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A Preliminary Study of the Inter-firm Network of Mobile Media Business in the U.S.

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Abstract

This paper explores the structural properties and mechanisms of a small set of inter-organizational links between firms involved in the mobile media services in the U.S. Guided by network exchange and resource dependency theories, this paper explores how firms from telecommunications, media and technology sectors establish ties with one another to access and exchange important resources, and how the structural roles and interdependence of these firms are associated with their sectorial affiliation, business models and performance. A sample was compiled for the dominant companies in the sectors of network operators, media content providers, equipment manufacturers and IT enablers which have had business operations in the U.S. for a five-year period from January 1, 2001 to December 31, 2005. The data analysis reveals several preliminary patterns in the mobile media business. The overall sectorial difference between firms explains a low percentage of ties in the network. The revenue status of firms is weakly associated with their tendency to form ties across sectors, but is more strongly associated with their structural power in the network. Media firms do not seem to have a more diversified and dense network pattern, and have no relatively stronger structural power over other sectors of industries. Wireless carriers, in comparison, are more likely to hold certain broker roles in the network, and have overall stronger structural power that is measured in betweenness and exact power measures. Policy implications are discussed and future research directions are suggested.

A Preliminary Study of the Inter-firm Network of Mobile Media Business in the U.S.

A wide array of data services are commercially available on wireless communication devices. This paper concerns the business of information and entertainment content services such as ringtones, music, games, video clips, instant messaging and web portals that can be accessed or downloaded on mobile phones. Thanks to the enhanced network bandwidth and the improved multimedia and computing functionalities of mobile devices, mobile media business is growing at a remarkable pace, and is poised to become an important component of mobile commerce. It is technologically the cornerstone for the development of next-generation mobile internet, and economically a promising, albeit still small, source of revenue for many telecommunications and information technology firms (Standard & Poor's, 2004).

In the U.S., several key industrial sectors of technology and communications approach this emerging business with different assets, business models and objectives. With closed, proprietary control over the infrastructure, equipment and customer base, wireless carriers have long been in the gatekeeper position for the market of wireless mobile communications. Under constant pressure to recoup hefty investments in the infrastructure and equipment, nevertheless, they need to execute effective business models to increase the revenue from voice and data services (measured by average revenue per user, or ARPU) while lowering churn rates. Media firms control the valuable assets of talent and content, and their objective for mobile media services is to diversify the accessibility of their products over many distribution platforms. Technology enablers, including equipment vendors, application developers and web portals, have the important technical resources that would guarantee the interoperable and compatible delivery of media products over different networks and devices. It is imperative that these technology

enablers provide cater to a broad range of carriers and content providers with effective technical standards and solutions.

Some researchers suggest that the network of inter-organizational ties has substantially shaped the business models of respective firms in the business of mobile media services (Maitland, 2006). Specifically, firms have attempted to build links with others, in the form of joint ventures, strategic partnerships or mergers and acquisitions (M&As), in order to exchange for resources held by others, such as customers and networks. Global media conglomerates, for example, have mostly built non-equity alliances with a large array of wireless carriers and technology vendors in order to access their distribution resources that complement the diversification strategies deemed necessary in particular regions (Chan-Olmsted & Chang, 2006). Wireless carriers, on the contrary, are in a different position and mindset to establish partnerships for mobile data services (Carter, 2006; Noam, 2003, 2006).

This situation necessitates a well-coordinated value chain, in which the owners of different assets and capability participate in the delivery and added-value creation of the mobile media service. It has been stipulated that the structure of resource exchange and power distribution in such a value chain has important economic and policy implications about network openness and consumer welfare in mobile communications (Benkler, 2006; Noam, 2006). It would be premature, however, to make judgment about the power distribution between network operators or media firms without a careful review of the network structure of this mobile business chain. The power distribution of this inter-organizational network is not only shaped by the attributes of each firm such as industry sector, assets and goals; it is also constantly and dynamically regulated by the structural properties of the network at several levels. As Monge and Contractor note, “power is defined as a function of dependence on others in the network.” (2003: 212). In

this case, the power is patterned by the structural roles occupied by firms in the network, and the interdependence between these roles at various stages of the value stream.

This article explore the structural properties and mechanisms of a small set of inter-organizational links between firms involved in the mobile media services in the U.S. Guided by network exchange and resource dependency theories, this paper examines how firms from telecommunications, media and technology sectors establish ties with one another to access and offer important resources, and how the structural roles and interdependence of these firms are associated with their sectorial affiliation, business models and performance.

Network exchange and resource dependency theory

Network exchange and resource dependency theories are a set of formulations that explain the mechanisms and consequences of relationships of resource exchanges between individuals and organizations. The basic generative mechanism is that individuals or organizations forge links in order to access valuable sources of resources possessed by others, and yield control over their own resources that might be valuable to others. Such exchange linkages place individuals or organizations in particular structural positions in the network of relationships, which in turn influence the pattern of individual or organizations for forming new ties, or breaking ties. The resources exchanged between individuals or organizations could be in material or abstract forms, and the development of exchange ties could also be related to other types of relationships (Monge & Contractor, 2003).

Researchers have been mainly concerned with the structural, or positional outcomes of intra- or inter-organizational ties as the measures of power with which actors access or control resources to achieve bargaining advantages in a network. Their studies examine the association between the autonomy and dependency of individuals or organizations, and the structuring of

relationships within the network. An early paper by Evan (1965) proposes that the decision-making autonomy of organizations is related to the balance in the exchanges of various material and personnel resources between them and their organization sets, or their neighborhoods of inter-organizational ties. Benson (1975) has further framed the inter-organizational exchange links as a political economy in which firms acquire and exert power by controlling scarce resources. As a methodological refinement, Brass (1984) has usefully formulated the power as a function of certain structural measures on the network centrality of actors.

The studies of power function have resulted in the formulation of resource dependency theory that, along with network exchange theory, specify the structural mechanisms for firms to shield themselves from over-dependence on external resources and acquire more structural autonomy by strategically forging or breaking ties (Pfeffer & Salanick, 1978). This framework has led to a large body of literature on the ecology and evolution of alliances between firms (Monge & Contractor, 2003: 217-9). But the dominant applications of this framework, according to Monge and Contractor (2003), have been concerned with the structural mechanisms and positional outcomes of inter-organizational networks. There seems to be insufficient attention to the content of the relationships and their underlying, embedding social processes.

Recent research has attempted to strike the balance between the short-term positional outcomes of individual organizations, and their longer-term embedding social and structural environments, in the context of joint ventures and alliances across a range of industries (Borgatti & Foster, 2003). The direction, as Monge and Contractor also note in the development of value chain concept, is to identify the inter-firm network as an emerging, dynamic and embedded organizational form and social process that are entailed and enabled by resource reallocation, technology and economics. Research, for example, has shown that the effects of inter-firm

linkages need to be studied across various levels of dyadic, sectorial, group and social environments (Osborn et al 1998; Hagedoorn, 2006; Uzzi, 1996; De Wever et al, 2005). These embedding relationship structures have been shown to have moderating effects on the effects of resource allocation and power distribution of firms in the network (Hardy et al, 2003; Tang & Xi, 2006). Two recent studies have revealed, in depth and scope respectively, the structural effects on tie formation and bargaining advantages in broader socially embedding environments (Lavie, 2006; Powell et al, 2005).

In sum, the recent application of network exchange and resource dependency theories has shown that the control of and access to various sources of resources are structurally and socially embedded in the pattern of links at various relational levels. The power distribution among firms in an inter-organizational network is a structural process that is shaped by and shapes the interdependency between firms across dyads, sectors, and groups. Firms in many sectors form inter-organizational ties to achieve a wide range of strategic and functional objectives, such as organizational learning and failure buffering. But oftentimes, these effects are structurally and socially moderated at dyadic, sectorial, and inter-organizational levels in a longer-term process of social, economic and technological transformations. Therefore, the process of distributing and redistributing power in an inter-organizational network happens on many relational levels, and involve many structural and social mechanisms.

As suggested by Monge and Contractor (2003), such study entails a multi-theoretical and multi-level model, which takes into consideration the larger social context for the resources differentials of firms, and the relational configuration of firms. The positioning of firms in this network is both a structural property that explains the power of firms at individual, dyadic and group levels, and a social process that involves the motives and outcomes of exchange

relationships. This balanced perspective lends certain substantive and structural weight to the sometimes fluid and circular conception of power as both a mechanism and outcome of the interdependency in an inter-organizational network.

The Inter-organizational network in wireless mobile businesses

The business of mobile media services provides an interesting case for one to examine the structural and social dynamics of the resource interdependency among firms in the communications industry. The sources of resource and knowledge, such as equipment, infrastructure or media content, are traditionally thought of as static, proprietary assets of communication and media firms under various regulatory and economic terms. The digital convergence, however, has entailed a more dynamic, relative perspective on the motives and structural outcomes for firms to participate in the value network of mobile media services.

By pooling in vital resources, these firms collectively contribute to a value chain that completes its revenue stream at the end consumers of the mobile media services. The distribution of value among these firms is no longer purely determined by the static evaluation of their overall assets, although such evaluation still applies in the negotiation of revenue sharing schemes. The value distribution is related to the structural power with which firms coordinate interdependencies and maintain autonomy in the ecosystem of alliances to maximize their shares of the revenue pie. In the context of the communication industry, the effect of such structural power has also to be substantively interpreted in its embedding legal, regulatory and economic contexts within and across separate sectors.

The structure of the ecosystem of different sectors of industries, and the pattern of their interdependency in the value chain have proven to play an important role in shaping the mobile data services in some markets such as I-Mode in Japan (Natsuno, 2005). In the U.S. market

where there is intense oligopolistic competition in the wireless mobile industry, each operator pursues their own strategic alliances with content providers, manufacturers, and technology vendors, based on a complex combination of factors such as technology, asset and regulatory environments. The inter-firm network among these operators and their distinctive ensemble of partners, as a result, has a more complicated pattern. It is therefore necessary to structurally examine a) how different this network is from the i-Mode ecosystem, b) how the structural outcomes of such a network of alliances have shaped the business models and power of each sector of players, and c) partly, the development of mobile media services in the U.S.

Structure / Business Models

The first set of inquiry concerns the structure of the inter-firm network and the strategies of firms in each industrial sector. It looks at the differential effects of firms' attributes and the structural effects of network configurations on the emergence of inter-organizational ties. Given the concern of this paper with the network formation as a particular business model among all firms, it is first asked if there is a general tendency among the participants in the value chain to form inter-organizational ties, with the number of arches as a predictor.

Research Question (RQ) 1: Do firms have a tendency to form inter-organizational ties?

Researchers have provided different categorization to sectorize participants in the mobile value chain. Maitland (2006) argues that there are seven categories of market players: technology platform vendors, infrastructure and equipment vendors, application developers, content providers, content aggregators, mobile portal providers and mobile service providers.

Resembling the original wireline Internet service, another typology is proposed which includes content providers, content enhancement, content delivery, network operators and services, access

device manufacturers (Bensche & Ritter, 2003). Combining recent typologies, it is suggested that four different sectors of market forces are involved in the value chain: network operators, equipment manufacturers, software and application enablers, and content providers (Dholakia et al., 2006; Steinbock, 2005). Previous research has found that firms from different sectors differ in their propensity for inter-firm partnerships (Hagedoorn, 1996, 2006; Osborn et al, 1998). It is then proposed that actors from different industries will have different tendencies to form ties in the inter-organizational network.

Hypothesis (H) 1: The sectorial differences of actors in the network are related to their propinquity to form ties (business model).

According to the network exchange theories, organizations establish links based on the analysis of the cost and benefit of exchanging resources with each other. The more valuable the resource is, the more likely the owner of that resource is sought after and consequently establishes ties to exercise power (Benson, 1975). It is thus proposed that the assets of firms should be related to their connectedness in the network. As asset is a relatively static measure, another more dynamic metric, the financial performance as measured by revenue, is proposed to be related their inter-organizational tie-formation. It is hard to make direct comparisons between the assets held by different sectors of businesses, especially when such valuation differentials concern intangible goods such as media content. Therefore it is thus inappropriate to predict the effect of the differential assets in financial terms on their inter-firm alliances. The nature of this association is formulated as an exploratory research question.

RQ2a: Will the monetary value of assets held by firms be related to their propensity to form inter-organizational ties?

RQ2b: Will the revenues of firms be related to their propensity to form inter-organizational ties?

It is also interesting to further explore the specific business models of each sector of firms. Research indicates that the world's largest media conglomerates have mostly taken up fairly cautious wireless strategies in order to achieve product or geographic diversification, and align with firms that own complementary resources such as distribution channels. Specifically, Chan-Olmsted and Chang (2006) reveal that media firms have mostly established non-equity alliances with telecommunication firms that can provide conduit, equipment or wireless application services simply to achieve minimal presence without engaging in too much risk. They also find that media firms' networking activities with other wireless sectors are based on both endogenous factors, such as their financial performance, assets, and capability to mobilize content, and exogenous factors such as the size, growth, profitability and demand of wireless services. It is thus proposed that the size and density of the ego networks of media firms should be large, but their tendency to form ties is also related to the financial attributes of both the egos and alters in their ego networks.

H2a: Media firms have a high number of alters in their ego networks.

H2b: Media firms achieve high densities in their ego networks.

H2c: The financial performance of media firms is positively related to their tendency to form inter-organizational ties.

Studies show that although networks operators have not overwhelmingly engaged in providing mobile media services, the inter-organizational links they did build with content providers and IT enablers effectively strengthen their control over their assets as well as their independence from a single source of equipment and content (Carter, 2006; Noam, 2006). It is therefore proposed that network operators are highly inclined to build inter-organizational linkages to exert more gateway control and achieve more balance with other firms. From a

generative perspective, this is to test if being a wireless operator positively correlates with their position as brokers and star-hub centers.

H3a: The network operators are more likely to serve as the gatekeeper in their ego networks.

H3b: The network operators form ties to realize more 2-star and 3-star clustering in the network.

Research has suggested that the goal of equipment manufacturers and IT enablers is to achieve higher degree of interoperability for mobile media services (Steinbock, 2005). Ordinarily, they should be more active in forming ties with as diverse firms from other sectors as possible to achieve this goal. It is thus proposed that firms in these two categories have a large number of alters in the network.

H4: The equipment manufacturers and IT enablers have a tendency to form ties with different sectors in the network.

Now the inquiry turns to the effect of endogenous structural properties on the inter-organizational network. According to Monge and Contractor (2003), the generative mechanisms for relationships of resource exchanges should also factor in the betweenness measures of actors. But as this research does not examine the time series effect of the structural patterns in an earlier network, it is hard to construct the betweenness centrality of actors as a predictor for the tendency of firms to build ties when it is simultaneously also an outcome of the ties. To avoid making circular formulations, the research question simply explores the association between several structural configurations in the network and the presence of inter-firm ties.

RQ3: How are other structural configurations related to the tendency of firms to form ties, such as reciprocities, transivities and clustering?

Power

The second set of inquiry concerns how the power is distributed in the network of mobile media services as a result of the structural properties and attributes of each type of firms. Maitland (2006) suggests that the power of firms in such a network derives from their contribution to the end-customer value. That is, the measure of power for each firm should be the average value distributed to each participant in the provisioning of particular services (Christensen & Rosenbloom, 1995; Kothandarman & Wilson, 2001). Given that the current revenue sharing schemes for mobile media services are still determined by network operators in the U.S., it is likely that the power in this inter-organizational network is positively skewed towards those telecommunication firms. But other research also suggests that the control yielded by network operators could be weakened by media firms and IT enablers, which build their own portals to provide media products and bypass the network operators as gatekeepers (Dholakia et al 2006). Therefore different sectors of firms should have different structural power in the network, which is also related to the revenues as a measure of their contribution to the value chain. It is then asked how different sectors of firms have different structural power in the network as measured by their centrality scores, and how this distribution of power in the network is related to the revenues generated from the wireless business.

RQ4: Will the sectorial difference of participants be related to their structural power, as measured by centrality scores?

RQ5: Will the structural power of firms, as measured by their centrality scores, be related to their revenues generated in the wireless business?

Other than exogenous attributes such as sectorial affiliation and revenues, the bargaining advantages of firms could also be a consequence of particular pattern of ties in the network. As Brass (1984) shows, two types of structural power, closeness and betweenness, could be derived from the particular location of individuals in the social exchange network. Such location is a product of actors' dyadic relationships and the properties of their ego networks. Therefore the

question is how the structural power of firms is related to the endogenous structural properties in the network.

RQ 6: How is the structural power of a firm in the inter-organizational network related to the particular structural configurations of the network?

Methods

Sampling and Instrumentation

The actors in the inter-organizational network of mobile media services were assembled with both first-hand and second-hand data. In Chan-Olmsted & Chang (2006: 174), a select list was provided on the worldwide inter-firm alliance activities by major media conglomerates. Building on this initial dataset, a complete list was compiled for the dominant companies in the sectors of network operators¹, media content providers, equipment manufacturers and IT enablers which have had business operations in the U.S. for a five-year period from January 1, 2001 to December 31, 2005². Using the search algorithms provided by OneSource, a professional business database, a list of top earning companies ranked by the revenues in 2005 was assembled for each of these four industrial sectors, and combined into an inter-organizational network of 37 actors.³ Whenever there were major mergers between firms, the merged entities were counted as one actor in the network with all their previous activities combined.

¹ Only the six largest national wireless operators in the U.S. with infrastructure assets are counted in this category.

² This period is selected for a series of initiatives taken by the Federal Communications Commission to investigate the spectrum policy for next-generation wireless data communications. The auction for 3G spectrum was scheduled in July 2001, but was postponed for many regulatory reasons. See <http://www.fcc.gov/3G/>.

³ The wireless operator and equipment manufacturers were ranked by the customized industry profiles provided by OneSource under the SIC codes of 4812 and 3663 respectively. The wireless operator list was streamlined down to 6 largest national carriers as of 2005. The equipment manufacturer list has top 10 firms ranked by their annual sales of 2005. The software and application providers were ranked by the combination of several search variables provided for high technology industry. The search variables used for IT enablers are: Internet transaction/security services, Internet multimedia services, Internet search/indexing services, Internet web site related services and Other Internet related services. The search results are then cut down to the top 10 companies ranked by annual sales of 2005. The top media content providers were ranked by integrated information from both OneSource and DataMonitor with the annual sales of 2005 of the ultimate parent firms as the ranking criterion

The inter-organizational linkages are defined in several forms: strategic partnerships, joint ventures, and mergers and acquisitions (M&As). These information was mainly collected by searching the press releases and analyst reports organized in the category of “Strategic Partnership, Joint Ventures, and Business Deals” under the banner of “Significant Developments” in the company profiles of OneSource database. When no such category was available for a particular firm, a comprehensive search was conducted within the news, articles and analyst reports with the keywords “strategic partnerships” and “joint ventures”. Based on the total revenues in the annual 10-K reports by firms for 2005, the revenue on the mobile media business was estimated based on the business and geographic segmentation related to wireless services in the U.S. The data on wireless or digital assets was collected in the similar way. Other than the high-profile mergers between four wireless carriers, there were very few acquisitions across sectors reported with regards to the mobile media business in the U.S. from 2001 and 2005. Therefore the several acquisition activities were pooled into the records of joint venture and strategic partnerships.

The adjacency matrix was generated by counting the strategic partnerships, joint ventures and alliances between firms as publicly announced or reported by either party in the deals from 2001 to 2005. The resulting matrix was then imported into UCINET for Windows 6 (Borgatti et al, 2002), and symmetrized with the algorithm of Maximum. That is, the ties were reciprocated whenever an announcement was made by either party in the dyads. When there were discrepancies in the number of ties reported by either party, the maximum value was retained to achieve reciprocity while avoiding double counting the same tie. The adjacency matrix was dichotomized by the algorithm of Greater Than Zero whenever a binary matrix is needed. All the

hypotheses and research questions were tested with both the UCINET and PNet ERGM modeling software (Wang et al, 2006).

Results

The descriptive statistics of the dichotomized network shows that there are altogether 504 ties formed within the network, with a mean degree of 0.378 and standard error of 0.485. The density of the dichotomized network is 0.378, indicating a quite low degree of tie-formation. However, although the densities are generally low within and across sectors, there is a high degree of densities between media firms and all other three sectors, especially between media firms and wireless operators (density=0.694). The network centralization is 36.35%, and when the ties are valued, the network gets even less centralized (10.45%). This suggests that the network of mobile media services is decentralized, tie formation is less than active, and ties are likely to be confined only between existing pairs. The graph confirms such trends, indicating the positions of firms in the network vary by both degrees (size) and sectorial attributes (color) (Figure 1).

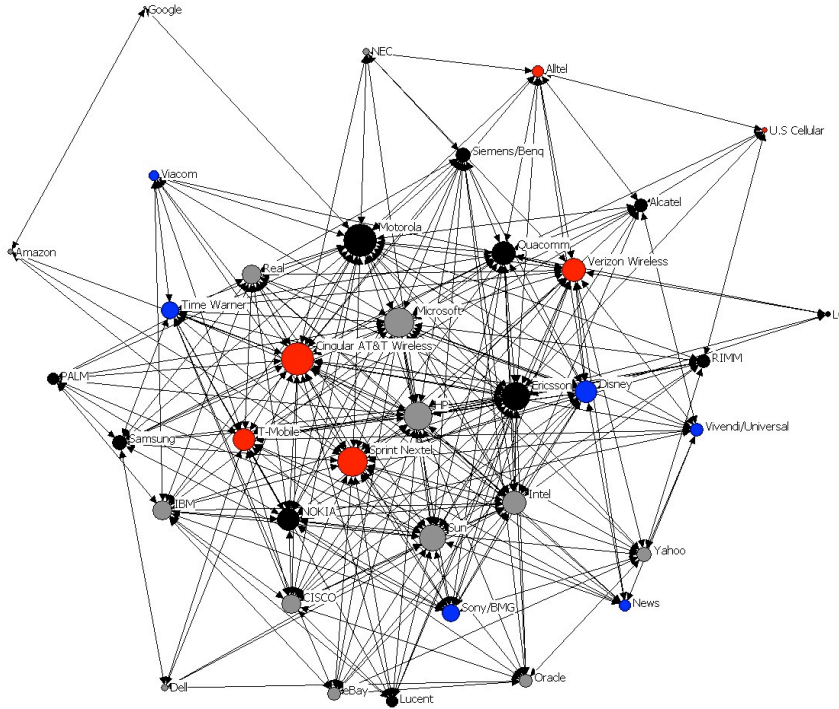


Figure 1 – Network of Mobile Media Services

The RQ1 asked if there is a tendency among firms to form ties. The ERGM model estimation procedure suggests that the presence of edges between nodes has a significantly negative association with the occurrence of the observed network, indicating that the tendency is low. (Edge: $\beta = -1.095219$, $t = -0.00357^*$). This is interpreted in the way that for any edge formed in the observed network, it decreases the likelihood of a tie between these actors in a random realization of the network. This trend is sustained even after the categorical attribute of firms was introduced. Neither the difference nor affiliation in nodes' business sectors has any obvious effect on the tendency of nodes to form ties (Edge: $\beta_1 = -1.102465$, $t = -0.00000^*$, Same Category Edge for Attribute1: $\beta_2 = 0.027736$, $t = 0.00000$, Different Category Edge for Attribute1: $\beta_3 = 0.000930$, $t = -0.00000$).

The H1 posited that there is a sectorial differential effect on the density of ties between actors. This was weakly supported. The analysis shows that the categorical differences between

media firms and wireless operators, and between media firms and equipment manufacturers, have significant effects on the development of ties between actors ($\beta_1 = 1.183, p < 0.005$; $\beta_2 = 0.729, p < 0.01$). But there are no significant effects for any other sectorial pairs, and the overall model only explains 11% of the variances in tie densities globally.

The RQ2a asked if the revenues of firms are related to their tendency to form inter-organizational ties. The analysis shows that there is significant but weak correlation between the revenue attribute and the normalized degrees of actors ($r = 0.565, p < 0.001$). The RQ2b asked if there is similar association between the assets and normalized degrees of firms. This was not supported, and there is no significant association between the two variables ($r = -0.226, \beta = -0.00003, p > 0.05$).

The combined P* model seems to partly confirm these results. The model with parameters on "Difference of Continuous Attribute: Revenue" and "Different category Edge for Attribute 1: Sector" converged, but the parameters themselves indicate that there is no significant effect of revenue differential on the likelihood of ties, and there is negative weak association between the sectorial difference and the occurrence of observed network. The edge parameter continues to indicate a negative association between the observed ties and the tendency of forms to form ties (Edge: $\beta_1 = -1.29, t_1 = 0.01^*$; Revenue Differential: $\beta_2 = 0.00002, t_2 = 0.0156^*$; Sectorial Differential: $\beta_3 = -0.11, t_3 = -0.08$). These parameters prove to be good fit in the Goodness of Fit tests ($t_1 = -0.06, t_2 = -0.07, t_3 = -0.08$).

The H2a and H2b posited that being a media firm makes it more likely to achieve a large size and density in their ego networks. These are not supported. Being a media firm or not does not significantly explain the variances in the sizes of ego networks ($F = 0.3451, p = 0.6$), although such effect on the densities of ego networks of media firms' ego networks approaches

significance ($F=2.99$, $p = 0.08$). The ego networks of media firms account for 75% of the total ties, indicating a moderate density of ties involving the media firms as content providers. The H2C posited that the revenues of firms are positively related to the densities of the ego networks of media firms. The analysis suggests the contrary. There is weak, but negative relationship between the revenue of actors and the densities of each actor in the ego networks of media firms ($\beta = -0.485$, $p = 0.01$). In addition, the association between the revenues of firms and the sizes of their connections in the media firms' ego networks is positive, but also weak ($\beta = 0.44$, $p = 0.015$).

The H3a posited that being a wireless operator makes it more likely for actors to be in the gatekeeper role in the network. This is partly supported. The ego networks of wireless operators comprise 97% of the overall ties in the global network, indicating a strong domination of wireless operators. The differentiation between wireless operators and all others has significant effects on the number of times an actor serves as a consultant ($F = 6.966$, $p < 0.05$), or as a Liaison ($F = 4.62$, $p < 0.05$). This indicates that wireless operators are more likely to broker links between firms from the same or different groups, despite that they do not belong to any of those groups (Hannemann, 2005). Although this finding does not directly translate into a gatekeeper role for operators, it does suggest that they have diversified links with firms from different groups.

The H3b proposed that wireless operators are likely to have a large size and high densities in their ego networks, and that they are likely to be in the 2-star or 3-star configurations in the network. This is partially supported. The ERGM model with 2-star and 3-star as structural parameters, and the binary dummy variable for wireless operators is inconclusive. The model parameters converge, but reveal weak effects of 2-star and 3-star parameters with the presence of wireless operator dummy variable. The Rb for Attribute parameter, measuring the "sameness" in

the sector of carrier, has a significant negative effect on tie formation likelihood, suggesting the tie formation between carriers is low ($\beta = -0.826$, $t = -0.03$). But there is no significant effect of other attribute parameters. ANOVA analyses were then conducted to examine the effect of differentiating wireless operators from all others on the size and densities of ego networks. The analyses show the categorical difference between operators and other firms significantly account for variances in the densities in their ego networks ($F = 3.99$, $p = 0.05$), but not size. This suggests that wireless operators are more likely to solidify ties in their neighborhood networks, but create ties with more firms.

The H4 proposed that the equipment manufacturers and IT enablers are also likely to have a wider range of alters in their ego networks. This is not supported. Neither of the dummy variables for these two sectors has significant effect on the variances in the sizes of their ego networks.

The RQ3 asked if the structural properties of the observed networks in general contribute to a higher likelihood of ties between firms, regardless of their sectorial differences. The ERGM model produces converged parameters, but does not turn out to be a good fit. The edge parameter turns positive ($\beta = 2.829$, $t = 0.01$), with all other structural parameters having weak effects on the occurrence of ties except for K-star ($\beta = -1.839$, $t = 0.01$). But the overall goodness of fit is less than satisfactory. It is thus determined it is unclear how the structural properties of the network beyond dyadic level have any effect on the tendency of firms to form ties.

The RQ4 asked if there is association between the sectorial difference and the structural power of firms as measured by their centrality scores. The analyses yield mixed results. When all four sectors are introduced in the model, the sectorial difference has no significant main effect on the variances in the Freedman degrees, betweenness and closeness scores. But when the global

difference variable is replaced with the dummy variable for wireless carriers, the sectorial difference has significant effect on the variances in the betweenness scores of firms ($F = 4.96$, $p < 0.05$). Being a wireless operator also has significant effect on having higher flow betweenness ($F = 3.9$, $p < 0.01$), and exact power ($F = 5.55$, $p < 0.05$). The other two dummy variables for media industry and equipment manufacturers have no significant effect.

The RQ5 asked if the financial performance of firms has any association with their centrality scores. The analyses show that the revenues of firms are significantly related to each of their centrality measures (Closeness: $r = 0.5$, $p < 0.001$; Betweenness: $r = 0.45$, $p < 0.005$; Degree: $r = 0.56$, $p < 0.01$). The correlation is weak, but there is positive relationship between the revenues and structural power of firms.

Discussion

The data and analysis only provide inconclusive information on the inter-organizational ties formed by firms involved in the mobile data services. For the time period from 2001 to 2005, the aggregate realization of this network indicates that there is low tendency among firms to form such ties. The overall sectorial difference between firms explains a low percentage of ties in the network. But the difference between media firms and wireless operators, and between media firms and equipment manufactures, have a stronger effect on the formation of inter-organizational alliances. The revenue status of firms is weakly associated with their tendency to form ties across sectors, but is more strongly associated with their structural power in the network.

As for specific industrial sectors, media firms do not seem to have a more diversified and dense network pattern, and have no relatively stronger structural power over other sectors of industries. The financial performance of firms does not seem to be a strong factor for media

firms to strengthen ties, but it does lead to a more diversified pattern of inter-firm alliances. Wireless carriers, in comparison, are more likely to hold certain broker roles in the network, and have overall stronger structural power that is measured in betweenness and exact power measures. They also tend to avoid ties with other carriers. Their ego networks have higher densities in their ego networks, indicating that they have close-knit, but not more diverse relationships with their partners. There is not obvious association between the structural properties at dyadic, triadic and cluster levels and the generation as well as structural power of firms.

The analysis reveals several preliminary patterns in the mobile media business. Different sectors of firms participate in the value chain, but it is unclear how the business models and power distribution can be generally differentiated among media firms, carriers, manufacturers and IT enablers. Therefore, it is no longer appropriate, in the case of mobile media business, to use the conventional business sector as an embedding social context to explain the development of inter-organizational ties for all actors. This indicates that the modern communication industries have greatly diversified their assets and activities in the current era of digital convergence. The social processes surrounding their networking patterns should no longer be bounded by their static industrial sectorization. This, in a way, underlies the similar changes identified by many scholars in the convergence of media and technology (Poole, 1983; Noam, 1994), which necessitate the modification of regulatory regimes for policy-makers, and reshuffling the business strategies for firms in the communications industry.

Being a carrier, however, does matter significantly to the business models and power distribution in this value chain. This might make sense, because although the digital technology is enabling more diversified cross-sector businesses, the telecommunications still remains a stronghold whose infrastructure, network and regulatory regimes are not likely to be changed in

the short term (Noam, 2006). If anything, the preliminary results confirm that wireless operators still hold great power and are more active in forming inter-firm ties, even under this generally obscure network of mobile media services. This raises questions as to if sufficient regulatory and market initiatives are taken to check on the exclusive control of wireless carriers over their assets and customer base, while the convergent trends are blurring the boundaries between other sectors of the communication industry and loosening the control over their assets or business models. Media firms, for example, have a less pronounced power over this inter-organizational network, save for the fact that they do intend to form partnerships with as many as possible to diversify the presence of their products. Scholars' concerns (Benkler, 2006) with the absolute control of carriers are justified in this case. But at the same time, revenue is also significantly associated with both the degrees and structural power of firms. The financial power does matter and seems to be a more reliable predictor for many indices of interest. It thus remains to be seen how the financial performance will continue to be a stronger factor in the inter-firm alliances, regardless of the sectorial differences that are no longer useful.

Limitations

As a preliminary project, this paper has serious limitations. It collects data on the aggregation of ties over a long time period, while in fact there is a time-series effect on the evolution of ties. It examines the statistical relationship as a purely univariate one, while in fact the models should be best tested with multiple independent categorical and continuous variables, as well as their interaction terms. It arbitrarily sets the sectors for firms as media firms or wireless operators, while in fact many firms have very diversified investments, assets and activities that are no longer bounded by one single sector. All these culminated in the poor support for hypotheses and research questions from the data.

Such limitations are attributed to both theoretical and methodological constraints in network analysis and communication studies. The UCINET, for example, does not have enough tools to support more flexible model specification with more than one predictor variable and more importantly, the possible interaction effects between possible predictor variables. The P*Net tool provides useful support in estimating the predicative power of both structural and attribute parameters, but it is hard to use the same exponential modeling techniques to model the distribution of power on various salient parameters, and examine the interaction relationship between the attributes of actors and their positions in specific structural configurations.

In addition to these technical and methodological constraints, there are also several theoretical caveats that delimit the effectiveness of this research. The first is the circular formulation of the structural roles of actors in exchange networks as both a generative factor and a power outcome, especially when such networks are examined in cross-sectional data. Although it would be ideal to model the relationship between the realization of certain configurations in an observed network and the distribution of centrality among actors, it is theoretically and technically infeasible to do so. But such an association should facilitate the substantive interpretations and predications over the structural development of the network. Designing a panel research on the development of inter-organizational network would have solved the ontological difficulty encountered in this research, but it would still require additional theoretical work to formulate the association between structural power and structural configurations at dyadic, triadic and group levels at any given time.

The second is in the application of inter-sectorial, or other less tangibly discriminating categorical attributes, into the study of inter-organizational networks or any other networks that involve resource exchange and dependencies. The original network exchange and dependency

theories examine the resources held by organizations and the pattern of interdependencies on these resources between entities, but it gets less clear how to formulate the effect of the additional sectorial layer on the inter-relationships and roles of actors, when a socially bounded collectivity of entities with similar assets and resources form inter-organizational ties. The set of community ecology theories could have solved some of the problems, but as many firms in different populations (sectors) hold diversified assets and business strategies, it gets difficult to define and operationalize their population or sector boundary in the formulation of inter-organizational network. This situation might require tedious modeling on the most powerful methodology to sectorize actors with many in-block and between-block specifications, before any structural analysis could be performed on a multi-sector network.

This paper builds on previous business studies on the strategies and power of media firms and operators in the new mobile data services. But its inconclusive results show that more work needs to be done to first operationalize the sectorization in a more rigid and dynamic way. As the cross-sector behavior proliferates among firms involved in digital media businesses, the arbitrary boundaries set for firms need to be constantly validated in the structural outcomes of the inter-firm ties. The sectorization of industries has to be informed by both the structural configuration in the network they form, and the social process that are simultaneously happening to them. That is, the embedding environments of actors, such as the sector, constantly interact with the structural configurations of actors' positions in the network. This mutual process shapes the very development of inter-firm ties, and the power distribution of actors within the network.

It does not suffice now to claim and examine if the media firms, or carriers, have more power. The question should be how the definitions of media industry or telecommunications industry as such are being reshaped by the restructuring of ties between various firms in the

network. Understanding this, it would be more revealing to discuss the power distribution between firms in a network that continues to blur the arbitrary categories imposed from conventional wisdom on the media, telecommunications and technology industries. If anything, this article confirms that the outcome of convergence is the inter-firm network between sectors, and such network continues to reinforce the trend towards convergence.

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