

# Suggestions of Nanotechnology Park and Observations on Industrial Challenges

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**Abstract:** - This study aims to clarify the establishment of the Nanotechnology Park in South Wales. The feasibility is observed through a survey, and reliability of the survey participants is justified with question structures. As the idea is a unique concept, the survey outcome is analyzed together with recent research and it is aimed to fill the gap in the field. Due to the nature of nanotechnology organizations, the challenges of the industry as well as the researchers are observed. Financial and organizational difficulties of the start-up companies are observed, including the constraints of the industry and research institutions. The outline and proposed issues to be considered are addressed for a nanotechnology park. Multi-disciplined field structure is observed and criticized with the current applications. Further research recommendations are pointed out through finalizing this study

**Key-Words:** - challenge, commercial, industry, nanotechnology park, organization, south wales.<sup>1</sup>

## I. Introduction

This study is undertaken in order to see the feasibility of a Nanotechnology Park in South Wales, and its effects on domestic and international entities. The idea of Nanotechnology Park is unique and in the literature there is a gap in this respect.

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China<sup>i</sup>, Sri Lanka<sup>ii</sup>, and India<sup>iii</sup> recently announced their efforts of establishing nanotechnology parks. All of the attempts are aiming for effectively utilizing technology for example, research institutes and national nanotechnology initiative bodies. However, in preparation of this research main difficulty was the lack of literature in commercialization of nanotechnology. Remarkably, there is lack of the basic aspects of business and behavioral sciences in practice and they are not properly implemented in nanotechnology organizations. In hence a direct location is given as South Wales it is believed that the findings will apply to any location and many fields related with not only nanotechnology but also for high technology organizations. According to the survey, the attitude of the industry members and scientists are observed. Whilst questioning the possible participation to the nanotechnology park, major pitfalls and dilemmas in the field become apparent. Such as the Intellectual property ownership is a major problem among venture capitalists and scientists. It is observed that in order to support the improvements, further research is suggested in various ways. By means of analysis, the comments and answers of the respondents were interpreted with critics approach. The aim of the constructive criticism is to highlight the lacking points and finding certain getaways or remedies for the benefit of the scientists, investors as well as policy makers.

It has to be realized that through the definition of nanotechnology by size, the challenges faced are in regular size, not in nano-size.

## II. Survey Analysis

The survey is conducted in 2 stages. According to the Plunkett Research it is estimated that there has been around 2500 active nanotechnology related

organizations including the start-ups.<sup>iv</sup> The first stage is to see how feasible the Nanotechnology Park in South Wales, second the prospects of the industry. An online questionnaire was sent to more than 2500 identified individuals and organizations worldwide,<sup>v</sup> 124 of them replied to the questionnaire. In order to legitimize the results and to confirm the reliability of the participants, the first question asked about their occupation and involvement with nanotechnology and micro technology. Due to the nature of the field, Nanotechnology and Microtechnology terms are asked together for the title of Nanotechnology Park. Meanwhile the participants' attitude for the relationship to these terms is justified as it will be clarified.

*A. Participant Statistics*

Majority of the participants were from the USA (40.3%), followed by the UK (25.8%) and Germany (7.3%), and the responses from other countries were evenly balanced, can be seen in figure 2. Organization types of the respondents can be seen in the figure 1 as the vast majority are private companies (63%) followed by academic organizations (22%). Relatively low proportion of the participants is not directly from technical or academic organizations, but they are indirectly related with the field, as they are finance, government and non-profit organizations that support the field. This figure and figure 3 which they are asked about their organization's involved to microtechnology and nanotechnology shows that target audience has been successfully reached in order to legitimize the reliability of the data provided.

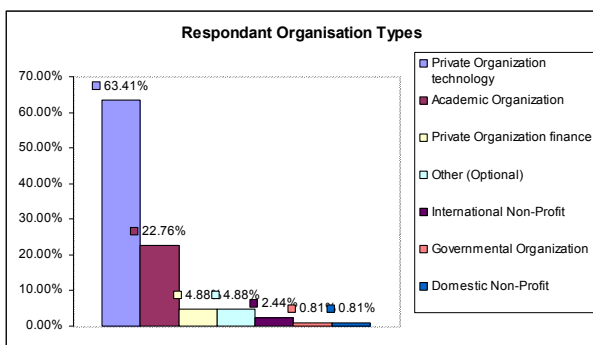


Fig 1 Participant Organizations

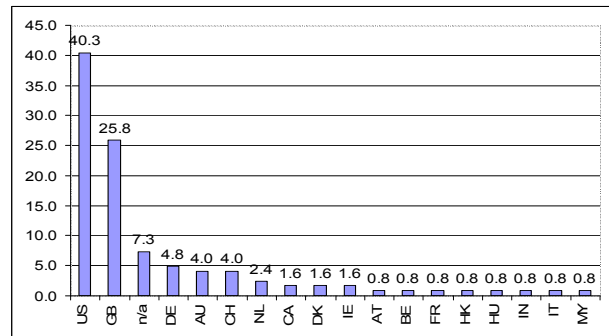


Fig 2 Participant geographical location

Also in figure 3 the involvement level of organizations to nanotechnology and microtechnology is interpreted. Almost all of the participants stated that their organization is involved with Nanotechnology and Microtechnology in certain levels.

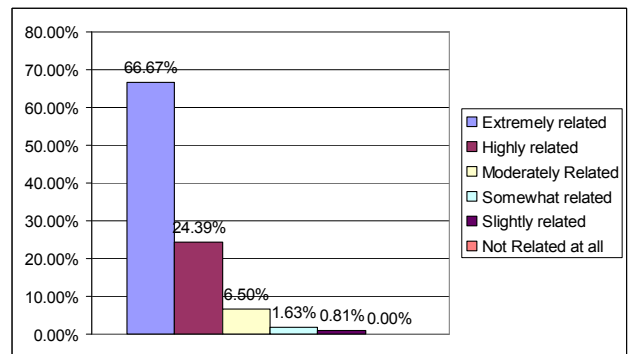


Fig 3 Involvement level of participants to nanotechnology

2.1.1 Research and Development Budgets  
In figure 4 the R&D budgets of the participants are shown. It is fairly distributed from less than 10.000 to more than £50 million and most weighted level is the interval of 100.000 and 1 million gbp with around 20%

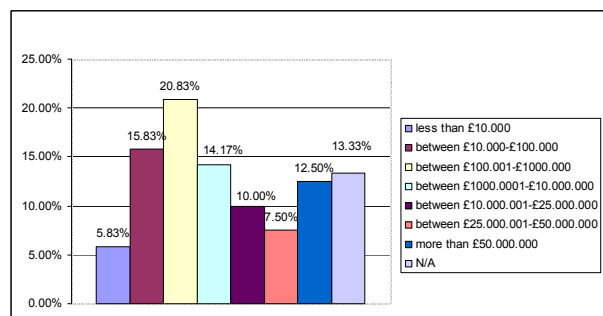


Fig 4 Research and Development Budget of the participants

*B. Participants attitudes*

Supplying funds to other companies  
 Majority of the participants (63%) do not supply funds to other companies for R&D, However 23% stated that they are supplying funds.

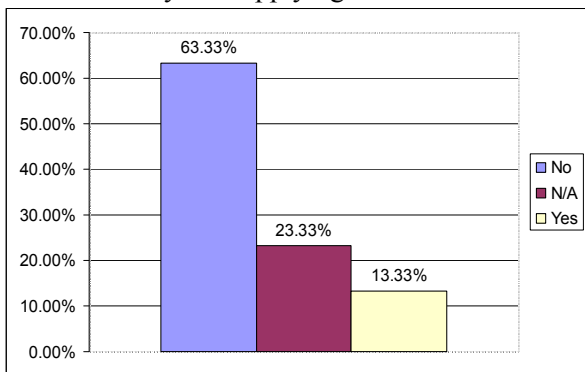


Figure 5 Participants attitude for supplying funds to other companies for R&D

*Supplying funds to nanotechnology business start-ups*

In the figure 6 it is shown that 40% of the participants stated ‘not applicable’ due to nature of their organization. However, it is interesting that approximately 13% is positive and 31% stated their response depending on the reliability of the project.

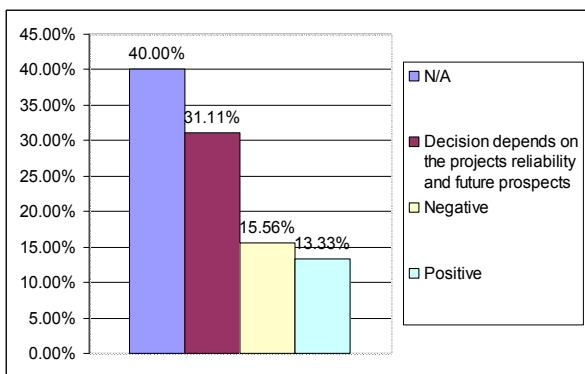


Figure 6 Attitude of participants for nanotechnology and microtechnology business start-up funding requests

*Nanotechnology Park*

At this stage the participants’ responses show their attitude for a Nanotechnology Park by means of participation and potential support for establishment. As can be seen in figure 7, vast majority of the participants have positive attitude to a business park focused of specifically microtechnology and nanotechnology

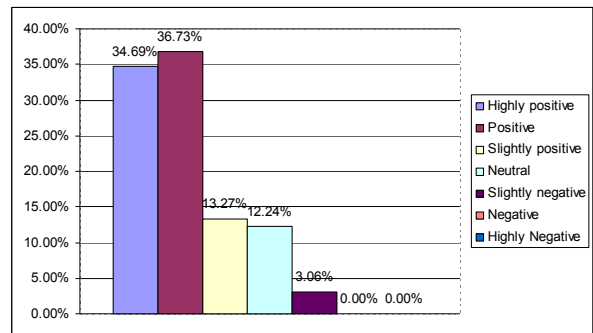


Fig 7 Attitude to a business park focused on nanotechnology and microtechnology.

When addressed a direct location of South Wales, majority remained neutral and more than 20% showed positive attitude in total. Interpreting of the approximately 55% of the neutral choice, shouldn’t be perceived as negative. It is not possible to get a direct answer which requires a strong decision making process, as well as referring to the interview with the Welsh Assembly Government, staying neutral is supposed to be focused on after further research and smooth investment approach in this scale is carried forward to realization. Also referring to the following figures that they were asked for the reasons affecting the support and participation, this high ratio of the neutral attitude will be clarified.

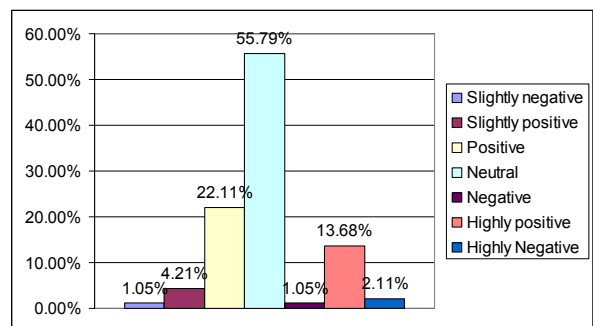


Fig 8 Attitude of Nanotechnology Park to be established in South Wales

They were also asked if they would support the establishment of a nanotechnology park that may lead to commercial start-ups, regardless to location. As can be seen in figure 9 positive response is 12% but ‘maybe’ is 32% leaving a positive potential.

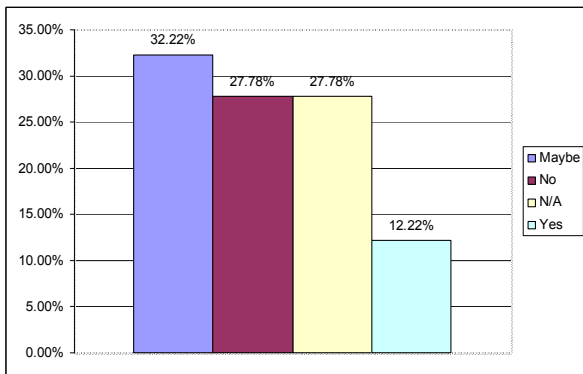


Fig 9 Potential support of participants to a nanotechnology park

And their level of participation is shown in figure 10. Majority of R&D with 42% and 14% of manufacturing level can be interpreted as the current stage of improvements in the industry.

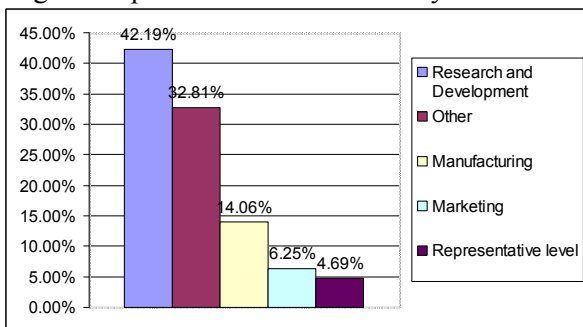


Fig 10 Level of participation of the respondents to a proposed nanotechnology park

Main reasons to participate for the respondents is stated in figure 11. Availability of project based funds and start-up funds are chosen by more than half of the respondents. Comparing to other factors, it can be interpreted as a major requirement for the whole field.

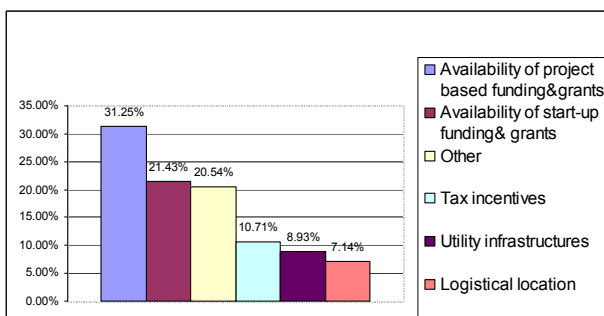


Fig 11 Main reasons for participating in a nanotechnology park.

### III. Challenges

#### A. Addressing the challenges

After analyzing the survey results with the open ended responses a proposed nanotechnology park has to involve with all aspects of organization, legal, behavioral social sciences. The reason for this statement is the following complaints of the respondents;

- ‘Scientists & Engineers do not understand business (whole product, value chain, supply chain, market segmentation, etc.) or communicate well with investors, large corporations, or business people in general’
- ‘Aggressive IP policies at Academic Institutions, which expect full ownership of developments even when funded and mainly carried out by private organization, do not encourage collaboration and consequent faster progress.
- ‘In nanotechnology there are literally hundreds of patents and many of the technologies have only been developed to proof of concept stage which makes it difficult to commercialize or find a co-development partner. Additionally, many of the technologies (from a biotech prospective) have not delivered value yet.’
- ‘Are there customers? Do they need the products?’
- ‘Incoherent or sporadic government support’

Literally there has been variety of books<sup>vi</sup> and articles in this respect. The addressed comments are interesting as for decades the cooperation of the industry and the university is being emphasized, and it seems like successful in most cases. However the critics for the scientists is questionable in respect to the nature of Nanotechnology – multidiscipline field – Mostly it is involved with engineering, information technologies, healthcare, earth and environment sciences<sup>vii</sup>. Societal issues are concerned as the lifestyle change or just pointing out the impacts of future improvements to the society.<sup>viii</sup> If we include the comment of ‘Are there customers? Do they need the products?’ considerable, it is clear that there are hundreds of nanotechnology involved products in the market. These are just minor attempts comparing to worldwide research activities. Also Intellectual Property does not have any value unless converted to a product and served to consumers. This is addressed by venture capitalists comparing to the clash of ‘dot com’ companies. The issue which has to be emphasized in this point is, Social Sciences are not involved to the multidiscipline nanotechnology organisations themselves in satisfaction level. Thinking just Business or Commercialization does not make any

sense without involvement of behavioural sciences. This is against the generic business culture as well. As it is a common fact that Organization Behaviour applies to all business and organizations as well. Further research is necessary in these aspects such as the ownership conflicts of IP, funding issues.

Human resource is another factor that is addressed by some participants. In realistic manner the nanotechnology park is expected to be established in a location with availability of all necessary infrastructure, proper logistic location and availability of the qualified human resource of scientists, technicians etc. In a wider perspective, qualified work force in nanotechnology and microtechnology is one of the problems in the whole field. It is not easy to find someone who has 5 years experience in developing carbon nanotubes as well as have knowledge in other fields due to the multi-disciplined nature of nanotechnology. Because of this many well known universities have short courses or general postgraduate degrees in nanotechnology. However it observed as current capacity of these courses are not enough to meet the industry needs and further realization on this issue in order utilize the reflection of the nanotechnology developments to the society. In this respect, the analysis of Nanoelectronics postgraduate degree of University of Athens by Triantis and Anastasiadis<sup>ix</sup> is a good attempt in understanding the industry sufficiency and the curriculum structure that focussed in nanoelectronics and microelectronics specifically. In addition they evaluated the course participant students attitude which gave higher motivation for the future developments on similar course subjects.

### *B. Commercialization*

By means of commercialization, Pharmaceutical sector has impressive results and obvious projects where the final products are to be in service of the society. With various nanotechnology involved drug-delivery applications in the literature, as an example commercialization timeline of drug delivery and cancer applications shows a proper current prospects and future projection until 2018<sup>x</sup>. This can be interpreted as a properly organized research and targeted product projection. Also, it is observed that many nanotechnology products in the market are a partial or completely result of individual research and development activities. A substitute engine lubricant (Borpower)<sup>xi</sup> is being developed and literally tested with the benefits to the consumers. It has been proven that this nano-

cyrstalline material MCDP (Boron Diamond Powder) containing lubricant improves the efficiency of the industrial applications where the carried tests shows significant fuel savings and performance improvements, comparing to other traditional lubricants in the market.<sup>xiii</sup> Considering the effectiveness of this product first think that people focus is the R&D challenge that has been carried out, as well as continuous development of the product. However after research and development, marketing stage and the success is vital as well, if the marketing was unsuccessful then no-one would be aware of this product. Even the final product has been released some issues has to be addressed for further discussion;

- What are the reasons of the low market volume of the product? In hence it is proven to be efficient and low costing. What is the consumer behaviour to this product?
- Are the marketing management patterns or generic, supply chain issues applied to any nanotechnology related product?
- If the selling price is relatively high, what are the reasons for not going to Economics of Scale by mass production?
- What are the reasons for multinational manufacturers or relatively small scale domestic companies not to choose, production with the latest technology? Is it because the cost of shifting to latest technology manufacturing systems or the choice of keeping the current demand from the market? Social and Ethical perspective is needed to answer this issue. Does it worth to keep the society away from more efficient products?
- What should be the attitude of the suppliers in bringing the innovative products to the market, in order to provide benefits to the society?
- Is there any collusion for the new products between market players and institutional bodies?

Considering the attitudes of the participants, in hence the industry thought is still in the research based mostly. Our aim is to develop a better understanding of the current stage, as well as the requirements of the researchers and industry members. By this way, it is believed that the market, field, research environment will be more robust. Currently there are hundreds of nanotechnology products in the markets directly served to consumers and the industry as raw material; with a better understanding of the constraints and identifying the solutions, it is possible to see thousands of

nanotechnology products. Even the patents owned by private organizations and research institutes prove this potential.

### *C. Structure of a Nanotechnology Park*

Building just a business park does not make any difference but, building a nanotechnology park aiming final products, sustainable support to the researchers, and industry professionals are fundamental requirements. Also according to the findings as a social organization the authority should have the attitude of serving to science and the society. As final products are encouraged it will be easier for further funding and research. In addition qualified human resource is another issue to be focussed on. If successfully established in anywhere, it will be an attractive location for foreign investments as well as domestic development

#### *A. Governance*

In addition to the survey, Welsh Assembly Government officials are also interviewed. In hence their attitude is positive they are unable to produce any specific information for the possibility of a project in this scale due to the necessity of the political decision and requirement of the investment amount. The current incentives and possible help is addressed to Welsh Development Agency<sup>xiii</sup> and UKTI<sup>xiv</sup>. Besides these organizations, there are various research institutes related in nanotechnology and microtechnology. Also some of the research programs are supported by EU FP7 program<sup>xv</sup> such as IPROMS<sup>xvi</sup> partner Cardiff University Mechanical Engineering Department. These are the supporting and encouraging elements by means of the availability of research environment and human resource for the project in Wales with subject to the political decision making.

Meanwhile the governing structure is supposed to be apart from dependant to any institute or body, with strong support from scientific organizations as well as governmental bodies. In order to prevent the collusions between industry and scientists, the governing body should be independent form the university and industry. Bercovitz and Feldman<sup>xvii</sup> addressed the issues of university and private firms' research alliances. The firms already have research and development facilities get benefit from university alliances as an outsourcer attitude.

However the difficulties of intellectual property and the certain issues such as binding by the firm's policy have negative effect on the research society. In hence support by the firms sounds attractive, if the university facilities deemed as an outsourcing facility and nothing more than that, then there is a questionable aspect of the existence of the university by means of contributing to the scientific society. Bercovitz's study fits to results of our survey in respect to the collusion among scientists and private organizations. Companies or any private organization's position against universities should be in getting a support level, they shouldn't bind research organizations by their own corporate policies.

Such as the structure of the European Union's cross-boundary research policies, nanotechnology park should not close its borders within the facility as well as country where it is located. Kuhlmann's<sup>xviii</sup> work observed the scenarios and the active research policy patterns in Europe. The three scenarios of Kuhlmann give some ideas about the policy and governance perspective of a proposed nanotechnology park. Regional development and competition issues are suggested to study further with the current trends as well as the national initiatives contribution should be investigated in respect to collaboration among research, industry and regulators. The idea is based on utilizing the research and development through commercializing in order to serve to the society. Kuhlmann's post national attitude applies to the whole governance structure in Europe but in practice if the nanotechnology park is established outside the European Union, then innovative models are supposed to developed in order to keep the ideal structure. Such as the national regulators and policy makers are suggested to work on creative justified perspective, and obtain the support of domestic and international science society in addition to the government level support.

Commercializing of the supported products or the research projects are supposed to be realised through research groups and entrepreneur students. This is suggested in order to establish a better system which serves to the society.

#### *B. Regulatory aspects, health and safety*

Observing the national nanotechnology initiatives and other domestic-international research institutes, the nature unique structure of the nanotechnology park will be beneficial to the society by the scientific

methods. Putting nanotechnology on the critical path is defined and explained by Sanhai et al<sup>xxix</sup>, they observed the applications of US Food and Drug Administration. The findings are partially stepping stone for the nanotechnology related pharmaceutical research with government legislation. And Walsh et al addressed the current regulatory programs would rapidly help technological developments by means of proper health and safety regulations to be addressed to keep the public safe against unknown dangers.<sup>xx</sup> Meanwhile they referred to the recent contamination costs caused by asbestos which cost over \$ 20 billion just for cleaning the industry as well as the liability costs projected for more than \$200 billion. The asbestos issue is addressed by some health and safety experts for the nanotechnology products as well. The properties of the nano-scale materials show impressive applications; however most of the potential harms are not known so far and still investigated. Recent studies on toxic effects of nanotubes are being stated as similar to asbestos<sup>xxi</sup>. Herzog and friends examined the human lung cells' response to carbon nanomaterial exposure, and stated the toxic effects are dependant on the vehicle used for particle dispersion.<sup>xxii</sup> Also further methods on toxicology studies are being addressed by McJilton et al for future research on toxic effects of carbon nanotubes to respiratory cells<sup>xxiii</sup>. Examples of these researches and their reliability are very important to figure out the potential harm of the nanoparticles that are very attractive in most applications. Especially, in coatings where it is easy for human interaction and easy for flying on the air that we breath. The regulations from this respect are very sensitive with the asbestos experience. Other than pharmaceutical and surface applications for the industrial materials, nanomaterials have strong potential in textile industry. Grancaric et al,<sup>xxiv</sup> stated the nanoparticles of zeolite applied to textile surfaces and gained good results in UV protection, antibacterial effect, regulating pHvalue of the skin etc. These finding are impressive by means of commercial respect, followed by many other research on textile aspects, which has huge potential market for commercial applications. The consideration in here is the direct contact of human body with nanoparticles, if the health and safety research and regulations are satisfaction enough to serve to public.

The dilemma at this point is whether making harder regulations of research and development as well as final products or making easier legislations would be dangerous? This issue has been investigated by many scientists and the legislative or regulatory

bodies should analyse the risks and the benefits in a realistic manner, where some participants of the survey addressed the unknown risks as well as complained for the tougher regulations. Wetmore and Posner discussed the involvement of corporations and other organizations to the regulations in a certain level<sup>xxv</sup>. Regulators shouldn't be affected completely by the corporations, however their expertise and scientific knowledge is addressed by to support nano-regulation. The regulators should involve more in the latest developments in research and development phase, in order to get the right attitude against any potential risks and for a more effective system with supporting regulations.

#### IV. Conclusion

Finally, this paper stated the potential of a Nanotechnology Park in South Wales as well as any other location addressing the model may apply. Also the lack of social sciences in the multidiscipline structure of Nanotechnology is addressed. The idea of Nanotechnology Park is unique and the attitude on preparing this paper stated as idealist and realist in order to help further research and developments in the field. Recent work on sector and country specific such as Valk et al<sup>xxvi</sup> addressing the conceptualization aspects for emerging technologies with firm networks and innovation policies in general. Organizational patterns observed are suggested to be evaluated for applications in different platforms and fields. In addition further research is suggested for any similar nanotechnology organization and involvement of traditional social sciences to nanotechnology organizations.

Nanotechnology is an innovative field, but the challenges are traditional.

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<sup>xi</sup> <http://www.borpoweronline.com/>

<sup>xii</sup> Tests were carried out by Southwest Research Institute San Antonio Texas April 2006; TUV Germany (Technical Inspection Agency) Hannover, Germany; Material analysis laboratory Shell, Turkey, Izmit. <http://www.nnt-nanotechnology.com/certificates-tests/>

<sup>xiii</sup> Welsh Development Agency promotes investments in Wales as a part of Department of Economy and Transport <http://wales.gov.uk/topics/businessandconomy/?lang=en>

<sup>xiv</sup> UK Trade and Investment is a governmental organization to promote and support investments in the United Kingdom

<https://www.uktradeinvest.gov.uk/>

<sup>xv</sup> More information can be found in [http://ec.europa.eu/research/fp7/index\\_en.cfm](http://ec.europa.eu/research/fp7/index_en.cfm)

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