy over time as firms churn through the system.

A SUB-REGIONAL INNOVATION SYSTEM?

Just as a regional IS shares many of the features of its parent national IS, so the emerging sub-regional system in south west Wales is still substantially embedded within the Welsh system. The developments described above were, however, stimulated and facilitated by characteristics which, though not necessarily unique individually, collectively help to shape the emerging local system. First, the structural weaknesses of the economy and relative deprivation call for a more overtly interventionist approach (if only in terms of funding), as compared to more dynamic and self-sufficient metropolitan regions (including, in this purely relative sense, south east Wales). Second, is the actual fact of opportunities arising from west Wales' eligibility for the highest level of EU Structural funds over a prolonged period. Third, are the particular industrial strengths of the sub-region in performance engineering, electronics and energy. Fourth are the particular strengths of the University in engineering, computing and, increasingly, life sciences. Fifth is the overall weakness of the pre-existing research base, both within but more especially outside the university. And finally, there is the spatial organization of governance, allowing key agencies such as the WDA/WAG an element of local distinctiveness in approach.

In some European regions it is possible to identify indigenous and deeply embedded dominant firms as focal points of the innovation milieu: Nokia in Finland (SCHIENSTOCK, KAUTONEN and KOSKI, 2004) and Siemens in Bavaria (STERNBERG and TAMÁSY, 1999) are examples. The only comparable example in south west Wales was the steel industry but that is no longer the case. The weakness of the non-HEI research capacity has thus led naturally to a focus on the local university as the only institution which could effectively develop adequate research mass. This might appear unexceptional in dynamic areas with strong research universities but it is far from universal. Renewing the autonomous regions of Spain, for example, has occurred despite, rather than because of, the presence of universities. INTXAURBURU and OLASKOAGA (1999) note that after 15 years of Basque technology policy, 'the university's contribution to the innovation system is much less than was desired'. According to BACARIA, BORRAS ALOMAR and FERNANDEZ-RIBAS (2004), Spanish universities generally have traditionally been teaching-oriented and, even though this has changed radically in recent years, those in Catalonia have successfully resisted developing links with industry. As a result, public innovation in these regions is generated largely by government-financed technology centres. This has not proved so necessary in south Wales largely because of the close historical relationship between university engineering departments and the local metalliferous and engineering industries. Although these industries have waned, the culture of industry links (manifested in collaboration, sponsorship and graduate recruitment) has remained strong.

Despite its links to industry, Swansea's historic status bears no comparison with the leading European universities like Oxford and Cambridge. In such places, the mutual

gains between commerce and the university are readily facilitated by 'thick' local linkages without the need of public funding of systemic developments (LAWTON SMITH *et al.,* 2001). What is unusual about the Swansea-based Techniums is that the Triple Helix interweaving of government, business and higher education (LEYDESDORFF and ETZKOWITZ, 1998) is strongly formalised within a single programme via its joint management arrangements.

SUMMARY AND CONCLUSIONS

Where does Technium stand in relation to the checklist of desirable characteristics for successful collective learning that were noted earlier? It is, quite obviously, an attempt to create local knowledge networks focusing on and exploiting a range of university disciplines. In terms of the focus of innovative activities, there is a balance to be struck between the respective advantages of specialisation and diversity; between the benefits of strong clusters and the dangers of industrial lock-in. Some Techniums build on existing industrial strengths (automotive parts), others, like life sciences, telecommunications and sustainable technologies look to exploit new opportunities. The system design incorporates the idea of inter-technology and inter-sectoral networks; and it positively encourages large corporations to externalise part of the R&D functions either to University spin-outs or directly into the University departments. It also builds in other types of external linkage (to overseas universities and SMEs) via the International Business Incubator facilities. The last points on the check-list concern the avoidance of entrenched attitudes and top-down modes of intervention. If the south west Wales

Technium project is fully to realise its potential it will need to maintain a degree of independence from agents that have their own agendas.

Only in respect of one characteristic is there a reversal of perceived need. This illustrates the point that what applies to dynamic labour-shortage regions need not be valid for peripheral and old industrial regions. For south west Wales, the aim (at this stage) is not so much to produce graduates to support the local labour market as to create greater opportunities for graduates to work locally. At the highest levels of educational attainment, it is the demand for skills that is weak, rather than the supply, with the result graduates leave the area to look for opportunities elsewhere. Retention of graduates is itself one of the necessary steps to creating a robust innovative milieu.

Many of the case studies in the literature deal with dynamic regions focused on equally successful universities. It is, relatively speaking, easier to emulate best practice when one is already close to the frontier and has solid foundations to build on. A much greater challenge is to build a successful innovation system in a region with long-standing structural weaknesses, focused on a modest-size university with a limited number of research strengths. The first prescription is to broaden the research base at the same time as the commercial interactions are developed. Poor regions need outside help to do this, and it would be difficult to imagine the Technium-ILS-IAT package happening (to the extent that it has) without either EU Structural Funds or committed support from central government. The second design requirement is to mix SME spin-outs with MNE spin-ins and to facilitate interaction between the two. The third is to use funding streams to provide complementary 'soft' support such as advice on intellectual property. The

last, and potentially most important, is to give universities some control over the way the programme evolves.

This model is neither necessary nor applicable to all regions but it may repay study by those EU regions, particularly in the new members states, which have similar structural legacies to south west Wales, have in place existing but under-performing universities, and have, or will have, access to EU Structural funds.

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NOTES

1 Despite this change, we avoid confusion by continuing to refer to this department as the WDA. Its successor title, the Department for Enterprise, Innovation and Networks, does, at least, signal a new intent in relation to the direction of economic strategy.

2 PHELPS et al. (2003), however, have shown that multinationals in Wales do undertake a considerable amount of local-market development activity.

3 An analysis of the patent stocks of production firms by MOORE and MAINWARING (2006) shows that compared to Ireland, Scotland and South West England, more firms in Wales are single-patent firms. This suggests, for these firms, either the inability or the inadvisability of building on the initial invention through downstream R&D.

4 For present purposes, south west Wales may be thought of as the combined unitary authorities of Pembrokeshire, Carmarthenshire, Swansea, Neath-Port Talbot, and Bridgend, and has a population of 775,000.

5 It was actually conceived by Marc Clement, then professor of Engineering at Swansea Institute of Higher Education (SIHE). Both he and the project transferred soon after to the nearby university. SIHE remains a partner in Techniums 1 and 2 (see below).

6 New EU regulations require companies to meet stringent targets concerning the recycling of materials incorporated in their products. For manufacturers of complex products, the product life-cycle is a major logistical consideration. IBM has seconded one of its staff to teach PLM to Masters students at the University's Engineering School. This is an example of how Technium has helped reinforce more direct university-business interactions.

7 This was reported in the *Western Mail* in December 2005. We have not been able to incorporate funding details here. There was also a private-sector proposal for a Media Technium at Gelli Aur in Carmarthenshire. This attracted WDA interest and Objective 1 funds were allocated to it, but the proposal fell through. According to a *Western Mail* report of July 2, 2003, some £434,000 remained

owed to the WDA.

8 COOKE and CLIFTON's claim (2005, pp.443-44) that 'the Californian flagship technology firm Agilent in Swansea's Technium folded in 2002' is simply untrue. Agilent remains a major University partner and is investing a further £4m. in its Laboratory in the IAT.

9 For example, Owain Llywelyn, 'Incubating pros and cons', *Western Mail*, 1 June, 2005.

10 The Best Science Incubator Award 2005, run by the Centre for Strategy and Evaluation Services, assessed 29 schemes (including some established in the 1980s) from 17 countries. Technium Swansea (i.e., T-1 and T-2) was one of five schemes from the UK. Technium was ranked fourth for return on investment, fifth for growth and unplaced (i.e., not in the top ten) for sustainability. None of the other UK schemes was placed (in the top ten) in any of the categories.

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Table 1. Swansea-based Technium Characteristics

Technium	Opened (Projected)	Sq. m	Spaces	Occupancy (at 01/06)	Jobs realised/ (predicted)
T -1	04/01	2,000	14	12	c. 300
T -2	05/04	3,639	13	10	
T-Digital	07/04	1,200	12	12	
T-Dig.@Sony	07/04	800	8	2	
T-Sust. Techs.	11/05	3,397	32	2	(c. 309)
T-Perf. Engin.	(04/06)	2,200	15		
T-Pembs.	(09/06)	814	14		
T-Life Sciences	(?)	1,600	12		
TOTAL		15,650	121	37	(c. 609)

Source: Innovation Office, Swansea University

Table 2. Funding breakdown for Swansea-based Techniums

	CAPITAL			REVENUE			TOTAL
	Total	Public	Private	Total	Public	Private	
T-1, T-2, T-Digital, T-Dig.@Sony	16.6	12.8	3.8	4.2	3.1	1.1	20.8
Projected investment (to 2007): £m.							
	CAPITAL			REVENUE			TOTAL
	Total	Public	Private	Total	Public	Private	
T-SS, T-PI, T-Pembs	25.7	19.5	6.2	5.5	3.5	2.0	31.2
TOTAL All	**42.3**	**32.3**	**10.0**	**9.7**	**6.6**	**3.1**	**52.0**

Source: Innovation Office, Swansea University

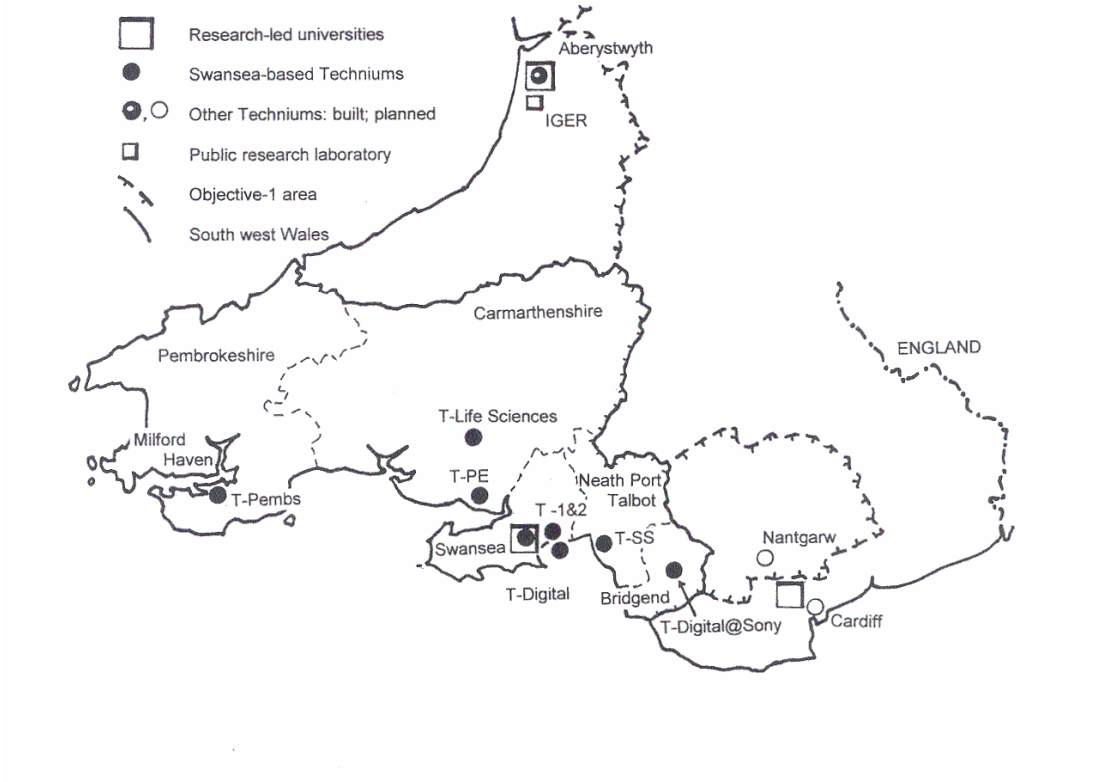

Fig. 1 Techniums and research facilities in south Wales

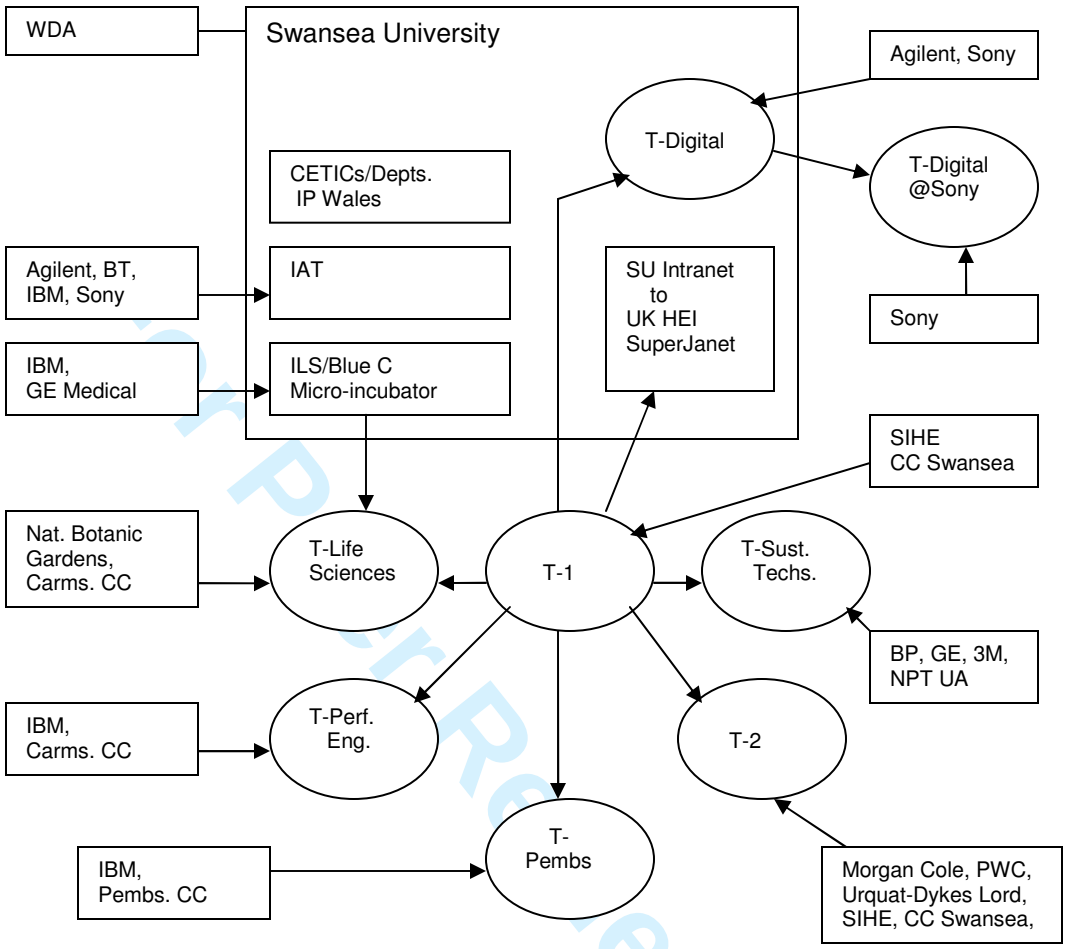

Fig. 2 Technium within the local innovation system

Carms. CC: Carmarthenshire County Council; CC Swansea: City and County of Swansea; Pembs. CC: Pembrokeshire County Council; NPT UA: Neath-PortTalbot Unitary Authority; PWC: PriceWaterhouseCoopers; SIHE: Swansea Institute of Higher Education; Others: see text.