Exploiting the business opportunities in biotech connections: The power of social networks

Ian P. McCarthy, Leyland Pitt, Colin Campbell, Rian van der Merwe and Esmail Salehi-Sangeri

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Ian P. McCarthy
worked for several years as a manufacturing engineer before earning his PhD in operations strategy from the University of Sheffield in Britain. His current research focusses on the design and operational performance of organisations; in particular, he is interested in operational complexity, mass customisation and new product development. He is also a specialist in classification, using methods from evolutionary theory to classify and represent different operational and technology strategies as an evolutionary tree.

Leyland Pitt
received his PhD from the University of Pretoria and is currently a Professor in the Segal Graduate School of Business at Simon Fraser University. His research focusses on the marketing–technology interface, and the interaction between marketing and information systems. He has been published in *The Journal of the Academy of Marketing Science* and *MIS Quarterly*.

Colin Campbell
is currently pursuing his PhD in marketing at Simon Fraser University. He is interested in electronic commerce, branding and new product development.

Rian van der Merwe
is a senior research analyst with eBay, based in San Jose, California. An engineer by training, he holds a PhD in marketing, and specialises in customer experience research. He has published a number of papers in marketing and management journals, including *Technovation*, *Industrial Marketing Management*, *European Management Journal* and *Corporate Reputation Review*.

Esmail Salehi-Sangeri
is currently a professor at Lulea University of Technology in Sweden. He has been published in journals such as *Industrial Marketing Management*, *Technovation* and the *European Journal of Marketing*.

Abstract

Networks have a well-established importance in business. Here network analysis, grounded in social network theory, is used to analyse two international biotech business-to-business environments. Of additional value, the methodology employed is described for the benefit of academics and practitioners alike. Swedish and Australian biotech firms are analysed through the examination of internet networks. Once gathered and analysed following the described methodology, several features of the networks can be determined. Most critically, identification of important actors and structural holes within networks allows valuable entrepreneurial opportunities to be unearthed. Biotech firms and suppliers, particularly those with a global reach, are best positioned to take advantage of such information.

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Correspondence: Colin Campbell, Segal Graduate School of Business, Simon Fraser University, 515 West Hastings Street, Vancouver BC, Canada V6B 5K3
Tel: +1 604 721 4652
Fax: +1 604 291 5122
E-mail: clcampbe@sfu.ca

WORTH IN THE NETWORK: THE VALUE OF SOCIAL TIES

The study of social networks has its origins in social psychology and sociology. The 'small world phenomenon' is the hypothesis that everyone in the world can be reached

through a short chain of social acquaintances, and was originally tested in the 1960s by social psychologist Stanley Milgram.[1,2] The sociologist Mark Granovetter[3] established that weak ties (ie indirect links between actors) enable the reaching of populations and audiences that are not accessible via strong ties (more direct links), and the concepts of this work were later published in the related monograph 'Getting A Job',[4] in which the author made what is today an obvious point: 'It is not what you know but who you know'. Social networks have since become important mechanisms to study for academics and practitioners in management disciplines such as marketing, strategy and entrepreneurship. Organisations are concerned with the social networks of which they, their suppliers and their customers become part, for they may determine how swiftly ideas and communication disperse. Those who study strategy see the potential in strategic alliances, and in knowing where influence is situated in a complex collection of entities. Entrepreneurs often realise that innovations come not only from the development of new products or markets, but from the assembly of diverse units (or 'objects')[5] into a new entrepreneurial form.

The internet has enabled a range of intra-organisational relations, from more formal strategic alliances to casual assemblies of organisations that are somehow connected. The value of these latter groupings might not be known – indeed, their members might not even be aware of their existence. They may merely be comprised of simple networks of links on the internet. Because of the social capital embedded within them, these unacknowledged connections and codes of conduct can, however, possess high value.

It has long been recognised that networks are critical to smaller firms in their toils to survive and compete with larger counterparts.[6–8] As markets become increasingly global, smaller firms find themselves struggling not only against local market incumbents, but also against large and small rivals around the world. While this is obviously true for firms competing in consumer markets, for those firms competing in high-technology markets, where other organisations are customers, the much-hyped hyper-competition has become a reality. Whether they want to be or not, indeed, whether they are aware of it or not, these firms will find themselves to be part of local and global networks. The strategic choices in this regard then are surprisingly simple: How to understand these networks in order to get them to work for you (or at least not against you), or ignore them at your peril. There is a dearth of empirical research on alliance networks that span national boundaries, and the advent of the internet provides a unique opportunity to study these interrelationships for the internet is indeed the largest social network of all. Moreover, the internet is becoming the most important vehicle for global commerce, particularly in business-to-business and high-technology markets. The current lack of research into international high-tech networks limits our understanding of how the links between global players really operate. This in turn has a negative effect on theory development and the advancement of management practice in the field of international commerce.

Here we investigate Swedish and Australian networks within which small-to-medium size (SMEs) biotechnology firms operate. Such examination allows for differences between the two countries and their resultant markets to emerge and be studied. Additionally, comparisons potentially reveal insights useful to member firms' effectiveness, social capital and financial returns.

Social network theory (SNT) forms the backbone of the present study by explaining the process through which actors come to both acquire and build power in social situations, and is thus related to the notion of social capital.[9,10] Social capital endows actors with opportunities to utilise social relationships for benefit in settings as diverse as business and romance. It can thus be thought of as an asset to those that possess enough of the resource.[11] Theoretically, SNT explains the value of social capital through the existence of structural holes in networks. These holes are 'entrepreneurial opportunities for information access, timing, and control'.[12]

Fundamental to this paper is explication of the technique used to pinpoint principal

actors in a network as well as to unearth the existence of somewhat unknown internet-based networks linking biotech SMEs in Australia and Sweden. To highlight the strategic value of association, notable features of key actors are pointed out in a method useful to managers. This includes identification of entrepreneurial opportunities within the network arising from structural holes. The paper is set out as follows: To begin, SNT and its accompanying concepts of social capital and structural holes are briefly reviewed. This is followed first by a description of the methodology employed in analysing biotech SMEs in Australia and Sweden, and then the actual analysis. Results are then described in terms relevant to the firms studied. Limitations of the study are touched upon before concluding with managerial implications and future research directions.

SNT: FUNDAMENTAL CONCEPTS AND PRINCIPLES

As SNT is not reductionist, the theory is not only rare among those in the social sciences, but also able to be applied at different levels of analysis to systems. In SNT, a *network* is defined by a description of relations (variously called, ties, links, mapping, etc) between a set of objects (variously called actors, individuals, nodes, etc). Anything ranging from individuals within a neighbourhood to divisions within a large multinational company can be considered *objects*.[10] *Objects* are linked by *ties*, which can be one of two forms. A directional tie indicates that one person feels a close relationship with another and need not be reciprocal. A second type of tie is non-directional and simply indicates proximity – such as working in the same company – but not necessarily any form of relationship.

As Wasserman and Faust[10] put it, the *network concept*, 'emphasizes the fact that each individual has ties to other individuals, each of whom in turn is tied to a few, some, or many others, and so on'. Decisions, according to SNT, are made with deliberate thought given to the network and the relationship an object has with others in it. By looking at social networks in such a manner, SNT permits for them to be modelled and allows for both theoretical and mathematical testing of the existence and influence of social relationships. A generic sociogram represents the hypothetical relationships among a group of actors, who are indicated by dots and linked by either a solid line, indicating a strong relationship, or a dashed line, indicating a weak relationship. This is illustrated in the simple diagram shown in Figure 1.

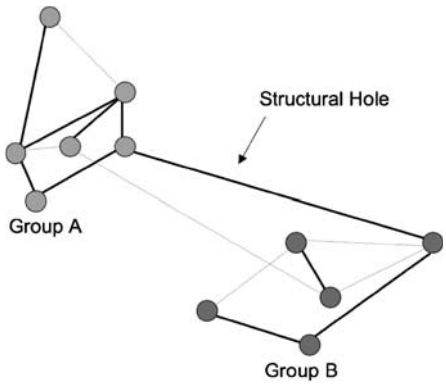

Figure 1: A sociogram example. Group A: 8 ties, 6 strong and 2 weak; Group B: 6 ties, 3 strong and 3 weak

Structural holes appear when groups of people are joined only by weak connections. This can occur when actors know of other groups but choose to interact only within their own group. As such, relative to other group members, they are not privy to any extra information or its resultant benefits. Instead, their contacts are mostly *redundant* in that they all connect to the same people and therefore the same information.[12] This is in contrast to actors with strong networks, as they tend to know more information and more rapidly.

As Burt[12] puts it, 'players with a network optimally structured to provide these benefits enjoy higher rates of return to their investments, because such players know about, and have a hand in, more rewarding opportunities'. Ironically, actors with weak connections create value for those with stronger networks through their propensity to operate among a single group. Structural holes form between groups of this nature and limit the sharing of information. By effectively managing the information flow between groups, a strong player with multiple

Table 1: Outputs of social network analysis (summarised from Wasserman and Faust[10])

Characteristic	Description
Actor prominence	The ties of the actor make it particularly visible to other actors in the network. These actors are identified using *centrality* measures and *prestige* measures.
Actor centrality	Different measures that investigate the amount of ties an actor is involved in: • *Degree centrality* measures the proportion of actors that are adjacent to a particular actor. • *Closeness centrality* measures how close an actor is to all the other actors in the network. • *Betweenness centrality* identifies actors that are between many actors in their linkages with each other.
Actor prestige	Different measures that investigate which actors are the object of extensive ties, thus focussing solely on the actor as a recipient. • *Degree prestige* measures the relative amount of actors that link to a particular actor. • *Proximity prestige* only measures actors adjacent to a particular actor.
Cohesive subgroups	Subsets of actors among whom there are relatively strong, direct, intense, frequent ties. Also referred to as *cliques*.

connections can control the accrual of benefits that results from information use. As the number of networks with structural holes that a person belongs to increases, so too does the amount of potential profit to be exploited. In terms of business, a strong player that can bridge two groups at the right time will enjoy considerable power from simply being able to link interested actors.

Social capital arises from individuals creating and controlling information flows around structural holes.[12] It 'consists of resources embedded in social relations and social structure, which can be mobilized when an actor wishes to increase the likelihood of success in a purposive action'.[13] The value of social capital is dependent on both the network and the actor, and the latter must be strategically located within a network such that they are able to access the resources necessary to provide a benefit. The network must also be itself capable of providing resources of any value. The accretion of social capital is as justifiable as the amassing of financial capital, for its value arises from the expenditure of time, energy or wealth.[14] For example, acquiring cultural assets or learning skills can be exchanged for other kinds of capital, such as additional wealth, power or influence.

Network analysis techniques can be applied to social networks following their exposition in the form of a sociogram. From this graphic representation, networks can be described in terms of their attributes. Wasserman and Faust[10] emphasise that it becomes feasible to 'study the impact of the structure on the functioning of the group and/or the influence of this structure on individuals within the group'. Table 1 outlines the characteristics and constructs that are used in this study.

A SNT-BASED MODEL FOR EXPLORING BUSINESS NETWORKS

We explore simple internet-based business networks comprised of hyperlinks on a particular website linking to another *actor* or *node*. These networks can be termed *one-mode* as the ties they model are unidirectional – a linkage in one direction does not imply the existence of a reverse relationship. Each linkage indicates that one website links to another. Actor dynamics such as centrality, prominence and prestige make it possible to examine such internet networks and determine those actors with influence.

The question of whether a website link necessarily represents a social linkage is worth exploring. The idea that a passive hyperlink is simply a cold technical connection and does not merit being tagged 'social' can be seen as having some validity. Websites do not, however, create themselves but are instead deliberately made by human designers. Conscious thought is necessary to choose and incorporate links into a website and for this reason, the view of Watts,[15] who characterises any links with origin in human behaviour as social, is adopted. Even with this conceded, the question then moves to identifying the

individual that chose to incorporate the link. Some may point out the fact that such links are often left to web designers' sole discretion and as such do not represent a profound partnership. While this may be true and the conception of a link may be random, its creation does not negate the possibility for alliance created or the social capital born through the link's creation. As such, hyperlinks are taken as the best representation of an online bond between two organisations. In fact, when chosen deliberately and by an informed marketing manager, hyperlinks have the potential to ignite strategic alliances due to the enhancement of existing social capital.

With these considerations in mind, this paper identifies, explores and compares the networks in two different biotech SME markets – Sweden and Australia – through the following process:

1. Developing sociograms of the relevant networks based on websites representing nodes and hyperlinks as ties.
2. Identifying key actors within each sociogram using principals of SNT.
3. Revealing potential entrepreneurial opportunities within the network by identifying possible structural holes.
4. Examining results in light of the strategic value of associations and the potential to increase social capital.
5. Identifying larger lessons for global biotech marketing evident from comparisons between the two countries.

APPLYING SNT TO ONLINE NETWORKS OF BIOTECH SMES

Biotechnology centres on the commercialisation of techniques using cells, or molecules derived from cells, to make products or solve problems. The nearly $30bn dollar international industry is comprised of approximately 1,500 companies, each of which has the potential to be global as biotech products tend to have universal application and appeal. Typical products range from food production technologies to pharmaceutical and health products. Biotech firms often are cited as excellent examples of new product development due to their rapid innovation and capitalisation of new ideas. Equally important is the speed at which new entrants build relationships within the business-to-business community. Owing to the youth of many companies, today most biotech firms around the world are SMEs with less than 100 employees. In many cases, the firms are very well-funded start-ups that have enjoyed very significant investments without earning a single sales dollar – for example, the blood substitute start-up BioPure[16] had invested $200m in its new product without having sold a single unit.

Analysis of the Australian and Swedish biotech firms' online networks involved a variety of steps. First, three biotech SMEs in each of the countries were identified in order to provide a starting point for the analysis. With the aid of specialised software, a visit was made to each of the three initial websites and all hyperlinks extending beyond a firm's were recorded. The process was then repeated for each of the hyperlinks identified. Sociograms of the information gathered were then constructed and allowed for data analysis involving two stages. The first stage examined centrality and prestige measures as part of overall prominence analysis. Structural hole analysis defined second-stage analysis.

The methodology used in analysing the networks is noteworthy as the procedure is both progressive and recursive. As one further step is performed in analysis it reveals increased information about an earlier stage while also laying a foundation for the next step. An example is prominence analysis that simultaneously identifies key nodes from those found earlier, and also provides groundwork for structural hole analysis. The procedure is explained in more detail below.

Choosing a start point

In order to begin analysis, three initial biotech firms were needed from both Sweden and Australia. Google was used to selectively search for Australian and Swedish websites that contained terms such as biotechnology, biotech, new product development and small-to-medium enterprise. Firms that ranked high on the results page of the search were investigated and the three most prominent firms were selected. In Sweden, the top three

biotech firms from the search were *Karo Bio* (www.karobio.se), a company that develops precision drugs to combat diseases related to nuclear receptors; *AgriSera* (www.agrisera.se), a firm that provides polyclonal and monoclonal antibody production services and *BioPhausia* (www.biophausia.se), which focusses on research involving micro-circulation, macromolecules and biopolymers. Australian biotech companies identified were *SOLBEC Pharmaceuticals Ltd*. (www.solbec.com.au), a pharmaceutical firm that focussed on human and animal healthcare; *Agen Biomedical Ltd*. (www.agen.com.au), an advanced medical and veterinary diagnostics company and *VRI BioMedical* (www.vribiomedical.com), a firm researching products for the prediction, prevention and treatment of disturbances of the body's natural defence systems.

Collecting site data

The next stage involved visiting each of the selected websites and collecting all of the hyperlinks referring to external websites. *SiteSweeper 2.0* software by Site Technologies, Inc. was used in this process. Each of these hyperlinks were then followed to discover further information. Specifically, whether the link was reciprocal and also which external websites were linked to by this website. This process then repeated on the newfound external web sites.

Building a network sociogram

Sociograms were constructed of the Swedish and Australian SME networks and are respectively shown in Figures 2a and 2b. Three levels characterise each network diagram, with the first level being the initial source website, the second level the external websites linked to by these source websites and the third level being the websites linked to by those from the second level.

Beyond simple aesthetic differences between the two sociograms, it is difficult to easily find meaning in the 49 Swedish and 73 Australian nodes representing SMEs. Social network analysis techniques grounded in SNT are therefore necessary to aid interpretation.

Analysing the resulting data

Prominence and structural hole analysis are the two techniques used in analysing the type of data collected. *Netminer 2.3.0* software (Cyram Co. Ltd.) was used for prominence analysis, which included centrality and prestige measurements. For centrality, three measures were calculated: *Degree centrality, Betweenness and Closeness*, which are defined in Table 2. Because we were dealing with directional networks, we divided degree centrality into two parts, namely 'out-degree' and 'in-degree'. *Out-degree* computes the number of links *sent* to another actor, while *in-degree* refers to the number of links *received* by each actor.[17] Different measures for closeness, namely, *Out-Closeness* and *In-Closeness* were calculated. Betweenness is strongly related to structural holes. Table 3 provides a summary of the results obtained from the analysis performed and identifies the most prominent actors.

Table 3 shows that all these sites are significantly prominent in the networks. In the Swedish situation, even though node 26 (*Karo Bio*) had very high out-degree centrality, none of the sites that it links to (or any other sites in the network) link back to it (ie in-degree centrality = 0). It is therefore not a prominent link in the network as prominence by definition incorporates the full extent of centrality measures, not just a high score on one of the measures. Table 3 also illustrates which of the websites are the most prominent in each network. Websites that have high scores on most of the measures are shown in Table 4.

Structural hole analysis: Looking for gaps

Structural hole analysis (SHA) was then conducted on the three most-prominent biotech websites in order to uncover patterns and entrepreneurial opportunities otherwise not apparent from mere visual scrutiny of the network diagram. Burt's *STRUCTURE* software identified the structural holes for the firms listed in Table 4. A summary of the most important measures used in this calculation are defined in Table 5 while Tables 6a–c and Tables 7a–c show the values for c_{ij} and p_{ij} for the three most-prominent websites for the Swedish and Australian biotech SMEs, respectively.

Burt[12] defines the *hole signature* of an actor as the difference between p_{ij} and c_{ij}, which

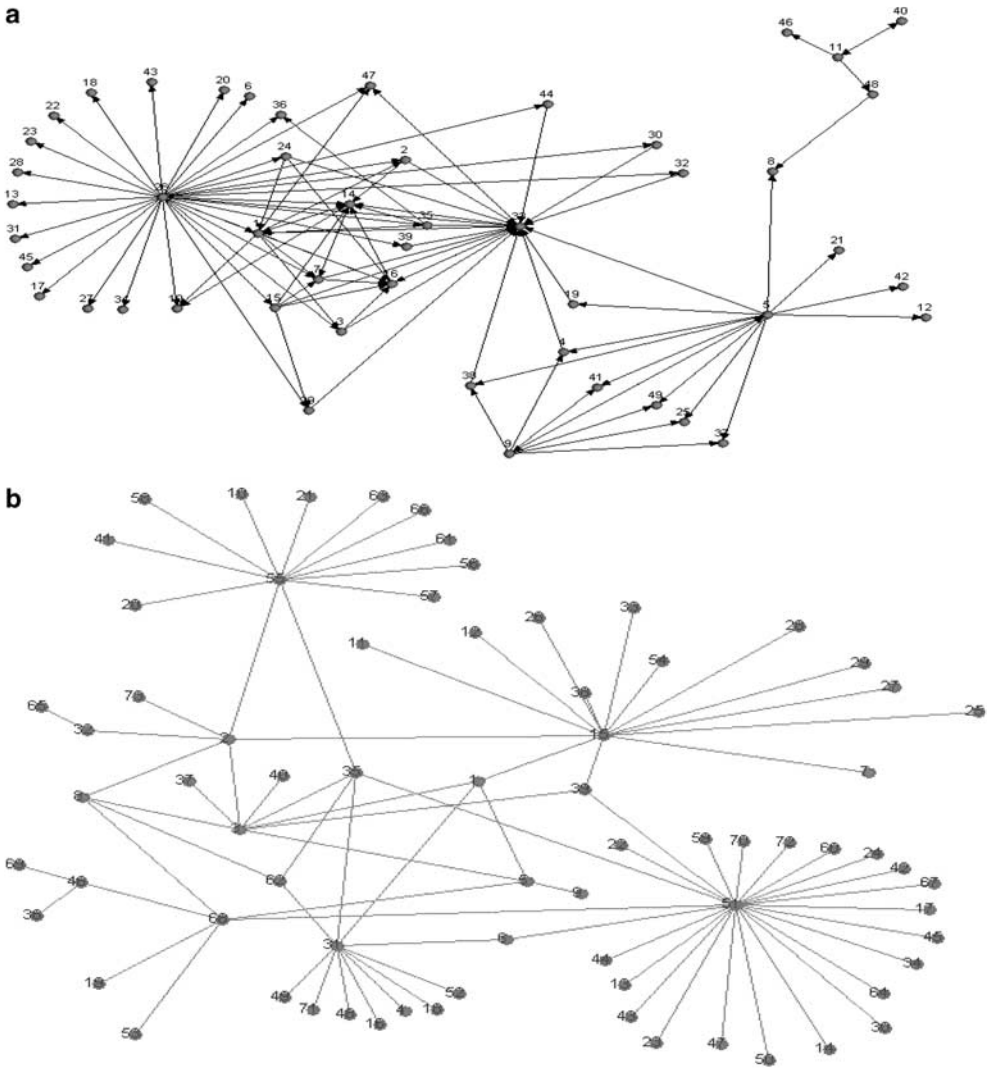

Figure 2: (a) Swedish biotech SME network. (b) Australian biotech SME network

Table 2: Measures of centrality – definitions and reasons for importance

Measure	Definition	Why important?	Reference
Degree centrality	A normalised value of the number of actors adjacent to a particular actor.	Provides a notion of how well connected a point is within its local environment. The corresponding agent is central in the sense of being 'well-connected'	Scott[9]
Closeness	A measure of how close an actor is to all the other actors in the network	'An actor is central if he/she can quickly interact with all others … actors occupying central locations with respect to *closeness* can be very productive in communicating information to other actors'. The measure finds actors with the shortest communication paths to the others	Wasserman and Faust[10]
Betweenness	Identifies actors that are between many actors in their linkages with each other	The betweenness of a point measures the extent to which an agent can play the 'broker' or 'gatekeeper' with a potential for control over others	Scott[9]

provides an easy way to identify the structural holes around a specific actor. Structural holes occur around a specific actor when it has a large O_i (no or few structural holes around the actor itself); and there is a large p_{ij} and a small c_{ij} at the other end of a relationship

Table 3: Prominence measures SME networks

In-degree	Out-degree	In-closeness	Out-closeness	Betweenness
(a) Swedish SMEs				
33 nih.gov	**26** karo bio	**33** nih.gov	**33** nih.gov	**33** nih.gov
14 cdc.gov	**5** agrisera	**14** cdc.gov	**14** cdc.gov	**1** 4woman.gov
16 diabetes.org	**9** antibodyresource	**16** diabetes.org	**16** diabetes.org	**14** cdc.gov
1 4woman.gov	**1** 4woman.gov	**1** 4woman.gov	**1** 4woman.gov	
7 americanheart.org	**14** cdc.gov	**47** ucsf.edu	**47** ucsf.edu	
	33 nih.gov			
(b) Australian SMEs				
15 Corbett Res.	**51** Pharmanex	**1** Adobe	**51** Pharmanex	**51** Pharmanex
35 Macromedia	**15** Corbett Res.	**35** Macromedia	**2** Agen	**15** Corbett Res.
1 Adobe	**31** Indepth	**39** Microsoft	**68** VRI Biomedical	**53** PNMC
8 ASX	**55** Ranbaxy	**15** Corbett Res.	**3** Agenix	**35** Macromedia
55 Ranbaxy	**3** Agenix	**8** ASX	**15** Corbett Res.	**2** Agen
39 Microsoft		**55** Ranbaxy	**45** Nuskin	**31** Indepth
				68 VRI Biomedical

Note: The numbers in the table refer to the website's reference number in the network sociogram in Figures 2a and b.

Table 4: Prominent companies/ websites in the networks

Swedish SMEs		Australian SMEs	
Number	**Organisation**	**Number**	**Organisation**
33	National Institutes of Health (nih.gov)	15	Corbett Research
14	Centers for Disease Control & Prevention (cdc.gov)	55	Ranbaxy
1	National Women's Health Information Center (nih.gov)	51	Pharmanex

Table 5: Structural hole analysis measures

Measure	Definition
O_i	The lack of holes around the actor itself
c_{ij}	The constraint of absent primary holes. An actor's (i) entrepreneurial opportunities are constrained to the extent that another of his contacts (q), with whom he has a strong relationship, invested heavily and therefore also has a strong relationship with actor j. c_{ij} must therefore be low for structural holes (entrepreneurial holes) to exist.
p_{ij}	The proportion of i's network time and energy invested in each relationship

with another actor (large amount of time and energy invested in the relationship, small constraint on the actor's entrepreneurial opportunities). To demonstrate this, the hole signature for *The Centres for Disease Control and Prevention* (CDC) in the Swedish data is shown in Figure 3. A large band in the hole signature indicates an *opportunity relationship*, 'in which the player has the greatest room to negotiate, and so control', while a narrow band indicates *constraint relationships*, where 'the player is most out of control'.[12] A third category, *residual relationships*, is reserved for instances where a small amount of time and energy is invested in a particular actor (small p_{ij}). These relationships are usually ignored, as 'there is little to protect and little to gain by alleviating constraint'.[12] On the basis of the above, it is possible to identify between which actors in the network entrepreneurial opportunities exist. In our example using CDC, these are: *CDC* and National Institutes of Health (*NIH*), *CDC* and *4Woman.org*, and *CDC* and *americanheart.org*.

Table 6: Structural hole analysis for (a) National Institutes of Health, (b) Centers for Disease Control & Prevention and (c) National Women's Health Information Center

Website		c_{ij}	p_{ij}	$p_{ij}-c_{ij}$
(a) National Institutes of Health				
A	4woman.gov	0.030	0.087	0.0570
B	cdc.gov	0.023	0.087	0.0640
C	diabetes.org	0.019	0.087	0.0680
D	karobio	0.057	0.043	−0.0135
E	agrisera	0.009	0.043	0.0345
F	americanheart.org	0.007	0.043	0.0365
G	chd-taskforce	0.007	0.043	0.0365
H	aace.com	0.004	0.043	0.0395
I	healthywomen.org	0.004	0.043	0.0395
J	aaaai.org	0.003	0.043	0.0405
K	lipidhealth.org	0.003	0.043	0.0405
L	nordea	0.003	0.043	0.0405
M	ucsf	0.003	0.043	0.0405
N	abcam	0.002	0.043	0.0415
O	dynalbiotech	0.002	0.043	0.0415
P	lungusa.org	0.002	0.043	0.0415
Q	nccn.org	0.002	0.043	0.0415
R	promega	0.002	0.043	0.0415
S	prostate-cancer.org	0.002	0.043	0.0415
T	sahlgrenska	0.002	0.043	0.0415
(b) Centers for Disease Control & Prevention				
A	nih.gov	0.083	0.167	0.0837
B	4woman.gov	0.080	0.167	0.0867
C	americanheart.org	0.045	0.167	0.1217
D	karobio	0.046	0.083	0.0373
E	diabetes.org	0.023	0.083	0.0603
F	chd-taskforce	0.016	0.083	0.0673
G	aaaai.org	0.011	0.083	0.0723
H	obesity.org	0.011	0.083	0.0723
I	arthritis.org	0.010	0.083	0.0733
(c) National Women's Health Information Center				
A	nih.gov	0.095	0.154	0.0588
B	cdc.gov	0.068	0.154	0.0858
C	karobio	0.058	0.077	0.0189
D	diabetes.org	0.024	0.077	0.0529
E	americanheart.org	0.014	0.077	0.0629
F	aaaai.org	0.010	0.077	0.0669
G	obesity.org	0.010	0.077	0.0669
H	aace.com	0.009	0.077	0.0679
I	arthritis.org	0.009	0.077	0.0679
J	healthywomen.org	0.009	0.077	0.0679
K	ucsf.edu	0.007	0.077	0.0699

WHAT DOES THIS MEAN TO INTERNATIONAL BIOTECH FIRMS?

In this study, the internet networks of Swedish and Australian biotech industries are analysed using SNT in an effort to uncover hidden value in the networks. A clear method of performing this procedure is explained and demonstrated using sociograms as representations of online networks. Sociograms, once constructed, can be analysed to determine prominent nodes – the most important actors in a network – as well as structural holes. Such results hold incredible potential for business-to-business marketers. By being able to pinpoint influential actors within a network, marketers can better target organisations capable of spreading information around a global network. Measures of prominence thus have the potential to both extend the reach and speed the transmission of marketing information. Diffusion of innovation theories complement and support this finding.[18,17] Uncovering structural holes and their associated entrepreneurial

Table 7: Structural hole analysis for (a) Corbett research, (b) Pharmanex and (c) Ranbaxy

Website		p_{ij}	c_{ij}	$p_{ij}-c_{ij}$
(a) Corbett research				
A	ARMIN TEB	0.1111	0.0123	0.0988
B	Biolabo	0.1111	0.0123	0.0988
C	Gene Company	0.1111	0.0123	0.0988
D	MeltCalc	0.1111	0.0123	0.0988
E	Adobe	0.0556	0.0031	0.0525
F	Agen	0.0556	0.0031	0.0525
G	Brennan and Company	0.0556	0.0031	0.0525
H	General Biosystem	0.0556	0.0031	0.0525
I	Genotek	0.0556	0.0031	0.0525
J	genXpress	0.0556	0.0031	0.0525
K	Global Science	0.0556	0.0031	0.0525
L	Kem-en-Tec	0.0556	0.0031	0.0525
M	Microsoft	0.0556	0.0031	0.0525
N	Pyrosequencing	0.0556	0.0031	0.0525
(b) Pharmanex				
A	Nuskin	0.08	0.006	0.074
B	Apple	0.04	0.002	0.038
C	CDC	0.04	0.002	0.038
D	CIDRAP	0.04	0.002	0.038
E	CRN USA	0.04	0.002	0.038
F	e-homoeopathy	0.04	0.002	0.038
G	FDA	0.04	0.002	0.038
H	Force for good	0.04	0.002	0.038
I	Healthscout	0.04	0.002	0.038
J	KFF	0.04	0.002	0.038
K	Macromedia	0.04	0.002	0.038
L	Microsoft	0.04	0.002	0.038
M	Newsalert	0.04	0.002	0.038
N	Newswise	0.04	0.002	0.038
O	Nourish the Children	0.04	0.002	0.038
P	Paho	0.04	0.002	0.038
Q	PDR	0.04	0.002	0.038
R	Real	0.04	0.002	0.038
S	Red Cross	0.04	0.002	0.038
T	Stanford Univeristy	0.04	0.002	0.038
U	USOC	0.04	0.002	0.038
V	VRI Biomedical	0.04	0.002	0.038
W	World Health Organisation	0.04	0.002	0.038
X	Yale	0.04	0.002	0.038
(c) Ranbaxy				
A	Doctor Anywhere	0.133	0.018	0.115
B	Ranbaxy USA	0.133	0.018	0.115
C	Rancs	0.133	0.018	0.115
D	Agen	0.067	0.004	0.063
E	Basics	0.067	0.004	0.063
F	Ecaverta	0.067	0.004	0.063
G	Macromedia	0.067	0.004	0.063
H	Medicines for malaria venture (MMV)	0.067	0.004	0.063
I	Ranbaxy for doctors	0.067	0.004	0.063
J	Reuters	0.067	0.004	0.063
K	SRL Ranbaxy	0.067	0.004	0.063
L	Thai Pharmacy	0.067	0.004	0.063

opportunities, can help global biotech firms reap otherwise missed financial rewards that may otherwise be discovered by their rivals.

An unexpected finding of the analysis is the profound effect of the internet on relationships. A firm may have no intentional aim of forming bonds online, yet find itself part of a global network. Australian firms are linked with large Indian firms. Likewise, departments of the American government are

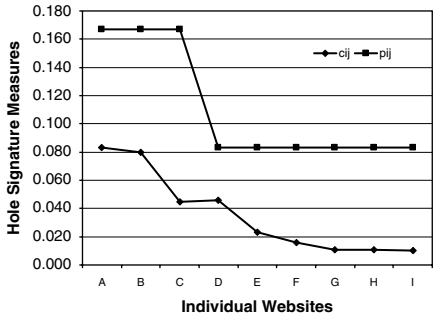

Figure 3: Hole Signature for CDC. Note: Figure 3 visually represents c_{ij} and p_{ij}, which are useful measures for identifying structural holes[12]. C_{ij} measures the extent to which an actor's (i) opportunity with an organisation (j) in question is constrained by the pre-existence of a strong relationship between both that organisation and a fellow actor (q), and also the fellow actor (q) and itself (i). P_{ij} measures in what proportion actor i's network time and energy is spent on each relationship. Opportunity relationships are indicated by large bands in the hole signature such as those between the CDC and websites A (nih.gov), B (4woman.gov) and C (americanheart.org)

very much connected with Swedish biotech firms. Failure to engage in social network analysis would severely curtail the ability of relevant firms to bolster those useful links or constrain those that may do harm. In addition to a firm being able to learn directly about its own network, the exact same analysis, run on competitors, provides incredibly useful information. By identifying structural holes within competitors' networks, a firm can work to exploit the gaps. On a broader level, information on the global biotech environment could identify optimal areas for business-to-business intermediaries to fill.

The most important players in each of the networks were identified using prominence analysis and its associated three measures. Using this information, biotech firms, suppliers and marketing managers can identify which of their links are unknown to competitors, and therefore of value. Efforts can then be allocated to building and maintaining a firm's social capital embodied in such relationships. The value sought in a network, as well as the nature of the network, determines the specific measure or measures used in interpretation. For a company looking at improving dissemination of information across the internet, measures such as *In-Degree centrality*, *In-Closeness centrality* and *Betweenness* would be the best to use, as these measures indicate which actors are most likely to be reached when someone visits one of the sites included in the network. In terms of the biotech networks studied, these measures would encourage a marketing manager to focus on websites like *Corbett Research*, *Ranbaxy* and *Pharmanex* for Australia and *NIH*, *CDC* and *diabetes.org* for Sweden when trying to spread information. The diffusion of innovations is also linked with measures of centrality. Structural centrality in networks is typically linked to a faster spread of positive innovations and vice versa.[17] Centrality is therefore not only an important measure in deciding whom the influential actors are, but also ties in closely in determining the speed of information transmission.

Entrepreneurial opportunities were also identified for firms and suppliers operating in the global biotech network. These opportunities are examinable in terms of their potential to hold a tertius strategy. A tertius strategy is one in which a third party is able to negotiate and regulate a relationship between two parties. The existence and growth of such opportunities creates social capital within a network that an actor is able to turn strategic and financially beneficial. For instance, such an opportunity exists between *Ranbaxy* and *Doctor Anywhere* in the Australian biotech network and the websites of *The Centres for Disease Control and Prevention* (CDC) and *The American Heart Association* (AHA) in the Swedish biotech network. An enterprising third-party organisation could place itself between each of these sets of groups in order to manage the relationship between them. This could involve working as an intermediary controlling information flow between the two as well as between the organisations and other third parties.

Table 3 highlights an interesting effect of the global nature of the World Wide Web. Australian biotech firms are much more linked to India than the US. Interestingly, Swedish SMEs are heavily connected to government information websites from the US. The underlying cause of such a difference

is unknown, but nonetheless represents a big opportunity in Sweden. A Swedish biotech marketer could position itself in the structural hole that exists between the CDC's and AHA's websites. Additionally, an SME or new firm could position itself as a link between Swedish biotech firms and global health information websites. Swedish SMEs would benefit from more information related to their research, and health information websites would similarly benefit from increased business as a result of increased ties to biotech companies. The Australian analysis yields a similar strategic opportunity. Here a third-party organisation could position itself between *Ranbaxy* (India's largest pharmaceutical company) and *Doctor Anywhere* (an online portal for medical practitioners in India linking doctors with specialists) to negotiate the relationship between them by controlling information flow between the two. These two examples represent only two cases of network analysis aiding biotech marketing managers find and exploit the entrepreneurial chances that structural holes represent. Different networks have different structural holes and thus need to be analysed individually.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study, like all research, has its limitations. A single industry is examined within only two countries; it is possible that results may differ in other arenas. The methodology provided, which applies SNT to international marketing networks, is not particular in any way to the countries or industry studied. As such, while the analysis of the calculated networks may yield specialised results, the overall approach is widely applicable. In addition, internet networks need not necessarily be the only networks studied. The choice of Google search results as a starting point was arbitrary and could be changed to a leading site within an industry, a company's own website or its competitor.

With business-to-business marketing literature identifying networks as an important issue,[19–23] there are a wide variety of future research opportunities related to this study. While here the focus has been on examining links between SMEs, a surprising result emerged. Biotech firms link to a variety of organisations including nonprofits, government arms and other firms. The implications of this are unknown and may be worth exploring. Extending even further, it may prove interesting to examine the potential existence of links and possible structural holes between industries. There may be untapped entrepreneurial opportunities for international business-to-business marketers able to bridge a possible gap between the electronics or chemical industry and biotech research firms.

The existence of surprising links in the biotech network between nations such as Sweden and the USA and India and Australia may appeal to international marketing researchers. Understanding how these links formed and their possible strategic value could prove enlightening. Should such surprising links be found in additional studies that are larger in scope, both managers and policy makers may find their occurrence intriguing.

While the present study is based upon internet links, there is value in investigating more networks using more traditional techniques. One such possibility is engaging firms through the use of surveys in which respondents need to indicate their relationship with fellow firms, customers and suppliers. The use of website links as indicators of relationships in international business-to-business markets, which we argue is both appropriate and informative, does not yet have empirical support for its value. This could be investigated with a qualitative study aimed at discovering what value managers place on this study's methodology and results.

The internet, as a tool of international trade and marketing, is an omnipresent aspect of modern business. Regardless of a firm's acknowledgement, interest or approval of the technology, networks within the internet exist. Firms do have a choice, however, in whether or not they recognise and exploit the potential of such networks, which may be enormous. Failure to do so may reduce a firm's competitive advantage and unknowingly strengthen its rivals.

References

1. Travers, J. & Milgram, S. (1969). An experimental study of the small world problem. *Sociometry* **32**, 425–443.
2. Barabási, A. (2003). *Linked: How Everything is Connected to Everything Else and What It Means for Business, Science, and Everyday Life*, Plume, New York.
3. Granovetter, M. S. (1973). The strength of weak ties. *Am. J. Sociol.* **78**, 1360–1380.
4. Granovetter, M. S. (1973). *Getting a Job: A Study of Contacts and Careers*, University of Chicago Press, Chicago, IL.
5. Watson, R. T., Zinkhan, G. & Pitt, L. F. (2004). Object-orientation: A tool for enterprise design. *Calif. Manage. Rev.* **46**, 89–110.
6. Lipparini, A. & Sobrero, M. (1994). The glue and the pieces: Entrepreneurship and innovation in small-firm networks trends of small tourism businesses in post-socialist Slovakia. *J. Bus. Venturing* **9**, 125–140.
7. Masurel, E. & Janszen, R. (1998). The relationship between SME cooperation and market concentration: Evidence from small retailers in the Netherlands. *J. Small Bus. Manage.* **36**, 68–73.
8. Copp, C. B. & Ivy, R. I. (2001). Networking trends of small tourism businesses in post-socialist Slovakia. *J. Small Bus. Manage.* **39**, 345–353.
9. Scott, J. (1991). *Social Network Analysis – A Handbook*, Sage Publications, London.
10. Wasserman, S. & Faust, K. (1994). *Social Network Analysis – Methods and Applications*, Cambridge University Press, Cambridge.
11. Coleman, J. S. (1990). *Foundations of Social Theory*, Harvard University Press, Cambridge, MA.
12. Burt, R. S. (1992). *Structural Holes: The Social Structure of Competition*, Harvard University Press, Cambridge, MA.
13. Lin, N. (2001). *Social Capital – A Theory of Social Structure and Action*, Cambridge University Press, Cambridge.
14. Bourdieu, P. (1977). *Outline of a Theory of Practice*, Cambridge University Press, Cambridge.
15. Watts, D. J. (2003). *Six Degrees: The Science of a Connected Age*, W.W. Norton & Company, New York, NY.
16. Gourville, J. (1999). Biopure corporation, Harvard Business School, Case #9-598-150, 27 May.
17. Valente, T. W. (1995). *Network Models of the Diffusion of Innovations*, Hampton Press, New Jersey.
18. Rogers, E. M. (1995). *Diffusion of Innovations* (4th edn) Free Press, New York.
19. Ehret, M. (2004). Managing the trade-off between relationships and value networks. Towards a value-based approach of customer relationship management in business-to-business markets. *Ind. Market. Manage.* **33**, 465–474.
20. Iyer, G. R. (2004). Internet-enable linkages: Balancing strategic considerations with operational efficiencies in business-to-business marketing. *J. Bus. Bus. Market.* **11**, 35–59.
21. Borders, A. L, Johnston, W. J. & Rigdon, E. E. (2001). Beyond the dyad: Electronic commerce and network perspectives in industrial marketing management. *Ind. Market. Manage.* **30**, 199–206.
22. McAfee, A. (2000). The Napsterization of B2B. *Harvard Bus. Rev.* **78**, 18–20.
23. Anderson, J. C., Håkansson, H. & Johanson, J. (1994). Dyadic business relationships within a business network context. *J. Market.* **58**, 1–16.