

## Exponential Growth of the Technium Concept on the Internet

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**Abstract:** The aim of this study to considers the exponential growth of the Technium concept on the Internet in relation to business incubation and support for new and existing enterprises in Wales. A simple calculation of the rate of increase in the posting of items on the Internet on the Technium concept has been made. This has involved the net rate of multiplication (geometric rate of increase) over the period 2001 to 2004. An elaborate method of determining the finite rate for increase $[\lambda]$ , which is the multiplication rate of increase which results in a stable distribution has been considered. The natural logarithm of  $\lambda$  is the innate capacity of increase  $[r]$ . This is an infinitesimal rate of increase expressed by the differential equation  $dN/dt = rN$ , where  $N$  is the number of postings on the Internet. Here  $N_t$  and  $N_{t+1}$  are the numbers before and after a time interval. It is accepted that the increase in the number of postings of items on the Internet reporting the development of the Technium concept cannot continue indefinitely. As the exploitation of the concept becomes complete the rate of increase will diminish until a saturation point is reached. At this point no further increase is achievable. This poses the question when will the saturation point be reached? The curve showing the increase from the initial to the saturation point delivers an S-shaped (sigmoidal) curve when the arithmetic increase in the number of items posted on the Internet is measured. These assumptions deliver the following equation:  $dN/dt = rN [K-N]/K$  where  $dN/dt$  is the rate of increase of the posting of items on the Internet on the Technium concept,  $N$  is the number of items present and  $K$  is the number that can be achieved at saturation. The above equations are the theoretical formulation of the growth of the posting of items on the Internet. Since in practice there is limited data due to the short period under consideration in order to answer the question when the saturation level will be reached for the postings a doubling time approximation has been formulated for a saturation time to be extrapolated. These formulations provide an understanding of the dynamics of the exponential growth of the use of the Internet for reporting the development of the Technium concept and answer the question as to when saturation will be reached.

**Key words:** Exponential, growth, technium, internet, business, incubation

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### INTRODUCTION

A new form of incubation developed in Wales is the Technium concept which has resulted in new participants entering the incubation industry<sup>[1]</sup>. This new wave of incubation, experienced in recent years, can be related to regional dynamism<sup>[2,3]</sup> and the creation of new incubators in Wales. It appears that existing incubators are at difference stages of development and serve different types of clients<sup>[4]</sup>. With regard to this UK Business Incubation (UKBI) is the main proponent of business incubation through its Web site<sup>[5]</sup> and has undertaken a study of the UK business incubation environment to create a benchmarking framework for the sector. In fact, UKBI<sup>[5]</sup> is the lead body promoting and supporting the successful operation of all types of incubation facilities at a regional and national level. A two-stage model of development described in the study parallels the

development of small businesses- foundation, development and mature incubation. The report provides standards of good practice applicable to differing incubator environments<sup>[6]</sup>. In Wales the Technium network is one of these incubator environments.

Supported by the Welsh Assembly Government (WAG) the Welsh Development Agency (WDA) has developed a programme of ten centres of excellence in Wales under the Technium banner for specific technology sectors. The technium concept has been defined as a new world-class commercial concept that is set to strengthen Wales as an innovation destination for knowledge based businesses<sup>[7]</sup> and this has an objective to create spin-off employment. The network has the aim to bring together industrial market leaders, researchers and developers, start-up and university entrepreneurs at the Technium sites. Technology-based entrepreneurship is central to the Technium idea<sup>[1]</sup>. Technium tenants are able to access business support, office space, telecom links

and venture finance. Access to the twelve thousand annual technology graduates in Wales will enable new businesses to take innovative products to market. In this way enterprises will be able to mature commercially and graduate from technium centres.

From the roll-out of the Technium programme an all-Wales integrated network of centres has been developed. This provides a supportive environment for enterprises to develop involving a cost of £150 million over three years<sup>[8]</sup>. The centre will:

- Provide incubation space for exciting companies with growth potential;
- Act as a highly-visible vehicle for company-academic links;
- Provide an attractive way for global companies to invest in Wales in high value-added activities;
- Host mixed private/public sector support teams;
- Act as strong physical focal points for (an) innovative communication campaign<sup>[8]</sup>.

The process of the development of the hub Technium centres has been ongoing with sector specific satellite Technium centres being rolled out across Wales.

In the body of understanding presented in the literature three incubation models have been identified for the management of new technology based firms (NTBFs)<sup>[9]</sup>. These are the low selective, supportive and incubator models. The low selective model involves initiatives from public bodies linking with universities with the aim to generate NTBFs. Private organisations undertake action for the supportive model to generate NTBFs that remain local. The incubator model commences with a centre of excellence in a technological area with close ties to academia or research establishments. Since this model is based on the profit motive less NTBFs are generated but it is more sustainable. A development of these models is the network incubator<sup>[10]</sup>. A further concept is technological incubation which takes place in a technology based incubator (TBI) of which techniums are a form. Here the stage model<sup>[11-15]</sup> will be characterised by the development of the idea involving resources, launch, start-up and development.

Three differences between TBIs and traditional incubators have been outlined by Phillips<sup>[16]</sup>. TBIs are concerned with NTBFs, they offer different support (laboratories, equipment, technical research resources, staff, researchers and learning resources) and are linked to Higher Education Institutions (HEIs) and research centres involving Technology Transfer Networks (TTNs). Added value for NTBFs is realised by the different support

provided. In fact, the overriding factor providing added value by TBIs to NTBFs is considered to be the linkage to academia<sup>[16]</sup>. Indeed, the added value from universities is perceived to be essential for the success of the incubator. In particular, significant aspects of TBIs are considered to be the development of innovation networks<sup>[17]</sup>. Here the TBI is not only the link between the HEI and the business but is also part of the overall innovation network. This suggests an integrative dynamic for TBI performance<sup>[18]</sup> although Colombo and Delmastro<sup>[19]</sup> have doubted the success of TBIs in assisting start-up development. This contention is obviously debateable based upon the evidence presented in this paper with regard to the exponential growth of the Technium concept on the internet and the implications of the findings for both theory and practice.

The establishment of techniums is a major strand for programmes such as Entrepreneurship Action plan<sup>[20]</sup>, A Winning Wales<sup>[21]</sup> and the Global Entrepreneurship Monitor for Wales<sup>[22]</sup>. Initiatives include the Knowledge Exploitation Fund (KEF), Know How Wales, Intellectual Property (IP) Wales, the Technology Exploitation Programme and Technology Transfer Centres. The significance of techniums in terms of these policies has evolved from the Regional Technology Plan (RTP)<sup>[23]</sup> with Wales at the forefront of EU regions developing this policy framework. The RTP<sup>[23]</sup> has now been succeeded by the national Innovation Action Plan (launched March 2003)<sup>[8]</sup> as the long-term technology and innovation strategy. An important role will be played by the development of techniums in the long-term plan to create a culture in Wales to enhance innovation. The RTP first phase involved the development of a strategy to improve technology and innovation for the Welsh economy and a significant aspect of the development of this strategy is the technium infrastructure.

Previous research has described techniums established in Wales<sup>[1]</sup>. These include Optic Technium, Technium centre Swansea, Bio Technium and techniums at Natgarw, Aberystwyth and Technium II at Swansea. Since technium and business incubator premises development is a fast growing area the author is aware of considerable activity. This is set against the background of the distribution of incubator premises available in the UK for new business starts which shows approximately 77% of premises located in England, 14% in Scotland, 6% in Wales, 2% in Northern Ireland and 1% in the Isle of Man<sup>[24]</sup>. More recent data for the UK<sup>[25]</sup> shows Wales with 5% of the business incubators.

The Technium at Swansea was developed from the Innovation Centre at the University of Wales Swansea

originally established in 1986. Located at the Prince of Wales Dock in 2000 it is a purpose-built two million pound facility initially let to twelve fast growing technology firms. The purpose built building houses up to 18 high growth businesses. There is specialised business support in the form of the technology transfer team of the WDA, ITC and Know-How Wales representative. Such high-level support allows businesses to access finance, technology and business support directly. Due to success of the centre the WDA, in October 2001, decided to develop five further centres to enhance high technology innovation in the Welsh economy.

One of the centres, AutoTechnium, will cater for performance engineering and motorsport located at an 18 acre study site at Llanelli for fifteen new companies and at the Pembrey Circuit in Carmarthenshire and is near to car component manufacturers employing hundreds of people. With students from the Motor Sport Engineering course at Swansea Institute for Higher Education the aim is to develop motor racing technology. The MediaTechnium at the Gelli Aur stately home, Llandeilo, will develop digital media professionals at a cost of £9.7 million. BioTechnium, for the biotechnology sector, has been set up to work from the National Botanic Gardens of Wales, Llanarthne, Carmarthenshire. Additionally, there is Digital Technium, Technium II at Swansea and OptTIC Technium located at St Asaph, Denbighshire for the North Wales Opto-electronic industry. An opto-electronic and enabling technologies resource, Optic Technium, accommodates up to 24 start-up companies. In addition to housing a technology centre for the development of new products and processes it provides a range of business start-up support activities. Further techniums are Sustainable Technologies, Aber and the Centre for Advanced Software Technology (CAST). These technium developments (Table 1) show that there has been concerted activity in Wales, in recent years, based on European, all Wales regional and local incubation initiatives.

The objective of this study is to consider the exponential growth of the Technium concept on the

Internet in relation to business incubation and support for new and existing enterprises in Wales.

## MATERIALS AND METHODS

A simple calculation of the rate of increase in the posting of items on the Internet on the Technium concept has been made. This has involved the net rate of multiplication (geometric rate of increase) over the period 2001 to 2004. An elaborate method of determining the finite rate for increase  $[\lambda]$ , which is the multiplication rate of increase which results in a stable distribution has been considered. The natural logarithm of  $\lambda$  is the innate capacity of increase  $[r]$ . This is an infinitesimal rate of increase expressed by the differential equation:

$$dN/dt = rN$$

where  $N$  is the number of postings on the Internet. If  $N_t$  and  $N_{t+1}$  are the numbers before and after a time interval the relationship between  $\lambda$  and  $r$  is:

$$N_{t+1}/N_t = e^r = \lambda, \text{ or } \lambda = \log_e \lambda \text{ (where } e = 2.7181)$$

It is accepted that the increase in the number of postings of items on the Internet reporting the development of the Technium concept cannot continue indefinitely. As the exploitation of the concept becomes complete the rate of increase will diminish until a saturation point is reached. At this point no further increase is achievable. This poses the question when will the saturation point be reached? The curve showing the increase from the initial to the saturation point delivers an S-shaped (sigmoidal) curve when the arithmetic increase in the number of items posted on the Internet is measured. These assumptions deliver the following equation:

$$dN/dt = rN [K-N]/K$$

where,  $dN/dt$  is the rate of increase of the posting of items on the Internet on the Technium concept,  $N$  is the number

Table 1: Technium network in wales

Technium site	Location	Technology	Cost to develop (£M)	Start date	No. of NTBFs
Technium	Swansea	General	52	2000	12/18
Auto Technium	Pembrey	Motorsport	-	2002	15
Media Technium	Llandeilo	Digital media	9.7	2002	-
Bio Technium	Llanarthne	Biotechnology	43.6	2000	12
Digital Technium	Swansea	Digital technologies	-	2003	13
Technium II	Swansea	General	-	2001	-
Optic Technium	St. Asaph	Opto-electronics	15	2003	24
Sustainable technologies	Baglan	Sustainable technology	9	2005	25
Aber	Aberystwyth	Bio science, software, Film and media	1.7	2004	10
CAST	Bangor	Software Technology	-	-	-

of items present and K is the number that can be achieved at saturation. An equivalent of this equation in relation to the growth curve is:

$$N = K / (1 + e^{-at})$$

Where, a and b are constants related to steepness and height of curve and t is time on the x axis.

The above equations are the theoretical formulation of the growth of the posting of items on the Internet. Since in practice there is limited data due to the short period under consideration in order to answer the question when the saturation level will be reached for the postings a doubling time approximation has been formulated for a saturation time to be extrapolated. These formulations provide an understanding of the dynamics of the exponential growth of the use of the Internet for reporting the development of the Technium concept and answer the question as to when saturation will be reached.

The study considered published materials, initiatives and project papers highlighting techniums in Wales reported on the Internet. This was carried out as follows:

- Internet literature searches involving publications and journal articles regarding technium developments.
- General Internet searches to identify and quantify practices and perspectives in Wales.
- Enquiries with appropriate agencies such as universities and the Welsh Development Agency.

The survey method had the following salient features since it was:

- Appropriate for collecting specific technium data and information.
- Feasible given deadlines.
- Able to provide broad generalisations and inferences from a small sample and enabled greater possibility for replication.

The study also analysed data on techniums and this was considered according to developments in Wales.

## RESULTS AND DISCUSSION

Internet searches were carried out in June and October 2004 and these provided 141 and 313 results for the posting of items on the Technium concept, respectively. This showed an increase of 172 sites providing postings which is a 122% increase. An analysis of the year of posting from the results in October 2004 (Table 2).

Table 2: Internet Search on Techniums (October 2004)

Year of posting	Percentage (%)
2001	4
2002	16
2003	38
2004	42

Table 3: Subject Areas of the postings for items concerning the Technium concept on the Internet

Subject areas specified	Postings (%)
Technium concept	32
Objective 1 funding	12
Regional plans	12
WDA plans	12
Business	8
Economic development	8
Commons debates	8
Manufacturing	8

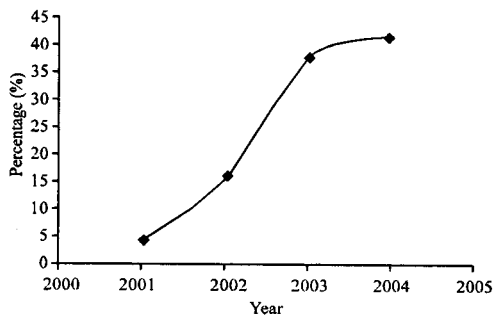


Fig. 1: The exponential growth of the posting of items concerning the technium concept on the Internet

By plotting the result shown in Table 2 for the years 2001 to 2004 this shows an exponential increase (Fig. 1).

Further analysis has been undertaken of the postings including the subject areas specified relating to the Technium concept, the organisations posting items and the location of organisations. The subject areas of the

The largest number of postings was for items concerning the Technium concept itself (32%). Considerably behind this were postings covering the Technium concept and Objective 1 funding, regional plans and WDA plans (12%). The lowest number of postings for the concept was for the subject areas of business, economic development, Commons debates and manufacturing (8%)(Table 3).

The organisation making the largest number of postings was the National Assembly for Wales (21%) and the least was the Welsh European Funding Office (WEFO) (5%)(Table 4).

As expected the largest percentage of postings for the location of organisations was Wales (81%) and then England some way behind (10%)(Table 5).

The approximate doubling time of postings in the sample can be derived from the total growth described as

Table 4: Organisations making postings concerning the Technium concept on the Internet

Organisation	Percentage (%)
National Assembly for Wales	21
BBC News Wales	9
Carmarthenshire County Council	9
ELWa	9
House of Commons	9
Welsh Labour	8
Corporate Wales	6
Cyfenter	6
Deeside College	6
IT Wales	6
Potentia	6
WEFO	5

Table 5: Locations of Organisations making postings concerning the Technium concept on the Internet

Location	Percentage (%)
Australia	1
England	10
Spain	1
Switzerland	1
USA	1
Wales	81

$P_n - P_i$  where  $P_n$  is the number of postings in the  $n$ th year or month and  $P_i$  is the number of postings in the first year or month. The growth per year or month can be described as:

$$\frac{P_n - P_i}{N}$$

where,  $N$  is the number of years or months.

To determine the doubling time ( $D$ ) at certain time intervals on the exponential curve the following equation has been used:

$$D = \frac{N}{P_n - P_i} \times 2$$

where,  $N$  is the number of years or months.

Applying this to the findings, as expressed in the table showing the growth of postings (Table 2) and exponential growth (Fig. 1), the Doubling time ( $D$ ) for the 12 month period from the beginning of January 2001 to the end of December 2001 and from the start of January 2002 to the close of December 2002 is 4.8 months for both time periods. These findings are in agreement with the high growth rates for the Internet<sup>[26,27]</sup>. This exhibits a constant exponential increase for these two years with slower rates for the previous year 2001 and the following year 2004. The data collected for 2004 implies a slowing down in the increase and therefore a levelling off.

## CONCLUSIONS

This study describes the Technium concept as an example of an integrated support network (WDA, 2002) for small technology-based businesses. Techniums provide state-of-the-art premises for these companies which may vary from straight forward spinouts to global start-ups. Types of support include tailor-made specialist and technical support. The key to the success of the Technium at Swansea is the link with Research and Development (R and D) and training at centres of excellence at the University of Wales, Swansea and Swansea Institute of Higher Education. This is reinforced by good working relationships with sector forums and underpinned by Broadband connection. Follow-on is catered for by the provision of appropriate accommodation for enterprises that require larger premises for expansion. The Technium at Swansea is the hub for the Technium network in South West Wales. Each concerns a particular sector with links to local higher education research and sector forum. It is shown that techniums include specialist centres such as Auo-Technium at the Pembrey Race Circuit and Bio-Technium at the National Botanic Garden of Wales. Regional techniums are located at Bangor, a satellite Opto-Electronics Technium, St. Asaph, South East Wales and Aberystwyth. Additional techniums will cover aerospace and e-media, for example. Twenty techniums are planned which follows UK government policy to build a knowledge-based economy (supporting incubators to seed clusters)<sup>[27]</sup>. According to Cooke<sup>[28]</sup> problems with policy towards techniums in Wales include replication of old incubation approaches that have failed to prioritise assistance and properties leasing space that are not necessarily innovative. Although around four hundred incubator spaces will be filled developments could fall short of this if international rates are taken into account<sup>[29]</sup>.

This study has been conducted at a time of considerable development for the technium concept on the Internet. One of the salient features of the survey method was that it offered greater possibility for replication and could be used to provide a cyclical picture of technium development throughout Wales lending itself to becoming a longitudinal study. Results of the study show the importance of facilities and the main types of support services provided by the techniums. A significant outcome of the findings of the research will be to inform future developments. The analysis has addressed the factors involved in the development of techniums in Wales as reported on the Internet. This has shown that:

- Initiatives such as Know How Wales<sup>[30-31]</sup> and the Technology exploitation programme provide an infrastructure for technium activity in a knowledge based economy<sup>[32,33]</sup>.
- To enhance success and encourage networking for start-up enterprises technium environments should provide comprehensive technical, administration, accountancy, legal and marketing services.
- Technologies need to be properly protected especially where prior knowledge is concerned and assistance needs to be provided so that Intellectual Property Rights (IPR) are secure.
- Many enterprises will take 10 to 15 years to reach maturity. It is therefore necessary for techniums to provide early support in this light.

**Implications for study and policy:** Developments for techniums in Wales are influenced by initiatives like Know-How Wales, the Wales Spinout Programme and the Innovation Action Plan. Strong drivers to support the development of techniums are expressed in the introduction to this paper. The significance of techniums in Wales are considered in terms of analysis of the exponential growth of the Technium concept on the Internet and communicating the results of the research to policymakers. Indeed, policymakers in Wales involved with Technium centres should receive the findings presented in this paper. In particular, strategies need to be formulated to realise the considerable benefits of techniums as a new concept for technology driven incubation. Indeed, in these terms techniums are significant for the evolution of incubation and innovation for the future development of technology-based entrepreneurship in Wales.

**Recommendations for future development:** The recommendations for future development of the measurement of the exponential growth of the Technium concept on the Internet require researching larger data sets arising from longer time frames for postings on the Internet in order to determine whether the saturation level has been reached for these postings. This can be achieved by determining the overall doubling time approximation which will give an indication to policy makers as to whether the concept has been fully established. By noting the equation:

$$\frac{P_n - P_i}{(n-1)}$$

the doubling time approximation can be expressed as follows:

Let N be the number of months or years in excess of n required to double the number of postings in the first year or month, then the approximation is:

$$2P_i = \frac{P_n + (P_n - P_i) N}{(n - 1)}$$

$$\text{giving } N = \frac{(2P_i - P_n) (n-1)}{(P_n - P_i)}$$

Hence if D is the doubling time

$$D = n + N$$

By using the doubling time approximation it will be possible for policy makers to determine when the doubling time has slowed down and there is a levelling off in terms of the saturation of interest in the concept. This has implications not only for general awareness to the concept but also for incubation policy initiatives and programmes.

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