

## Abstract

Access to technologies by small firms, it has been suggested, can best be achieved by encouraging the formation of networks of innovators. Such collaborative arrangements have become essential to improving the competitive position of many companies, predominantly through the accomplishment of mutually beneficial goals involving the acquisition of state-of-the-art technology. Such inter-firm collaboration networks serve to externalise the innovation function through the transfer of technology between firms. There exists considerable evidence that during the last fifteen years, industrial innovation has become significantly more of a networking process, with the number of strategic alliances increasing considerably. In particular, there is increasing evidence of network relationships between innovative Small and Medium-sized Enterprises (SMEs), especially in the transfer of technologies. This is not surprising, as the small firm sector is making an important contribution to technological innovations in technologically sensitive industries.

Whilst research has examined the transfer of technology from small to large organisations, there has been comparatively little study of the technology transfer process into the small innovative firm. This is surprising, as with the continuing proliferation of information, knowledge, and scientific and technological specialities, it is likely that innovative small firms will become increasingly dependent on external sources during the innovation process. Accordingly, this paper considers technology transfer networks, within Industrial South Wales, involving external sources of inputs in the development of successful technological innovation within small firms. In particular the impact of networks of firms and organisations linked together in patterns of co-operation and affiliation is considered. To facilitate this, the paper draws on a number of research methods including analysis of secondary sources, policy interviews, a study of support services and a case study. Secondary sources include existing literature in the area, which consist of both published material and 'grey' literature (including reports from the European Commission, universities and consultants). In addition a series of interviews with key policy-makers at regional level, a study of technology transfer network support services and a case study of an innovation network partnership are reported.

From the study of technology transfer support services it is found that there are 221 known support services referenced for innovation and technology support in Wales with 205 located within Wales and 16 in England. Of the 205 located in Wales there are 33 networks with 4 specific to small firms and SMEs and 29 non-specific. For Industrial South Wales there are 159 support services located within the region involving 24 networks with 2 specific to small firms and SMEs and 22 non-specific.

For regional innovation and technology support services to benefit the small firm and the technology transfer process there is a need to build network relationships and to overcome the reluctance of small firms to interact. The

managerial conclusions of the paper recommend that technology transfer strategies in Industrial South Wales relevant to small firm networks be developed by policy makers creating a positive 'climate' involving support and advisory mechanisms, making small firms aware of technology transfer services, and providing better mechanisms to forge network relationships.

## Introduction

At the start of the new Millennium many European regions are attempting to support the transfer of technology to Small and Medium-sized Enterprises (SMEs) in an organised way, through regional networks involving higher education institutions, chambers of commerce and industry. By doing this SMEs are able to communicate in various networks to develop market strength.

The objectives of this paper are threefold: first, to consider technology transfer networks, within Industrial South Wales (ISW), involving external sources of inputs in the development of successful innovation within small firms; second, to report on analysis of secondary sources, policy interviews, a study of support services and a case study; and third, to recommend that technology transfer strategies in ISW relevant to small firm networks be developed by policy makers creating a positive 'climate' involving support and advisory mechanisms, making small firms aware of technology transfer services, and providing better mechanisms to forge network relationships.

At regional level there is a growing recognition of the importance of small firms to growth and employment and the need to effectively transfer technology to SMEs. In order to achieve this, a regional network requires resources, pervasiveness and cohesion<sup>1</sup> to provide a high level of accessibility to support. Cluster formation creates an exchange network of technological information supported by transfer agencies that assist the learning process. The "innovative regional cluster" in ISW, according to Cooke<sup>2</sup>, consists of large and small firms, comprising an industrial sector where network relationships exist involving Research Organisations (ROs), Higher Education Institutions (HEIs), R&D laboratories, Technology Transfer Agencies (TTAs), Chambers of Commerce (CCs), Business Associations (BAs), Training Agencies (TAs), Government Agencies (GAs) and Government Departments (GDs). ISW is seen as a re-conversion economy, one that is *"learning to network and aiming to build clusters from the ashes of old"*<sup>3</sup>.

The Business Connect network has brought together local enterprises and business support agencies to provide advisory and consultancy services to businesses in ISW. Within the consortia the network of Innovation and Technology Counsellors (ITCs) provides relevant advice and support. Welsh institutions are also linked through a network of Industrial Liaison Officers (ILOs). Networks such as the Cardiff University Innovation Network and fora such as the Wales Medical Technology Forum have been established.

In ISW, innovation networks provide SMEs with opportunities for networking and universities are proactive in these networks through their ILOs. Following the "Know-How Centre" Proposals<sup>4,5</sup> SMEs seeking assistance will be referred, as appropriate, to the "Know-How Wales" Co-ordinator, who, whether through the ITCs/ILOs or other means, will be responsible for identifying necessary "know-how" support and will be dedicated to helping SMEs gain access to HE/FE sectors for technology/knowledge transfer. Help, guidance, know-how and collaboration for SMEs to access institutions' knowledge bases will be provided. In these terms the transfer of technology involves a wider embrace of relevant issues including knowledge transfer from the research side. Key aspects are financial institutions (funding), the scientific and technological base (inputs) and regional government (policy)<sup>6,7</sup>. The regional problems of a lack of finance for small firms have been highlighted by venture capitalists<sup>8</sup>.

## **The Literature on Technology Transfer Networks**

The importance of technology transfer networks is being given increasing attention in the literature on SMEs<sup>9,10</sup>. Studies have taken place at both the national<sup>11</sup> and the regional level<sup>12,13</sup>. Other dimensions studied have included the origins and dynamics of production networks<sup>14</sup>, the role of New Technology Based Firms (NTBFs) in innovation networks<sup>15</sup>, the formation of networks across R&D organisations<sup>16</sup>, formal and informal networks in industry<sup>17</sup>, predatory networking and small firms in the development of the British biotechnology industry<sup>18</sup>, and external networking and innovation in small and medium-sized manufacturing firms in Europe<sup>19</sup>. In the Fifth Framework Programme<sup>20</sup> European networks in support of innovation and research are intended particularly for SMEs and direct assistance will supplement the assistance provided by local networks.

It has been increasingly suggested that access to technology by SMEs can best be achieved by encouraging the formation of networks of innovators<sup>21</sup>. Such collaborative arrangements have become essential to improving the competitive position of many research-intensive companies, predominantly through the accomplishment of mutually beneficial goals such as the funding of new research and development and the acquisition of state-of-the-art technology<sup>22,23</sup>. Such inter-firm collaboration networks serve to externalise the innovation function through the transfer of technology between firms<sup>24</sup>.

Indeed, there exists considerable evidence that during the last fifteen years, industrial innovation has become significantly more of a networking process, with the number of strategic alliances and collaborative R&D consortia increasing considerably<sup>25</sup>. In particular, there is increasing evidence of network relationships between innovative SMEs and larger firms, especially in the transfer of technologies<sup>26</sup>. This is not surprising, as the small firm sector is contributing a disproportionately high number of technological innovations<sup>27</sup> and many larger companies are beginning to develop partnerships with small, specialist firms in order to maintain and sustain efficient performance in technologically-intensive industries. However, whilst research has examined the transfer of technology from small to large organisations, there has been

little study of the technology transfer process into the small innovative firm. This is surprising, as with the continuing proliferation of information, knowledge, and scientific and technological specialities.

It has been found that external networking is a demanding and time-consuming activity with opportunity costs for SMEs with limited resources<sup>28</sup>. There is therefore a need to enable SMEs to overcome innovation-related disadvantages associated with external networking. Since networking has become a key feature of industrial technological change this increases SME's innovatory capabilities. Both the negative as well as the positive aspects with networks need to be noted since, for example, the use of IT systems carries dangers for SMEs as well as opportunities, especially where industry-wide operating standards lock SMEs into large company networks.

With networking technology equates with knowledge. In university-industry links systems there are a multiplicity of technology transfer mechanisms, which appear to be well integrated<sup>29</sup>. Chambers of commerce complement the higher education system by delivering innovative support to SMEs. An example of this is the case of Cardiff Chamber of Commerce, who in partnership with the Welsh Enterprise Institute, are undertaking a "Learning Chamber" survey to find out what additional support services are required by local firms in ISW<sup>30</sup>. Chambers of commerce can support technology transfer by acting as the prime entry point into the local technology transfer support network, offering basic consultancy, and using knowledge of the network to redirect firms as necessary to the appropriate technology transfer agent, such as a higher education institution or independent research centres<sup>31</sup>. Personal contacts are a non-trivial source of the exchange of information on problems of common interest within an informal network<sup>32</sup>. Co-operation is a problem that is particularly acute for SMEs, which tend not to be well integrated into the academic/government/large company network.

With a network of co-operation partners they operate together to form a "focal point" of business innovation<sup>33</sup>. The hub of the process needs to be well organised and to have a network of co-operation partners including business innovation centres, technology transfer companies, science parks, and venture capital companies. They are responsible for developing the technology from the business idea to the establishment of a new SME.

Forming networks of relationships between organisations with complementary skills can be a way in which SMEs can maximise their innovative output from limited R&D resources. However, 'networking' is not a remedy to the human, technical and financial resource problems of SMEs. The deficiency of innovative capacity in SMEs is unlikely to be overcome by simply substituting indigenous R&D activity by externally developed technology and know-how; in-house R&D not only generates new information but also develops a firm's capacity to identify, assimilate, and exploit external technology and know-how<sup>34</sup>. Indeed, Freeman<sup>35</sup> argues that 'the successful exploitation of imported technology is strongly related to the capacity to adapt and improve this technology through indigenous R&D'. It would appear then, that the innovative capacity of SMEs is best served by a balance between developing the technical and network assets of the enterprise, rather than on a reliance on

one or the other. Freeman<sup>36</sup> also argues that *'although rarely measured systematically ... informal networks are extremely important, but very hard to classify and measure'*.

## Studies of SMEs and Technology Transfer Networks in ISW

A study undertaken at the Welsh Enterprise Institute considered the views of eight key policy makers concerning SMEs and technology transfer networks in ISW<sup>37,38</sup>, and forms part of stage one of a study examining the transfer of technology within the small firm sector in Wales<sup>39</sup>, especially the importance of external sources of inputs in the development of successful technological innovation<sup>40</sup>. Table 1 shows the views of key policy makers regarding the main external sources for SMEs and technology transfer networks in ISW.

*Table 1: The Views of Key Policy Makers regarding the main External Sources for SMEs and Technology Transfer Networks in ISW*

Importance	Important	More Important	Most Important
Rating	1	2	3
External Sources	Technology Transfer Agencies  Teaching Company Scheme (TCS)  Regional Technology Plan (RTP)  Other SMEs  Exhibits  Europe  College Business Partnerships  Banks	Welsh Development Agency (WDA)  Public Sector Programmes/ Local Authorities  Large Firm Laboratories  Journals/Public Information Sources  Business Connect	Suppliers  Firms/Industries/ Competitors  Customers  Academic Institutions

The study showed that through an internal culture of innovation an SME will be more receptive to taking advantage of external sources. The question that needs to be answered is how to develop the internal culture of innovation. An example of how to do this is the Welsh Medical Technology Forum<sup>41</sup>, which holds seminars with themes relating to the Medical Technology sector to influence firms' innovative thinking. The study also found that the way the present Small Firms Merit Award for Research and Technology (SMART)<sup>42</sup> is operating appears successful. SMART enables small firms to buy new technology and encourages firms to work in groups and networks.

Tables 2-5 show technology transfer networks in Industrial South Wales and Wales which are being researched at the Welsh Enterprise Institute as part of a study of "SME Innovation and Technology Support Services in Wales"<sup>43</sup>. There were 221 known support services referenced for Innovation and Technology in Wales<sup>44</sup> with 205 located in Wales and 16 in England. Of the 205 located in Wales there are 33 networks with 4 specific to small firms and SMEs and 29 non-specific. For Industrial South Wales there are 159 support

services located within the region involving 24 networks with 2 specific to small firms and SMEs and 22 non-specific.

*Table 2: Technology Transfer Networks in ISW and Wales*

	<b>Specific to SMEs</b>	<b>Non Specific</b>	<b>Total</b>
ISW	2	22	24
Wales outside ISW	2	7	9
Total for Wales	4	29	33

Table 2 shows technology transfer networks in ISW and Wales and Table 3 shows networks in Industrial South Wales. The networks outside ISW are shown in Table 4 and Table 5 gives the location of networks in Wales.

*Table 3: Networks in Industrial South Wales*

<b>Network</b>	<b>Type</b>	<b>Location</b>	<b>SME specific</b>
Automotive Forum	Forum	Cardiff	
Automotive Thematic Group	Group	Cardiff	
Biotechnology Thematic Group	Group	Cardiff	
Business Connect	Network	Local	
Business Co-operation Network – BC-NET	Network	Cardiff	
Cardiff University Innovation Network	Network	Cardiff	
Clean Technology Group	Group	Cardiff	SMEs
Electronics Forum	Forum	Cardiff	
Industrial Liaison Officers	Network	Local	
Local Investment Company (LINC)	Network	Cardiff	
Materials Technology Forum in Wales	Forum	Cardiff	
Materials Thematic Group	Group	Cardiff	
Mechatronic Systems Forum in Wales	Forum	Cardiff	
Medical Technology Thematic Group	Group	Cardiff	
MIDAS-NET	Network	Cardiff	
Printing and Coating Forum in Wales	Forum	Swansea	
Product Innovation Network (PIN)	Network	Local	SMEs
South Wales Innovation in Material Management (SWIMM)	Network	Pontypridd	
South West Wales Association of Purchasing and Supply (SWAPPS)	Forum	Swansea	
Strategic Approaches to Global Economy (SAGE)	Network	Cardiff	
Welsh Medical Technology Forum	Forum	Swansea	
Welsh Overseas Trade Services	Network	Cardiff	
Welsh Pest Management Forum	Forum	Cardiff	
Xenos – Wales Business Angels Network	Network	Cardiff	

*Table 4: Networks outside ISW in Wales*

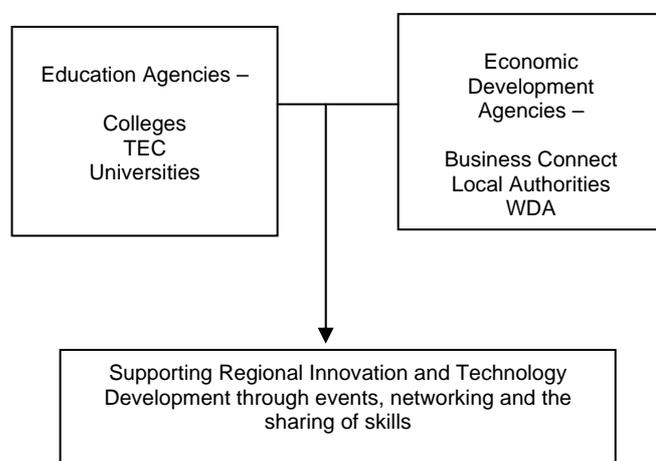
<b>Network</b>	<b>Type</b>	<b>Location</b>	<b>SME specific</b>
Aries (The Welsh Re-usable Energy Network)	Network	Machynlleth	
Carmarthenshire Information Network – CAIN	Network	Carmarthen	SMEs
CELTIC Associate Groups	Group	St Asaph	
Cwmnia – Creating Business Networks	Network	Cross Hands	
Dyfed Electronic Trading Network – Deltran	Network	Carmarthen	SMEs
Mid Wales Manufacturing Group	Group	Newtown	
Model Based Systems Network – MONET	Network	Aberystwyth	
Vice Chancellors Business Network	Network	Bangor	
Welsh Opto-Electronics Forum	Forum	St Asaph	

*Table 5: Location of Networks in Wales*

<b>Location</b>	<b>Forum</b>	<b>Group</b>	<b>Network</b>	<b>Total</b>
Cardiff	5	5	7	17
Local	0	0	3	3
Pontypridd	0	0	1	1
Swansea	3	0	0	3
<b>Total ISW</b>	<b>8</b>	<b>5</b>	<b>11</b>	<b>24</b>
Aberystwyth	0	0	1	1
Bangor	0	0	1	1
Carmarthen	0	0	2	2
Cross Hands	0	0	1	1
Machynlleth	0	0	1	1
Newtown	0	1	0	1
St Asaph	1	1	0	2
<b>Total outside ISW</b>	<b>1</b>	<b>2</b>	<b>6</b>	<b>9</b>
<b>Total Wales</b>	<b>9</b>	<b>7</b>	<b>17</b>	<b>33</b>

A case study has been carried out into the Valleys Innovation Partnership (VIP) network<sup>45</sup> (one of the 221 known support services referenced in Wales) and is shown in Figure 1.

*Figure 1: The Valleys Innovation Partnership Network*



VIP is located at the Valleys Innovation Centre, Navigation Park, Abercynon in South Wales. It connects a number of education and economic development agencies including Business Connect, colleges, local authorities, TEC, universities and the WDA. Its remit is to support innovation and technology development in the Rhondda Cynon Taff (RCT) "Valleys" region.

The main objective of VIP is to foster a business culture through partnership and the use of new technologies and innovation. The priorities involve addressing company-identified needs including technology transfer, research, training and management. By holding events, networking and the sharing of skills across companies, especially SMEs, and support organisations, VIP provides a forum to influence and respond to the requirements of SMEs. It offers innovation and project development advice and access to local resources and information.

Two further projects undertaken by the Welsh Enterprise Institute are the Wales Fast Fifty Network and the ISW Higher Education Spinout Enterprises Network. The Wales Fast Fifty project has established a network of 'Fast Growth Firms in Wales'<sup>46</sup>. This will create a specific regional cluster of the most entrepreneurial and innovative firms in Wales to share experiences and develop new collaborative trade and business links with each other across several sectors, localities and areas of management need. The cohort of firms will also serve as 'role-models' for other 'growth potential' small firms in Wales. The Higher Education Spinout Enterprises project is being carried out by the Welsh Enterprise Institute for the WDA and is assessing the challenges and requirements of spinouts in ISW. Following completion of the preliminary work in section one of the project twenty identified spinouts will be recruited to a cluster of willing participants involving older, newer, low and high technology businesses in section two. Based upon the experience of the Centre for

Entrepreneurship at Linköping University, in developing a network of new technology-based firms, it is intended to hold four network meetings with the twenty spin-off companies identified earlier (in September 2000 and January, May and September 2001). The initial twenty firms will form the base for a network of academic spin-offs in ISW.

## **Technology Transfer Networks, "Best Practice" and the Implications for Policy**

Support through technology transfer networks includes specific support provided to individual SMEs (assistance during the establishment of network relationships) and technology transfer support to SMEs in general through drivers such as the Wales Regional Technology Plan (RTP)<sup>47,48</sup> (to foster technological knowledge and establish network links with external sources such as Further Education (FE) colleges and universities for the dissemination of know-how into SMEs).

Coupled to these forms of policy action the three main types of external sources involved in the diffusion of technology to SMEs are public and non-profit organisations (regional/national development organisations (R/NDOs) such as the Welsh Development Agency), regional technology advice centres (such as Business Connect), and Regional and Technology Organisations (RTOs) (contract research firms, technology centres, and science parks such as the Imperial Science Park at Newport).

Amongst the three types, public bodies undertake policy programmes, regional technology advice centres concentrate on providing focused assistance, and technology centres provide technology knowledge and know-how. For SMEs involved in networks key mechanisms include information transfer, technology transfer, skills transfer and specialist support. Policy makers will need to be careful that changes in priorities will not make an SME withdraw from technology transfer activities and that policy reacts to difficult situations by providing SMEs with incentives.

Technology transfer networks are one of the best forums for small firms to learn from each other, to exchange experiences, and to diffuse technology. Networks are usually segmented by geographical region, industry sector or by technology and they can work with a mixed sector-technology focus. The danger with specialisation is that it carries the disadvantage that eventually the potential market will be exhausted. It is possible to overcome this by anticipating and looking for opportunities in complementary technology areas.

"Best practice" procedures for the diffusion of technology<sup>49</sup> within networks include minimum standards for small firms, external funding apportionment, expected performance, and confidentiality. Procedures will usually become less formal over time due to ideal size attainment and growth realisation. Good practice for the successful operation of a network is the realisation by small firms that it is not only an alliance of enterprises but also a partnership of entrepreneurs. (Entrepreneurs will act as technological gatekeepers and

will have an important role to play in the operation of networks<sup>50</sup>.) This needs to be reflected in network communications and good relationships between small firms will form the basis of good practice for the operation of the network.

Success in the diffusion of technology within networks is often the result of small firms following "best practice" and this usually involves performance management. This is not easy to attain since the process of technology transfer can be long and without success, the results of the network are difficult to define and there may be discrepancies between the small firms. "Low" activity may arise due to conflicts in a network. When these are efficiently managed and resolved they provide opportunities for the small firms to broaden their experience and widen their understanding of other small firms' views. When they are not conflict may lead to "low" activity. Conflict management and identification will form part of the "best practice" of successful technology diffusion. Typical examples of "low" activity are misunderstanding between small firms, different objectives and motives and under-performance of a small firm.

## Conclusions

Studies describing SMEs and technology transfer networks have considered the importance of external sources, the different mechanisms of transfer and the nature of relationships in the innovation process, which exhibit many similarities but also differences. Although the similarities can be reinforced the differences need to be investigated. These "gaps" in knowledge arise from contradictory findings between, and within studies, theory and practice, and cultural boundaries arising from inter and intra regional, national and continental dissimilarities. It is possible to attempt to address this by relating the body of knowledge encompassed within technological innovation theory to an understanding of the many processes, mechanisms and relationships characterised by the dichotomy of near and supra-national technology transfer networks. Near technology transfer networks operate at regional level and involve industrial clusters with overarching technology transfer policies guided by local and regional government bodies. ISW is characterised by the automobile and electronics industrial clusters with the various technology transfer networks involved.

Technology transfer strategies in ISW relevant to small firm networks should be developed by policy makers creating a positive 'climate' involving support and advisory mechanisms, making small firms aware of technology transfer services and providing better mechanisms to forge network relationships. This can be achieved through the three principal technology transfer strategies in ISW relevant to SMEs which are the Regional Technology Plan (RTP), the "Know How" Initiative and technology transfer support services.

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