

**A Tale of Two Networks:
Clusters, Institutional Investors and Innovation**

By: Michael Lee

Class: POLS673

Professor: Armando Razo

Discussant: W. Travis Selmier

© 2009 by author

A Tale of Two Networks: Clusters, Institutional Investors and Innovation

By: Michael Lee

Introduction

Adam Smith (1994) argued that “it is not from the benevolence” of private industry that ordinary citizens expect goods, but rather from the self-interest of industry. How well does that famous statement apply to innovation or many of the other public goods produced by private firms? New knowledge is a public good, and new products often spawn widespread benefits that are not fully captured by innovating firms. Why do firms produce public goods that they cannot profit from? What sorts of conditions make them likely to produce more or fewer of such public goods? How can governments encourage more of this behavior? The answer to these questions is surely non-trivial – innovation has driven a 15-fold increase in the GDP per capita of many western countries in the past century and a half (Maddison, 2003). For both countries, firms and individuals, the stakes of innovation policy are undeniably high.

Michael Porter (1990) offers a popular answer to the questions above. He contends that governments should aid in the establishment of industry clusters, by developing a favorable environment for firms. Clustering industries increases the degree to which firms within an industry can benefit from “spillover effects” stemming from their various activities. A given project produces ideas that are adopted elsewhere, gives workers experience they may bring to other firms, and may develop specialized equipment that other firms can rent. Krugman (1991) emphasizes economies of scale and scope in the emergence of an industrialized core within a state – concentrating industry reduces transport costs by locating near the centers of demand.

However, collective action problems pose a wrinkle in Porter’s theory. While firms within clusters benefit increasingly from spillovers as the cluster grows, they also have less of an incentive produce public goods. Mancur Olson argues that group size is inversely related to the production of public goods (Olson, 1965). A firm in a large cluster could allow others to foot the bill of new innovation, adapt the ideas of others, and undercut their competitors having saved the considerable fixed cost of innovation. In other words, subsidizing growing clusters may reduce innovation if the cluster grows too large. That industries often do cluster, moreover, does not necessarily mean that clusters add to growth. Indeed, many of the public goods in question are mobile. Knowledge, in particular, is easy to move over long distances, reducing the benefits of proximity (Krugman and Venables, 1996). Finally, it is unclear that governments are well-suited to picking *which* clusters to support, even if they were unambiguously positive for economic growth (Buss, 1999).

This paper emphasizes an alternative explanation to that of geographic clustering. The production of public goods at the industry level represents not only a collective action problem, but also an enormous profit potential. If some entity could internalize the industry-level externalities of some innovation, they would be able to yield a tidy profit (Rugman, 1980). However, outright collusion on many fronts (such as pricing) is illegal, while industry agreements are hard to enforce due to free-riding – coordination requires a third party. Institutional investors (eg. Barclay Global Investors) offer such a third party, in what is essentially a hybrid network structure (Menard, 2004). While some investors invest in particular firms, others adopt an industry-wide strategy, buying shares in many companies within an industry (Pagano, 1993). Investors with industry-wide holdings have a strong incentive to use their often considerable clout (both through voting and the threat of exit) to push for greater investments in research and other public goods because positive externalities from research will benefit their other investments (Hill and Jones, 1992). Firms without this sort of ownership, driven only by the incentives of the firm itself, are more likely to adopt a free-riding strategy. If confirmed this has clear policy implications – governments would do well to subsidize industry-wide investment portfolios (or penalize investors that only invest in a few firms).

Network analysis techniques provide a methodological approach to compare the relative importance of the two competing models presented above. Social network analysis employs linkages between actors as an explanatory factor (Wasserman and Faust, 1994). Industry clusters are geographic networks where firms are linked by proximity. Investors provide a social network, linking firms within the same industry. This paper tests the impact of both factors on firm investment in R&D within the electronic computer, computer storage device, computer terminal, and computer peripheral equipment industries (respectively, SIC codes 3571, 3572, 3575, 3577) (IDEA, 2009). Computer hardware offers a good test case because it exhibits strong spillover effects. Moreover, it represents a tough case for the investment explanation, as computer technology is often put forth as the textbook case of geographic clustering fostering increased research and development.

This paper will first review the literature on growth theory, establishing that indeed, encouraging innovation represents a critical issue for governments. Secondly, it will review the industry cluster argument, making the case that clusters have definite limits to effectiveness at best, and are a drag on innovation at worst. As an alternative argument, this paper will then review the literature on institutional investors. This will help in addressing three critical questions: how do investors influence managers in firms? What are the benefits to investors of those networks? How might governments influence those incentives? This paper will make the case that coordination potential offers another substantial benefit to membership in a network. That coordination can enable investment firms to internalize the positive

externalities to innovation. Technology benefitting the industry may be a public good from the perspective of the firm, but it is not from the perspective of the industry as a whole.

Literature review

Where does growth come from?

In order to ascertain the best course of action for economic growth one must first have a theory of economic growth. Neoclassical growth theory, expounded in Solow's (1956) model and that of Swan (1956) emphasized increases in the capital and labor stock as the main source of economic growth. Given a particular savings rate, the capital stock would increase each year. However, since capital exhibits decreasing returns to scale, and some non-zero rate of depreciation as machinery ages, the rate of capital accumulation will eventually equal the rate of depreciation. As Abramowitz (1986) argues, this kind of model has clear implications – because of decreasing returns to scale to increases in capital, economic growth should decline over time, as economies converge upon the position of the lead economy (assuming equal rates of saving). Empirically, however, this relationship has not been observed. Maddison (2003) shows that there was convergence between European economies and the United States (and East-Asian economies and the United States) from the end of the Second World War till the early 90's. Since then, there has actually been some de-convergence. Moreover, even within the United States itself, growth rates have increased over time, rather than decreasing, till the 1970's. Outside of the OECD evidence runs counter to theory – much of the developing world has *diverged* from the lead economy. The problem is that such an approach does not account for changing rates of productivity growth – leaving it as part of the residual. If productivity growth is the critical factor in separating the giants from the midjets of economic growth, it surely makes more sense to construct a model where productivity and innovation are not treated endogenously.

Responding to the shortcomings of the neoclassical model, a few early solutions were attempted. These models tried to endogenize “A”, which represents productivity and grows such that $F(K, AL)$ can exhibit constant returns to scale (Aghion et al.). Arrow (1962) considers a third factor, “A”, which represents gains in productivity from learning. Aghion and Powitt (1998) point out that this model was not very robust, and required a fixed ratio of capital and labor. This implied that long-run economic growth would occur irrespective of the savings rate and be limited by growth in labor – an assumption running counter to empirical evidence and indeed, most economic theory. Nordhaus (1969) and Shell (1973) developed a model wherein innovation resulted from an intentional choice by firms seeking the prospect of monopoly rents. The models, however, could still not account for increasing returns. Uzawa (1965) instead argued that “A” was the result of increases in the stock of human capital. As with Arrow, however, Aghion and Powitt (1998) point out that it is not clear how an economy might compensate such

activities. On a similar vein, Mankiw et. al (1995) argued that the neoclassical model would hold if we could operationalize human capital appropriately.

Faced with these difficulties, Romer (1986), built on the work of Frankel (1962). Frankel had developed an AK model (eg. growth is a function of labor, capital and technology – $F(L,AK)$), which treated knowledge as a kind of capital good. Knowledge can be stored and used in conjunction with other inputs in order to produce output, making it very much resemble other forms of capital (although it does not exhibit depreciation). Romer (1986) added the notion of externalities to the model – individuals do not internalize the externalities of an expanding knowledge base. For Romer the critical issue was whether there were increasing, decreasing or constant *social* returns to capital. In the case of the former, Romer predicts sustained economic growth. However, although he brought technology into the model, he notes that firms do not internalize the externalities of knowledge, which is a public good. The implications of economic growth in the Romer model are stark as well – they imply income divergence. Romer (1986) gave endogenous growth theorists a powerful model with which to explain reality. Empirical results have been mixed, certainly favoring an endogenous growth approach, though not always an AK model (Aghion and Powitt, 1998). For instance Barro (1999; and Sala-i Martin, 1995) finds that democracy and educational attainment matter for growth. Benhabib and Spiegel (1994) find support for both education and technological progress are both strong predictors of economic growth.

From a policy standpoint, an important element of Romer's (1986) model offers a challenge to governments. The issue is that while growth in the stock of knowledge makes long-term growth possible, profits do not always capture the full social return of innovation because other firms (or ordinary citizens) capture some of the rewards of technical progress. Mansfield et al (1977) find some empirical vindication to such a notion. They look at three kinds of innovations – process innovations, and product innovations used by firms or households. In almost every case they found a sizeable gap – the median private return on investment in innovation was 25%, versus a 56% social return. Grossman and Helpman (1991) express this in terms of spillover effects of knowledge. Indeed, Gertler and Gilchrist (1993) and Jones and Williams (1998) find that investment in innovation in the United States is far below the optimal level.

Paul Krugman's (1991, 1995) revival of the literature on clusters, however, spawned a distinct policy course promising to bring those two returns into line. Paul Krugman argues that due to increasing returns to production, pooling of the labor market in particular areas (for example the close proximity of many universities with excellent computer science and engineering programs to Silicon Valley), the clustering of intermediate suppliers near to intended markets and the prospect of technological spillover effects drive the formation of industry clusters. For instance, Markusen et al (1991) investigate the emergence of a "gunbelt" – regions of the country where military spending has produced high tech clusters. Porter (1990) derives an explicit policy stance from the cluster literature. Rather than explicitly

creating clusters, Porter advocates governments improving the business environment within clusters. Porter's diamond model argues, controversially, that "factor conditions" (the factors of production) are explicitly created, rather than pre-existing. Thus governments have another positive role to play by building and supporting institutions of higher learning and constructing general infrastructure. Porter argues that as competitive advantage replaces comparative advantage, the prosperity becomes a choice, and government intervention an imperative.

H1: The existence and density of regional clusters positively predicts the level of innovative activity.

There is much to recommend the cluster approach. For one, it appears to offer governments a means to stimulate innovation while escaping the problems of old-fashioned industrial policy. Governments have a mixed record of "picking winners". For instance, Wallsten (2000) finds that government grants to firms does not result in increased R&D spending – firms simply use the grants to free up funds for other projects. Acs and Audretsch (1990), Baldwin and Gorecki (1991) and Geroski (1991, 1995) all find supporting evidence for such an approach. Increasing numbers of firms increase economic activity. Nelson (1993) found that government policy mattered in impacting innovation as well. At the same time he notes that US productivity and economic growth lagged much of Europe, despite American leadership in many high technology industries. He also found mixed evidence of the importance of localized supplier networks – while Japanese automobiles, Danish agricultural product processing and Italian textile producers exhibited strong links with upstream firms; pharmaceutical industries did not have strong connections with downstream suppliers, while aerospace firms have increasingly outsourced production internationally.

This paper takes the view that Porter underestimates the dark side of clustering. Research in Porter's construct is conducted largely by individual firms. The benefits of that research are of two distinct types – to some extent, firms may be able to capture newly generated information internally. For instance, Coca-Cola has managed to maintain its recipe as a trade secret for over a century, while intellectual property laws give pharmaceutical firms some degree of private ownership of their research. At the same time, another proportion of innovation is of a public good sort. Innovative activities employ give experience and knowledge to those working on them – benefits that could easily leave the firm if employees switched jobs. Moreover, even if a new innovation is protected legally, other firms can use the knowledge to develop new products just different enough to avoid legal problems. Finally, as innovation cuts costs, it can help the bottom line of all downstream firms. An Olson-ian (1965) logic would suggest that there is a tension inherent in the cluster argument. While it is true, as emphasized by the literature, that firms benefit from spillovers, the existence (and enlargement through government policies like encouraging clusters) of spillovers – a public good – should make firms less likely to invest in R&D in

the first place. Nowhere would this be truer than within an industry – that the proceeds of innovative activity are not entirely internalized by the innovating firm is disincentive enough, but when the beneficiaries are often competing firms, one might question why firms would innovate at all. The larger a cluster grows and the wider the range of its spillover effects get, the greater will be the tendency for firms to free-ride in actual knowledge production.

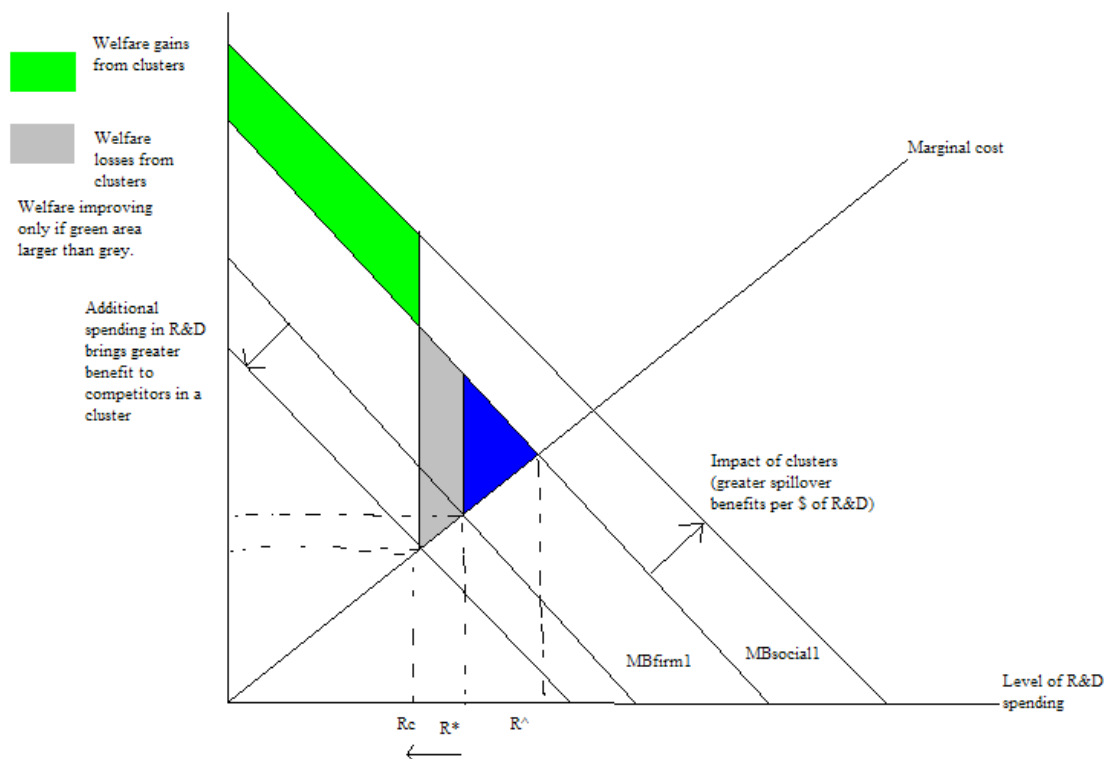
Other scholars suggest the existence of additional reasons for skepticism about the ability of governments to manage clusters. Baptista and Swann (1998) separate the benefits of clusters to firms into demand and supply sides. In the former case, they follow Hotelling's (1929) argument that firms tend to cluster in particular locales (particularly when those locales have a large local market for their product). On the supply side, there are usually positive externalities (eg. spillovers, or the presence of public goods) that motivate location decisions. However, they argue that increasing returns eventually level off, such that clusters lose their special advantages upon getting too large. Romer (2000) expresses skepticism in one of the main mechanisms of nurturing clusters, in showing that private returns for researchers are sufficient compensation without government support.

Secondly, Porter's argument that nurturing the "business environment" avoids picking winners is problematic. While governments do not pick specific firms to subsidize, innovation policy almost always benefits some industries more than it does others. Consider some popular tools – governments can invest scarce dollars in higher education, in military research, or in healthcare. The spinoffs of these government projects will benefit some sectors of the economy more than others. Governments can set lax intellectual property laws which stimulate competition in industries with low costs of innovation, or they can set strict intellectual property laws, which guard the innovations made in industries like pharmaceuticals where each step up the technological ladder is quite expensive. The more localized policies that Porter recommends (eg. building a government research lab or altering the terms of federalism to benefit regions with industry clusters) pick winners in an even more obvious manner, since it is rare (and problematic if maintaining regional income equality is an objective of the state) for all of a country's high technology industries to cluster in the same place. Adding a political dimension to this further complicates the picture. The political costs of removing increasingly inefficient subsidies to a particular region are likely to be high. For instance Rogowski and Kayser (2002) suggest that regional concentration is one of the best predictors of lobbying strength. Thus the very factor that Baptista and Swann (1998) suggest as a cause of potential inefficiency provides firms with the ability to maintain sub-optimal policies.

The problems discussed above are demonstrated below in figure 1. The graph below illustrates a baseline of a firm which invests in innovation, until the marginal benefit to the firm equals the marginal cost of an additional unit of investment. Because the firm does not internalize the social benefits of that investment, it invests R^* into research, below the socially optimal amount, R^\wedge . The externalities (the

benefits society would have enjoyed if investment was at the socially optimal level) are represented by the grey area plus the blue area. The creation of industry clusters expand out the marginal benefit curve for society because each additional dollar invested in R&D now benefits more firms within the industry cluster (ie. spillover effects). However, because the beneficiaries include competitor firms, the private benefit of innovation actually decreases. The green area represents the gains in social benefits, while the grey area represents the losses from reductions in the private return of investment. It is clearly possible for the grey area to exceed the green area – for instance, if a cluster were especially large already.

Figure 1: Externalities in R&D Investment decisions – impact of clusters



Theory

If industrial policy is likely to fail, and developing clusters is also not an option, does this mean there is nothing governments can do in order to stimulate growth? This paper responds in the negative. In the theory that follows, it will first be demonstrated that investors play an important role in decision-making. Secondly, it will establish baseline incentives for institutional investors. This paper focuses on institutional investors because they are both large enough to exert influence and also because it is easier to tease out their incentives. Moreover, unlike, for instance, the founder of a firm holding a large amount of stock, the investing institution is clearly delineated from the firm in its interests. Finally, it will elaborate

conditions under which the structure of investors in an industry might be induced towards more socially optimal levels of investment in R&D.

How do investors exert influence?

One of the assumptions underlying the logic of clusters is that firms are unitary actors. In many settings this assumption has proved robust and able to generate novel, verifiable predictions. However, it would also be possible to separate a firm into an operational and collective choice level of analysis, to employ the language of the IAD framework (Ostrom, 2005). On the one hand, managers make decisions about to invest in research (as well as other decisions). Firms, in this respect, can be seen as something like unitary actors, vis-à-vis other firms. However, there is a higher level process going on wherein a board of directors governs management, and one level above all of this, shareholders govern the board of directors. Institutional investors have two main tools by which they can influence firm behavior. The first is “activism” and the second, exit (Ryan and Schneider, 2002). Investors that own a large share of stocks can exert influence on the board of directors through voting power, and use their greater access to company information to monitor management more effectively than ordinary investors. Secondly, as Hirschman (1970) might suggest, they have the power of exit. No manager is ever happy to see large stockholders exit the company. These traditionally explored avenues may understate a third element. Institutional investors, and particularly those with wide holdings, may have access to information about an industry (such as what other firms are doing) that managers do not. Losing such a connection inhibits the ability of firms to act strategically. Moreover, an investor’s position within the network of institutional investors may also carry a degree of prestige. Markets would react negatively to exit by a prestigious player, and many could lower their evaluation of the value of the firm being exited from, even though they have learned no new information about the firm.

The empirical literature finds some support for the notion that institutional investors have an impact on the companies they invest in. Hartzell and Starks (2003) find that institutional investors are effective at clamping down on executive pay; Bhojraj and Sengupta (2003) find that greater board control by institutional investors drives lower bond yields and higher bond issues; Chaganti and Damanpour (1991) find that institutional investors (and various factors, such as familial relations among them) impact the capital structure of firms; Gillan and Starks (2000) find that institutional investors are a strong predictor of shareholder activism in corporate governance. However, there are also some dissenting voices. David et al (1998), finds that institutional investors are unable to influence CEO compensation; David et al (1998) finds that institutional ownership did not enable investors to influence R&D decisions;

What incentives to investors have?

Kochar and David (1996) find three competing sets of hypotheses within the literature regarding the impact of institutional investors on innovation. Drucker (1986) and Mitroff (1987) argue that

institutional investors are largely driven by the prospect of short term returns. Allen (1993), Jarrel et al (1985) and Jensen et al (1988) instead emphasize that institutional investment is driven by a desire to seek out the most innovative firms as long-term investment opportunities. Finally, Aoki (1984), Taylor (1990) and Useem (1993) reverse the causal arrows of the previous school of thought. Institutional investors buy large shares of firms, so as to monitor those firms, and ensure that they engage in innovative activities. Empirically, the preponderance has come out in favor of either the “superior investor” (school 2) or the “active investor” (school 3) hypothesis. While Graves (1988) finds some support for myopic investment, Baysinger et al (1985), Jensen (1991) and Hansen and Hill (1991) find support for the latter. Moreover, there is good reason to question Graves’ approach. Graves looked only at the computer industry, and simply used a trend to capture potential time dynamics. While a trend term can account for trend stationarity, it cannot account for a host of time series issues including autocorrelation, moving average processes, or other types of stationarity (Enders, 2004). Kochar and David (1996) sought to evaluate all three hypotheses empirically – first testing the relationship between intuitional investment and new products, and then testing whether innovation was greater in firms where investors had more or less leeway. Their results strongly rejected the myopic view, and found strong empirical support for the active investor view. From this, we can deduce the following hypothesis:

H2: The greater the ownership of a firm by institutional investors, the greater the amount of R&D spending.

How might the incentives of institutional investors be altered

Kochar and David (1996) provide interesting results, but are partly hampered by yet another black box. Among institutional investors, which investors would tend to favor innovation more, and which less? Most institutional investors own shares in multiple companies. As such, it is fallacious to model the impact of institutional investment on a company independent of the other investments owned by such companies. An institutional investor that owned a large amount of shares in every single company within an industry, for instance, would be much more likely to support greater levels of R&D spending than an institutional investor with shares in only one company. This is because positive externalities to other firms would be captured by the first investor, but not the second one.

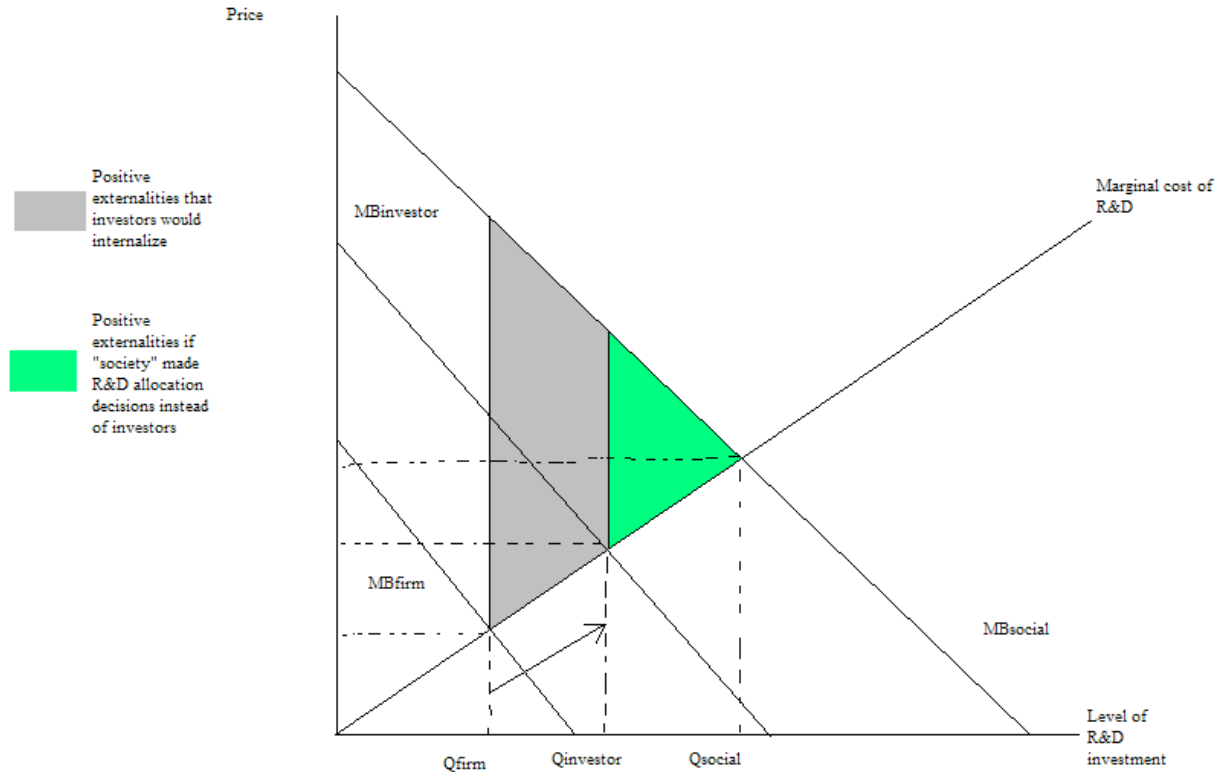
Social network analysis offers a means to capture the above relationship more clearly than traditional techniques. Unlike conventional statistical techniques, social network analysis treats actors as being mutually dependent upon other actors, depending upon their position within a network (Wasserman and Faust, 1994). For instance, in high schools, teenagers often make decisions about whom they befriend not only on the basis of the individual attributes of such a person, but also based on the various friendships that the prospective friend has with others. A well-connected brings the prospect of prestige, information and resources that a less connected friend does not. Menard (2004) employs social network

analysis in the business setting, arguing that in addition to traditional discussions of hierarchies and firms, there are hybrid structures that may obtain different results. Institutional investor networks offer a good example of a hybrid structure. Firms make decisions about investment in R&D, while institutional investors make decisions about which firms to invest in (and who to elect to the board of directors). Even where institutional investors lack explicit voting power, they have the threat of exit, bringing with them funds invested in the firm. The optimal hybrid structure would be one that maximizes the degree to which investors desire to internalize the externalities of R&D, up to and approaching the socially optimal level. The analysis above would suggest that the investors closest to this position would be those with the greatest centrality within the network. The most central players will have ties to the greatest number of firms and thus incentives closer to those of the industry as a whole. From this we can deduce a testable hypothesis.

H3: The greater the centrality of an institutional investor within the network of investors, the greater the amount of R&D in firms they invest in.

It may be instructive to return to the externalities graph developed earlier to demonstrate the above argument visually. **Figure 2** below posits the existence of three actors. On the one hand, there are firms, which have fairly myopic incentives in a certain level of innovation. On the other hand, there is “society”, which prefers some high level of investment in innovation. Institutional investors lie in-between these two extremes, according to the preponderance of empirical evidence. In practice, neither managers nor investors have perfect control over firms, and so the ultimate level of investment should lie somewhere between the preferred position of investors and that of managers. Hypotheses two and three would suggest that increasing the amount of investment and changing the rules to benefit investors would push the result closer to the ideal position of investors, and that of society. Hypothesis four would suggest that among investors those with greater centrality will be closer to the socially optimal position. All of the three hypotheses developed above suggest policy directions for governments. By incentivizing institutional investment, by increasing the relative control of shareholders over companies or by encouraging industry-wide investment by investors, governments can increase the amount of private research, without playing the dangerous game of picking winners.

Figure 2: Externalities and R&D decisions with an investor



The theory developed above understated the ability of institutional investors engaging in collusive behavior. Close competitors could avoid competitive research, instead coasting on existing discoveries. Such a strategy could easily survive in industries with relatively high barriers to entry. Adding that possibility would give eigenvector centrality in investor networks a non-linear form – low centrality firms would have neither the incentive nor ability to collude; moderately central firms would have the ability to collude, but insufficient preponderance of the market to be overly concerned with negative externalities to the industry as a whole; while the largest firms would have clear and overwhelming incentives to mitigate collusion, and foster long-term growth in the industry. From this we can draw a hypothesis:

H4: Innovation should be positively related to the square of eigenvector centrality.

Application

In order to test the hypotheses developed above, this paper opted to focus on a single industry group – the computer industry group as identified by the SIC (2009). While this decision necessarily limits generalizability, it has much to recommend it. Firstly, focusing on one industry group reduces the number of controls necessary, and allows us to focus on the key variables at hand. Secondly, the computer industry group offers a particularly hard case for hypotheses 2 and 3, and an easy case for hypothesis 1.

Graves (1988) based his myopic investor argument on the computer industry, while Silicon Valley formed an important case study for Porter (1990). Failing to confirm hypothesis 1, or failing to reject hypotheses 2 and 3 would offer considerable doubt on the cluster argument and myopic investor arguments respectively. Thirdly, it is worth stipulating that the analysis of this paper is far more relevant for high tech industries than it is for less research-intensive ones. It makes sense to focus on an industry where there is a clear case of the existence of externalities. A study with many industries might find its conclusions muddled by the combination of factors that are too unlike each other.

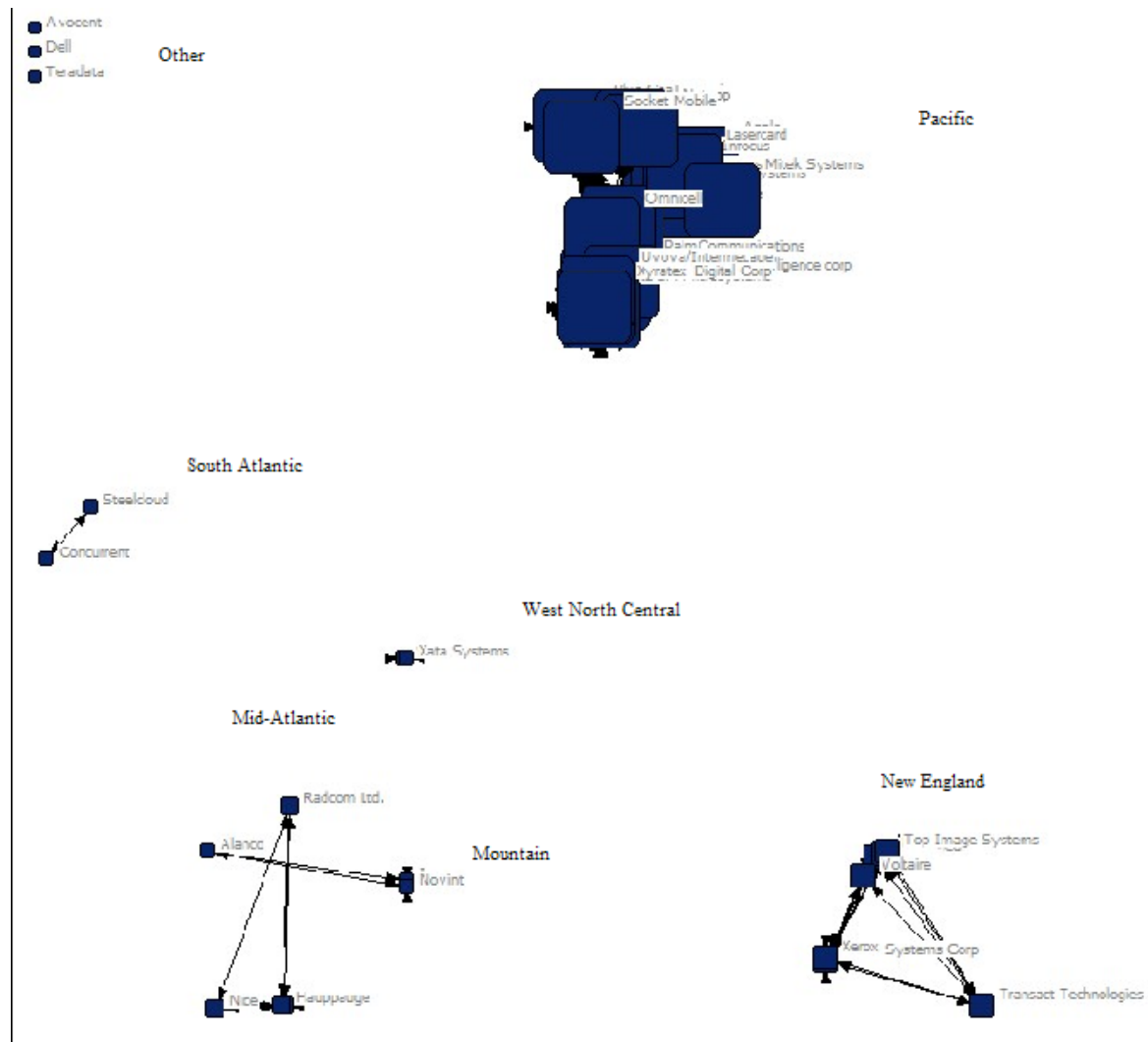
Data

As suggested in the theory section, this paper modeled the computer industry employing the insights of social network analysis. Following Kenny et al. (2006), this meant taking a multilevel approach. The computer industry is made up of mutually dependent pairs of firms (dyads), within which are nested individual firms themselves (monads). Leaving out particular levels of analysis induces bias into the model, and compromises results (Bryk and Raudenbush, 2002). Modeling each dyad accounts effectively for dyadic dependence. However, a simple multilevel model was impossible because monads are members of multiple dyads. In this case, a social relations model (SRM) was necessary (Kenny, 2006). There are multiple ways to build an SRM, but this paper opted for a round robin design. In a round-robin design, every member interacts with every other member (there is no interaction with oneself). Analysts must model any group interactions, within-dyad interactions and between-dyad interactions as distinct levels. In this case, there were five different levels (dyad, company, partner, industry and location). Random effects were included for each, except dyads, for which fixed effects were employed instead (Kenny, 2006). In order to limit heteroskedasticity and spatial autocorrelation, an unstructured variance-covariance structure was employed. A Satterthwaite approximation of degrees of freedom was used so that the multiple entries of monads (each monad appears 56 times). A minimum variance quadratic unbiased estimation of covariance parameters was undertaken (in place of MLE) to ensure a positive definite Hessian matrix.

In social network analysis actors, called nodes, exist in space, and hold relationships with one another. For our analysis, the relevant nodes were all active companies within the industry (SIC, 2009), trading on either the Nasdaq or New York Stock Exchange (Nasdaq.com, 2009), that had completed up to date SEC filings (SEC 2009) for the year 2008/9. Two kinds of networks were examined using that set of nodes. The first was a network relating nodes by membership in a cluster. If nodes had corporate headquarters in the same census region of the United States, they were considered to be part of the same cluster. Headquarter data was drawn from the SEC (SEC 2009). From the cluster data, UCINET's netdraw function was used to generate a degree centrality measure. Centrality is a measure of a node's

“importance” within a network, of which there are many variants. Degree centrality considers a variable to be “most important” if it has many linkages (Hafner-Burton et al, 2008). This is relevant to the cluster argument, since larger clusters have been hypothesized by Porter (1990) and others to correlate with greater levels of innovation. The cluster network is depicted graphically below in **figure 3**.

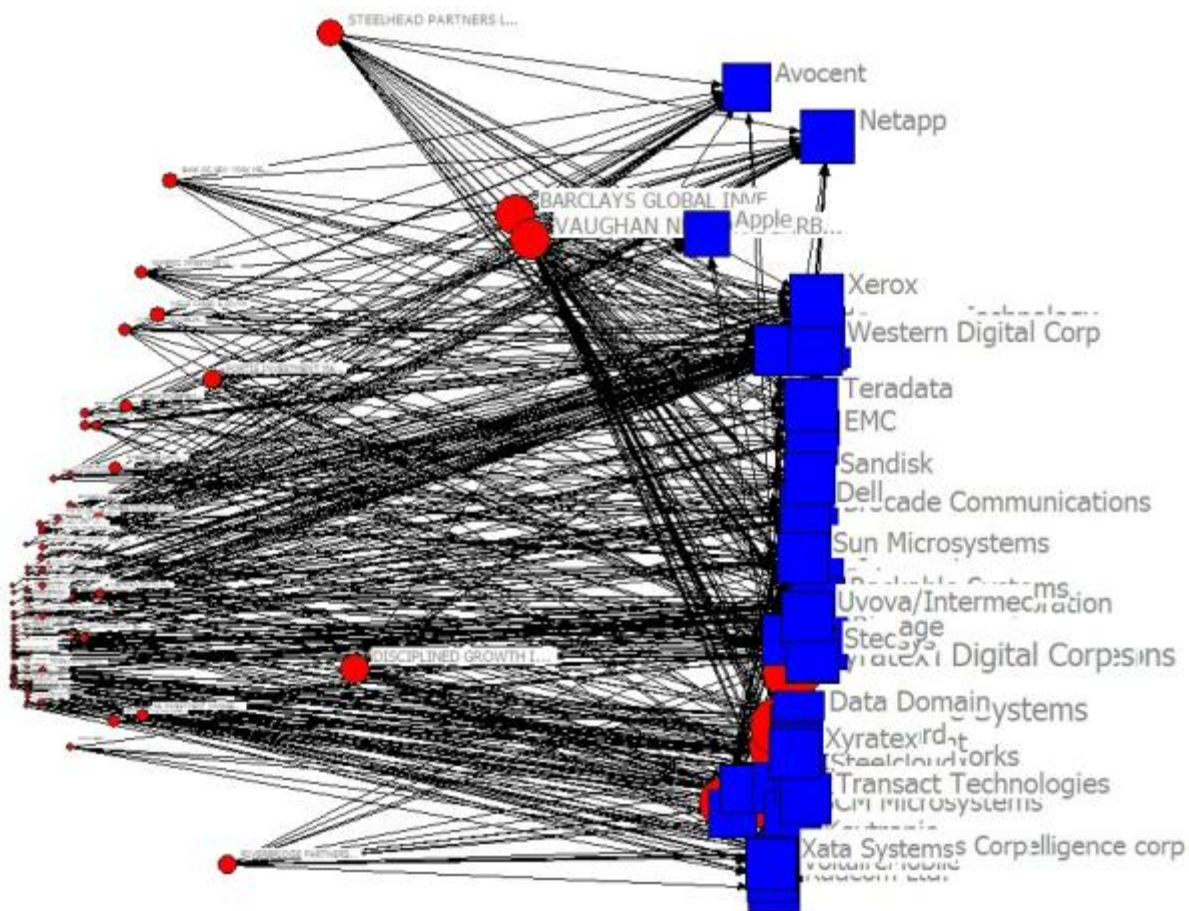
Figure 3



The second network, following Wasserman and Faust (1994) was a two-mode network of 252 institutional investors and the 56 firms (Nasdaq.com, 2009). Nodes in that network were said to have a relationship if an investor invested in a firm. The linkages in the two-mode network varied in strength depending upon the amount of investment. Once again, a measure of centrality was employed, but in this case, eigenvector centrality was employed. Eigenvector centrality reflects not only the number and strength of links between nodes, but also the centrality of nodes to which a node is connected. In other

words nodes get extra points for “sitting at the cool table” with other highly central nodes. For regression purposes, this paper was only interested in the eigenvector centrality of the firms. That data gives a good measure of how central each firm is within a network of investors. A highly central firm would have received investments from many highly central institutional investors with holdings across the industry - making it ideal to test hypothesis 3. The two-mode investor network is shown below in **figure 4**. Hypothesis 2 was much easier to test – the share of institutional ownership of a company was drawn from Nasdaq.com.

Figure 4



Finally, two simple controls were included in the model. Firstly, research spending is likely to be higher the larger a firm is. As such, revenue figures were taken from the latest annual report of each firm within the dataset (SEC, 2009). Secondly, it was also plausible that profits would be related to innovative activity. Firms facing troubled economic circumstances are less likely to either have funds for innovation or to be able to focus on the long-run, even if they had the money. After-tax profit figures were also drawn from annual reports (SEC, 2009).

Results

With all of the necessary data collected, a regression was run of research on the various controls and independent variables discussed above. First, an exploratory random effects GLS model was run. Many of the specification decisions above are quite conservative, and amplify the likelihood of missing some part of reality. The more conservative results can be compared in order to gauge the robustness of the model. The exploratory model below (see **table 2**) largely confirmed the expectations of this paper. Hypothesis 1 was not only rejected, but the sign of clusters was negative, as argued above. The data suggests that the larger the cluster, the lower the level of innovation. Institutional ownership and revenue were both positive and statistically significant, in line with expectations (and hypothesis 2). However, profit and the eigenvector (*inv32loc*) were statistically significant but negative, contrary to the hypothesized sign.

Table 2

Random-effects GLS regression		Number of obs	=	3080	
Group variable (i): dyadid		Number of groups	=	1541	
R-sq:	within = 0.5137	obs per group: min	=	1	
	between = 0.5136	avg	=	2.0	
	overall = 0.5136	max	=	2	
Random effects u_i ~ Gaussian		wald chi2(5)	=	2003.46	
corr(u_i, x) = 0 (assumed)		Prob > chi2	=	0.0000	
research	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]
<i>inv32loc</i>	-770.8667	72.61016	-10.62	0.000	-913.18 -628.5534
<i>instowners~p</i>	2715.895	157.0449	17.29	0.000	2408.093 3023.698
<i>profits</i>	-.1108224	.0123911	-8.94	0.000	-.1351085 -.0865364
<i>revenue</i>	.0419028	.0028464	14.72	0.000	.036324 .0474816
<i>clustdeg</i>	-1089.468	281.6406	-3.87	0.000	-1641.473 -537.4622
<i>_cons</i>	2404616	222140.9	10.82	0.000	1969228 2840004

Next, the more conservative model was run, in order to get more reliable estimates. The model was statistically significant overall, as indicated by the high Chi-Square value (See **table 3**). By far the most notable result was, unsurprisingly, that revenues were statistically significant and positive, suggesting that larger firms would spend a greater amount of money on conducting research. The second expected result was that the degree of institutional ownership was also statistically significant and positive. However, this result was only weakly significant, though it was fairly close to the 95% significance level. Of course, it is worth considering that Graves (1988) found a negative relationship in his investigation of the computer industry – this certainly does offer a firm rebuff to the myopic investor hypothesis. The other results observed truly defy expectations were largely challenged by interesting results. Cluster degree centrality

was not statistically significant, posing a blow to the cluster argument. Hypothesis 3, however, was also not supported by the evidence, in fact, the greater the centrality of a firm within a network of institutional investors, the lower the amount of research it conducted. Finally, the impact of profits of research and development was negative, contrary to expectations. This may reflect the fact that spending on research reduces net income, and represents an alternative to dividends. Some firms may tend to plough profits into research, while others, into higher dividends.

Table 3

Fit Statistics					
-2 Res Log Likelihood					78098.0
AIC (smaller is better)					78112.0
AICC (smaller is better)					78112.1
BIC (smaller is better)					78098.0
Null Model Likelihood Ratio Test					
DF	Chi-Square	Pr > ChiSq			
6	6563.19	<.0001			
Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > t
Intercept	2761545	1554451	41.9	1.78	0.0829
clusterdegree	4445.65	3775.47	129	1.18	0.2412
inst_Ownership	2329.91	1248.27	42.2	1.87	0.0689
profits	-0.1264	0.04398	39	-2.88	0.0065
revenue	0.04659	0.009341	41	4.99	<.0001
inv32loc	-930.83	506.45	41.9	-1.84	0.0732

Of course, the rejection of hypothesis 3 may suggest a very different dynamic at play. The theory developed above understated the ability of institutional investors engaging in collusive behavior. Close competitors could avoid competitive research, instead coasting on existing discoveries. Adding that possibility would give eigenvector centrality in investor networks a non-linear form – low centrality firms would have neither the incentive nor ability to collude; moderately central firms would have the ability to collude, and insufficient preponderance of the market to be overly concerned with negative externalities to the industry of doing so; while the largest firms would have clear and overwhelming incentives to mitigate collusion, and foster long-term growth in the industry. From this we can draw a hypothesis:

H4: Innovation should be positively related to the square of eigenvector centrality.

Finally, we turn to hypothesis 4, that there is a non-linear and positive relationship between eigenvector centrality and investment in innovation by firms. The model below (see table 4) offers strong

support to just that hypothesis – while centrality was linked with less innovation linearly, the most central investors appear to have strongly encouraged robust investment in R&D. The other signs remained unchanged, with the exception of the degree of institutional ownership, which lost significance.

Table 4

Fit Statistics					
-2 Res Log Likelihood					78058.0
AIC (smaller is better)					78072.0
AICC (smaller is better)					78072.0
BIC (smaller is better)					78058.0
Null Model Likelihood Ratio Test					
DF	Chi-Square	Pr > ChiSq			
6	5942.73	<.0001			
Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > t
Intercept	1.0509E8	32258305	40.7	3.26	0.0023
clusterdegree	4728.54	3614.97	147	1.31	0.1929
inst_Ownership	134.75	1338.64	41.1	0.10	0.9203
revenue	0.05730	0.009119	40.7	6.28	<.0001
profits	-0.2011	0.04647	40	-4.33	<.0001
eigensquare	10.7453	3.3839	40.6	3.18	0.0029
inv32loc	-67256	20892	40.7	-3.22	0.0025

Discussion and Conclusion

This paper examined a case where the odds were stacked against it – both the myopic investor argument and cluster argument have drawn much from Silicon Valley – yet has found evidence for hypotheses 2 and 4. That said, there are also some important qualifications that must be made to the above analysis. Looking at a single industry has some advantages, but also limits generalizability. Future research would do well to extend this analysis to the aerospace or pharmaceutical industries, for instance. Secondly, the addition of a time dimension would also add to the strength of any conclusions made. In particular, it may matter that this analysis is being conducted within the midst of a global recession. Moreover, adding a time dimension would enable the addition of changing government as a factor.

While the confirmation of hypothesis 2 was largely in keeping with an emerging consensus in the literature, the rejection of the cluster argument should give pause to policymakers. The notion that promoting regional clusters is the key to prosperity has become something of a panacea – an idea of some utility is being applied in many situations where it is not likely to yield positive results. The most

interesting findings of this paper regard hypotheses 3 and 4. What they suggest is that institutional investors in general have incentives that are similar to the firms they invest in – innovation is appealing largely because of the prospect of private returns. Indeed, there may be a dark side to networks in the capacity of institutional investors to organize collusion and anti-competitive behavior – something antitrust regulation has largely been silent on. At the same time, the firms at the highest echelons strongly encourage research, because their holdings are so wide that they can internalize the externalities of innovation. Barclay's, for instance, had 7 billion dollars invested amongst over 40 of the members of the sample under analysis. For policymakers, a nuanced result like this creates more confusion than clarity. How can governments encourage the latter sort of institutional investor, while discouraging the former?

Bibliography

- Abramowitz, Moses. (1986) "Catching Up, Forging Ahead and Falling Behind" in *The Journal of Economic History* 46. Pp. 385-406
- Acs, Zoltan and Audretsch, David. (1990) *Innovation and Small Firms*. Cambridge, The MIT Press
- Aghion, Philippe; Howitt, Peter; Brant-Collette, Maxine and Garcia-Penalosa, Cecilia. (1998) *Endogenous Growth Theory*. Cambridge, MIT Press
- Allen, F. (1993) "Stock Markets and Resource Allocation" in ed. Mayer and Vives. *Capital Markets and Financial Intermediation*. Cambridge, Cambridge University Press. Pp. 81-116
- Arrow, Kenneth (1962). "The Economic Implications of Learning By Doing" in *The Review of Economic Studies* 29. Pp. 155-173
- Aoki, Masahiko. (1984) *The Cooperative Game Theory of the Firm*. New York, Oxford University Press.
- Baldwin, John. and Gorecki, Paul. (1991) "Firm Entry and Exit in the Canadian Manufacturing Sector, 1970-1982) in *Canadian Journal of Economics* 24. Pp. 300-324
- Baptista, Rui and Swann, Peter. (1998) "Do Firms in Clusters Research More?" in *Research Policy* 27. Pp. 525-540
- Baysinger, B; Kosnik, R and Turk, T. (1991) "Effects of Board and Ownership Structure on Corporate Strategy." In *Academy of Management Journal* 34. Pp. 205-214
- Ben-habib, Jess and Spiegel, Mark. (1994) "The Role of Human Capital in Economic Development" in *Journal of Monetary Economics* 34. Pp. 143-173
- Bhojraj, Sanjeev and Sengupta, Partha. (2003) "Effect of Corporate Governance on Bond Ratings and Yields" in *The Journal of Business* 76. Pp. 455-475
- Bryk, Anthony and Raudenbush, Stephen. (2002) *Hierarchical Linear Models: Applications and Data Analysis Methods* Thousand Oaks, NJ, Sage Publications
- Buss, Terry. (1999) "The Case Against Targeted Industry Strategies" in *Economic Development Quarterly* 13. Pp. 339-356
- Chaganti and Damanpour. (1991) "Institutional Ownership, Capital Structure and Firm Performance" in *Strategic Management Journal* 12. Pp. 479-491
- David, Parthiban, Kochar, Rahul and Levitas, Edward. (1998) "The Effect of institutional investment on the level and mix of CEO compensation" in *Academy of Management Journal* 41. Pp. 200-208
- Drucker, P. F. (1986) "The end to the raiding roulette game" in *Across the Board* 23. Pp. 30-39
- Enders, Walter. (2004) *Applied Econometric Time Series*. New York, Wiley.
- Frankel, Marvin. (1962) "The Production Function in Allocation and Growth: A synthesis" in *The American Economic Review* 56. Pp. 966-1022
- Geroski, Paul. (1991) *Market Dynamics and Entry*. Cambridge, Blackwell.

- Geroski, Paul. (1995) "What do we know about entry?" in *International Journal of Industrial Organization* 13. Pp. 421-440
- Gertler, Mark and Gilchrist, Simon. (1993) "The Role of Credit Market Imperfections in the Monetary Transmission Network" in *The Scandinavian Journal of Economics* 95. Pp. 43-64
- Gillan, Stuart and Starks, Laura. (2000) "Corporate Governance Proposals and Corporate Governance" in *Journal of Financial Economics* 57. Pp. 275-305
- Graves, S. B. (1988) "Institutional Ownership and Corporate R&D in the Computer Industry" in *Academy of Management Journal* 31. Pp. 417-428
- Grossman, Gene and Helpman, Elhanan. (1991) "Trade, Knowledge Spillovers and Growth" in *European Economic Review* 35. Pp. 517-526
- Hafner-Burton, Emilie; Kahler, Miles and Montgomery, Alexander. (2008) "Network Analysis for International Relations" *working paper*
- Hansen, G. and Hill, C. (1991) "Are institutional investors myopic?" in *Strategic Management Journal* 12. Pp. 1-16
- Hartzell, Jay and Starks, Laura. (2003) "Institutional Investors and Executive Compensation" in *Journal of Finance* 58. Pp. 2351-2374
- Hill, Charles and Jones, Thomas. (1992) "Stakeholder Agency Theory" in *Journal of Management Studies* 29. Pp. 131-154
- Hirschmann, Albert. (1970) *Exit, Voice and Loyalty*. Cambridge, Harvard University Press.
- Hotelling, Harold. (1929) "Stability in Competition" in *The Economic Journal* 39. Pp. 41-57
- Jarrel, G; Brickley, J and Netter, J. (1988) "The Market for Capital Control: The Evidence Since 1980" in *Journal of Economic Perspectives* 2. pp. 49-68
- Jensen, M. (1988) "The Takeover Controversy: analysis and evidence" in eds. Coffee et al. *Knights, Raiders and Targets*. Oxford, Oxford University Press. Pp. 315-354.
- Jensen, M. (1991) "Corporate Control and the Politics of Finance" in *Journal of Applied Corporate Finance* 4. Pp.831-880
- Jones, Charles and Williams, John. (1998) "Measuring the Social Returns to R&D" in *The Quarterly Journal of Economics* 113. Pp. 1119-1135
- Kenny, David; Kashy, Deborah and Cook, William. (2006) *Dyadic Data Analysis*. New York, Guilford Press
- Kochar, Rahul and David, Parthiban. (1996) "Institutional Investors and Firm Innovation: A Test of Competing hypotheses" in *Strategic Management Journal* 17. Pp. 73-84.
- Krugman, Paul. (1991) "Increasing Returns and Economic Geography" in *Journal of Political Economy* 99. pp. 483-500

[Maddison, Angus. \(2003\) "World Population, GDP and GDP per Capita, 1-2003 AD" in Angus Maddison Faculty Page http://www.ggdc.net/maddison/Historical_Statistics/horizontal-file_03-2007.xls \(Accessed April, 2007\)](http://www.ggdc.net/maddison/Historical_Statistics/horizontal-file_03-2007.xls)

Mankiw, Gregory; Barro, Robert and Sala-I-Martin, Xavier. (1995) "Capital mobility in Neoclassical Models of Economic Growth" in *The American Economic Review* 85. Pp. 103-115

Mansfield, Edwin; Rapaport, John; Romero, Anthony; Wagner, Samuel and Beardsley, George. (1977) "Social and Private Rates of Return from Industrial Innovations" in *The Quarterly Journal of Economics* 91. Pp. 221-240

Markusen, Ann, Hall, Peter, Campbell, Scott and Deitrick, Sabrina. (1991) *The Rise of the Gunbelt*. New York, Oxford University Press

Menard, Claude. (2004) "The Economics of Hybrid Organizations" in *Journal of Institutional and Theoretical Economics* 160. Pp. 345-376

Mitroff, I. (1987) *Business Not as Usual*. San Francisco, Jossey-Bass.

Nelson, Richard. (1993) *National Innovation Systems: A Comparative Analysis*. New York, Oxford University Press

"Nasdaq.com" <http://www.nasdaq.com/> (accessed April 20th, 2009)

Nordhaus, William. (1969) *Invention growth and welfare. A Theoretical Treatment of Technological Change*. Cambridge, MIT Press

Olson, Mancur. (1965) *The Logic of Collective Action*. Cambridge, Harvard University Press

Ostrom, Elinor. (2005) *Understanding Institutional Diversity* Princeton, Princeton University Press

Pagano, Marco. (1993) "The Flotation of Companies on the Stock Market: A Coordination Failure Model" in *European Economic Review* 37. Pp. 1101-1125

Porter (1990). *The Competitive Advantage of Nations*. New York, Free Press

Rogowski, Ronald and Kayser, Mark (2002) "Majoritarian Systems and Consumer Power" in *American Journal of Political Science* 36. Pp 526-539.

Romer, Paul. (1986) "Increasing Returns and Long-run Economic Growth" in *The Journal of Political Economy* 94. Pp. 1002-1037

Romer, Paul. (2000) "Should the government subsidize supply or demand in the market for scientists or engineers?" in *NBER Working paper* 7723

Rugman, Alan. (1980) "Internalization as a General Theory of Foreign Direct Investment." In *Review of World Economics* 116. Pp. 365-379

Ryan, Lori and Schneider, Marguerite. (2002) "The Antecedents of Institutional Investor Activism" in *Academy of Management Review* 27. Pp. 554-573

Shell, Karl. (1973) "Inventive Activity, Industrial Organization and Economic Growth" in *Models of Economic Growth*. New York, Halsted Press

Smith Adam. (1994) *The Wealth of Nations*. New York, Modern Library Classics

Solow, Robert. (1956) "A Contribution to the Theory of Economic Growth" in *The Quarterly Journal of Economics* 70. Pp. 65-94

"Standard Industrial Classification system Search" in *United States Department of Labor: Occupational Safety and Health Administration website*. <http://www.osha.gov/pls/imis/sicsearch.html> (accessed April 2009)

Taylor, W. (1990) "Can big owners make a difference?" in *Harvard Business Review* 70. Pp. 70-82

Useem, M. (1993) *Executive Defense: Shareholder power and Corporate Reorganization*. Cambridge, Harvard University Press.

Uzawa, Hirofumi. (1965) "Optimum Technical Change in an Aggregative Model of Economic Growth" in *International Economic Review* 6. Pp. 18-31

Venables, Anthony and Krugman, Paul. (1995) "Globalization and the Inequality of Nations" *The Quarterly Journal of Economics* 110. Pp. 857-880

Wallsten, Scott. (2000) "The Effects of Government-industry R&D Programs on Private R&D" in *The RAND Journal of Economics* 31. Pp. 81-100

Wasserman, Stanley and Faust, Katherine (1994) *Social Network Analysis: Methods and Applications*. New York, Cambridge University Press.

Interactive Data Exchange Applications in *United States Securities and Exchange Commission website*. <http://www.sec.gov/spotlight/idea.shtml> (accessed, April 2009)