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Network Structures in Industrial Pricing: The Effect of Emergent Roles in Tokyo Supplier-Chain Hierarchies

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Authors

Nakano, Tsutomu
White, Douglas R.

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INTRODUCTION: PRODUCTION-CHAIN MARKETS, BUYER-SELLER EXCHANGE RELATIONSHIPS, AND PRICE EQUILIBRIUM

This paper seeks to theorize tangible, interactive, social constructions of markets, following the lead of Harrison White's *Markets from Networks* (2002a). How do buyers and sellers, composed into markets, shape their ties? How do their ties, and the emergent structure of their networks, shape markets and economic behavior? Focusing on the duality of decision-making and market structure, network sociology shares with the field of network economics (e.g., Plott 2001a) a common concern with the foundations of economic systems as networks. In his book, White focuses on firms in modern production-chain hierarchies as organized "mobilizers of production in networks of continuing flows" (2002a:1). He looks beyond buyer-seller relations to how decisions are affected as well by the critical roles of supplier-producer-purchaser—one more role than usual in economics—as they are situated within the complex network structure of firms for which market links involve the stages and processes adding value in production chains.

Contemporary production markets show the hallmarks, in their network and role structure, of "persistent directionality in continuing flows of intermediate goods" in which "only a niche within an industry establishes you in a line of business" (Harrison White 2002b:87). White constructs a pricing model from the structural standpoint of networks. "Firms do indeed seek to maximize profits, but only as they find quality niches in recognized lines of business sustained as joint social constructions" (2002a:xiii). "There is also a larger view, in which each market is a by-product of dependencies of its own flows on actions around origin and destination markets. For more than a century, the social sciences have groped through a fog of custom that grew around and with this new institutional system centering on a new species of market."¹

Our study begins from an empirical study of production markets. We ask: What insights can we incorporate from network economics as to relational properties of the markets that are likely to affect pricing? What potentially price-affecting configurations might be evident in a complex production-chain market? A major and specific question, for example, is posed in the context of large-scale network analyses of a supplier-prime buyer network dataset for over 8,000 firms in the large-scale regional industrial cluster of Tokyo (Nakano and D. White 2006a, 2006b, 2006c): Does the larger network structure of commodity chain markets generate potentially noncompetitive prices that are then passed on and amplified by successive producers in the supply chain of manufacturers? If so, we shall have uncovered a major structural feature likely to generate noncompetitive prices in modern industrial markets, one that calls attention to global differences and variable constraints in markets. The most salient constraints relevant to this question begin at the lower levels of the supplier hierarchy and amplify upwards. These lower levels are where monopsony is common: solitary buyer arrangements that may preclude choice

¹ White (2002b:87): "most markets today regulate production flows of goods and services, rather than exchanges of existing stocks as in traditional views of markets." A fundamental difference between production markets based on the notion of exchange of goods and services and financial markets, according to Knorr-Cetina (2006), comes from the speculative nature of the latter. The actors in the financial markets constantly change their positions as either buyers or sellers and therefore there may be cases where an enduring institutionalized role structure does not exist in the markets, whereas actors in production markets tend to take more fixed roles as buyers and sellers over a prolonged period of time. These points are not salient in the economics literature on exchange.

among alternate buyers. This structural feature may lead toward lower prices by the suppliers affected, with these lower costs being passed upward in the production hierarchy.

Our findings on market network structure in Tokyo industrial markets bear close comparison with White's findings in *Markets from Networks*.²

- Our results showed that the supplier/prime buyer relationships are consistently hierarchical in direction and constitute a directed acyclic graph (DAG). This agrees with White's model of industrial hierarchy.
- The salient global properties of the large and sparse networks (LSN) that compose our specific Tokyo industry value-chain hierarchy are those, first, of a giant connected component of firms. Within it, second, we find a giant cohesive industrial core of firms that form a *bicomponent*, a maximal set of firms with multiple paths (ignoring direction of links) between every pair. Third, a bicomponent of buyer-seller ties suggests a network core whose properties, to the extent that there are many firms on each side of market transactions, may be sufficient to generate competitive market equilibrium pricing.
- The bicomponent of firms with multiple market choices for buyers and sellers also contained firms at the deepest end-production or "core" levels of the supply-chain hierarchy. This is sufficient to allow a focus of study on a production market hierarchy along lines suggested by H. White.
- These properties (Nakano and D. White 2006a), along with low clustering of ties and short average network distances (even lower and shorter than those of comparable random graphs), motivated rejection of both the small-world (Watts and Strogatz 1998) and scale-free (Barabási 2002) network models as models of hierarchical markets. Neither has any specific fit to Harrison White's framework or theory. Although the distribution of the number of suppliers for each firm approximates a power law, the notion that buyers have a scale-free "attraction" because suppliers imitate others already so attracted is misleading: Here, as elsewhere, supply chains are largely organized from producers downstream to the upstream (hierarchically lower ranked) suppliers. The conditions under which firms undertake and coordinate this network organization, reducing uncertainties in supply chains, are well theorized by H. White (2002a) rather than by Barabási.
- We found evidence in the Tokyo industrial cluster, not inconsistent with White (2002a), of a structural divide capable of recursively generating unequal distributions of wealth, not on the basis of firm size but by status ordering among firms in the "elite core" and the rest (Nakano and D. White 2006b). The more powerful core of "elite" firms within the network consists of a small number of original equipment manufacturers (OEMs) and their "elite" suppliers, all positioned toward the top of the hierarchy of the large cohesive core, i.e., among Harrison White's downstream end-producers that sell to global markets.

Our Tokyo findings led us to undertake a fresh study of general price mechanisms and of these production-chain markets from a network economics perspective. We noted that some exchange-network link configurations have the power to affect prices, and found evidence of network structures that may produce price advantages accruing to "elite core" firms downstream in the global markets at the expense of the vast majority of SMEs (small- and medium-sized enterprises) in the supplier upstream (Nakano and D. White 2006c). Consistent evidence for these possible effects on price advantages was found in the prevalence of single-buyer monopsonies upstream or low in the production hierarchy, precisely where structural effects on prices would favor elite high-end buyers.³

The present paper begins with some basic definitions and models from network economics

² Harrison White's model should be generally applicable, under certain conditions, to production-chain rather than financial markets. For debates over White's model, see for example, Swedberg (2002) and Knorr-Cetina (2004). In production markets actual exchange of tangible goods or services are involved among a limited number of producers as sellers, according to White, *who carefully watch one another's strategic actions regarding production volume and pricing*. This is consistent with our questions about pricing, wherein "sellers who carefully watch one another's strategic actions regarding production volume and pricing" constitute oligopolistic, not competitive markets. There are no strategic actions in fully competitive markets.

³ Data collection biases do not account for these results because each supplier was asked to report their top three buyers, so that potential monopsonies could be identified for firms that specifically reported one but not two or three buyers.

relevant to the study of pricing mechanisms in production-chain markets. These provide greater conceptual precision with which to incorporate our past insights and explore their ramifications. There follows an overview of the research design and methodological issues, including data, concepts, axioms and hypotheses, and analytical tools from the study of complex networks. We calculate network analytical measures, such as components, hierarchies, and different kinds of concepts and measures of hierarchical roles. We show illustrative graphs of the industrial production-chains for these different types of roles using Pajek software (De Nooy, Mrvar and Batagelj 2005). We show how the multiconnectivity of buyers and sellers as contrasted with single-buyer monopsony and single-seller monopoly may affect pricing and the differentiation in costs and benefits for buyers and suppliers located at different positions in a regional subcontracting hierarchy. After recounting some network properties and integration mechanisms of the production-chain market, we consider in detail how structural positions due to each firm's number of buyers and sellers and how firms are differentially situated in the hierarchy may affect pricing. Here, we build on the ambitious and useful modeling effort of Kranton and Minehart (2001) to provide network economic definitions, axioms, and theorems relevant to the relation of pricing to the network structure of exchange and market transactions.

As for generality of results, the particular Tokyo industrial district cluster that we study (Ohta and surrounding buyers of its suppliers' products in neighboring districts) is illustrative of one of the large-scale, production-chain markets found in many parts of the world where advanced, high-tech manufacturing is embedded in a regional cluster. The theory we apply is very general. Matched with the generally multinational characteristics of the leading firms of this district, our results on the questions we address should provide insights into similar problems in many market settings. We review the limitations generated by how our data were collected, the advantages of our means of extrapolating from our data, and why we stuck with extrapolating to buyers in the larger Tokyo regional industrial networks rather than limiting the analysis to Ohta proper. These and several other statistical sampling limitations did not necessarily detract from the generality of our findings but instead support important findings at the level of the larger regional hierarchy of production chains.

We advance two axioms that express the respective concerns and theoretical perspectives of network economics and network sociology, and we argue that both perspectives and conceptual frameworks are necessary in modeling elements of global and regional economies. From these complementary perspectives we advance and test four hypotheses concerning the effects of network configurations that may influence whether pricing is competitive or noncompetitive, and of the positions of buyers and suppliers in industrial hierarchies that may affect these configurations.

Network Economics and Price-Altering Mechanisms

There is a vast antitrust literature that uses terms like barriers to connection (a term unknown to many economists) or barriers to entry in a market,⁴ phrased as new connections, that deals in a remarkably accurate fashion with the effect of links in networks. Network and experimental economics also deal with the effect of links on prices, as does general equilibrium market economics in dealing with effects of monopsony, monopoly, duopoly, etc., although unable to derive equilibrium pricing from them. Economists deal with these problems in ways not easily

⁴ There are also many studies that discuss entry barriers theoretically or empirically, on the foundations of organization theory developed largely in the tradition of sociology and corporate strategy in business economics.

accessible to sociologists. Noussair, Plott, and Riezman (1997; 2007) show that the competitive pricing model works well in solving problems of coordination when the markets are organized as continuous double auctions. But they show that coordination is not effective in monopolistic markets. According to Plott (personal communication), “each link gets so clogged with attempts to get monopoly profits that work their way additively through the chain” that volume and profit almost dry up. Plott and Callander (2002) show that competitive equilibrium pricing emerges with knowledge of transaction histories in directed cycles in networks. Hirota, Hsu, Plott, and Rogers (2005) show in experiments that cyclical exchange can have the instability of “expanding orbits” in similar form to what is predicted by theory. Following the directions of Peng and Plott (1998), Plott's chapter (2001b) and his book (2001a) provide findings on economic interdependence wherein theoretical principles, simulation, experiment, and case-specific studies are brought together. What is missing, according to Plott (personal communication), is a complete and general theory of the link formation process. That is not our problem here, however, as we are addressing sociological questions raised in the framework of H. White (2002a) that we will expand further and more precisely through network economic definitions and models illustrated in the work of Kranton and Minehart (2001).

Network concepts have been widely applied in social sciences since the 1980s and, more recently, in the new field of network economics. Kranton and Minehart (2001), for example, proposed a theory of buyer/seller networks in which they attempted to explain equilibrium pricing mechanisms from the point of view of ties between buyers and sellers in economic exchange. For a simplified network model of buyer-seller pairing in transactions where no seller's good can be allocated to more than one buyer, and to no buyer from more than one seller, they show, by the marriage or pairing theorem (Roth and Sotomayor 1990), that a *feasible* allocation of goods requires that every subset of k buyers is directly linked to k or more sellers. They prove that (1) a Walrasian auction of ascending bids is able to clear offers by sellers for paired transactions in a fixed network with feasible allocations; (2) price equilibrium exists if each buyer remains in the bidding up to its valuation of the good; (3) this equilibrium is *efficient* for any given valuation of goods by buyers in the sense of yielding the highest possible surplus; and (4) the allocation of prices are pairwise *stable*.

Our interest now is to follow out the implications of one of Kranton and Minehart's goals by using their theorems to help evaluate *how the patterns of buyer-seller links might affect prices and competitive (or imperfectly competitive) allocations of goods*. They note that the outcome of the Walrasian auction is that buyer i pays the seller the valuation of the “next-best” buyer, i.e., the valuation of the buyer that would have obtained the good in i 's place, so that prices reflect the social opportunity costs of a given link structure. This implies that if, in the link structure, there is but a single buyer for a given good offered by a set of sellers, this *monopsony* operates even for a single seller to lower the price needed to clear the market—although there is no general solution to the monopoly-monopsony problem to determine this lowered price. The inverse, monopoly, is where a single seller for a given good is sought by a set of buyers. A single seller for a given good sought by a set of buyers, however, is excluded as infeasible in this particular model for sets of buyers greater than one. Their model simply makes the restriction here that “no seller's good can be allocated to more than one buyer” (Kranton and Minehart 2001:6).

Kranton and Minehart's economic models do not consider the problem in real terms of how network links may affect prices in a production-chain market. Instead, they reverse the problem to consider the motivations of buyers and sellers to *form links* so as to affect prices. A buyer that adds a costless link will decrease prices (sellers compete) while a seller that adds a costless link (buyers compete) will increase prices (Kranton and Minehart 2001). From this viewpoint of

approaches to competitive market equilibrium, assuming that opportunities exist to form costless links (and that buyers and sellers cannot preclude others from forming links), an empirical prediction would be that all buyers link to at least two sellers, and all sellers to at least two buyers.

Kranton and Minehart's (2001:487) main result "shows that when buyers compete in this way, their individual incentives to build links can be aligned with economic welfare." They include in economic welfare the gains to buyers who, by linking to a given supplier and increasing the supplier's level of output, can share the lower costs attributable to economies of scale. This is what they term the *economies of sharing* of which they say "it may be optimal for the buyers to share the capacity of just two sellers," and in this model they do allow buyers to have two sellers and sellers two buyers. They also redefine *efficient* link patterns as those where the cost of any additional link is more than balanced by the expected gains from exchange, and they allow the number of sellers in the network to fall below that of the number of buyers. The gain from fewer sellers relative to buyers in this case "arises from the variability of the buyers' valuations and the implicit assumption that productive capacity is costly," and they later introduce these costs. The view here is one of buyer "investment in links as long-run investments in anticipation of short-run uncertain demand for goods" (Kranton and Minehart 2001:492).

Research Objectives: Comparing Network Economics with Our Network Analysis

Using Kranton and Minehart's network economics model as a comparative baseline, the objective of the present research is to further study market mechanisms of production-chains from a theoretical viewpoint that engages our empirical results from the industrial district in Tokyo. One key unanswered sociological question in our previous study is whether the heterogeneous mix of large and small firms at different scales and hierarchical levels within an industrial district breeds noncompetitive price-affecting power. Another is the relevance of network positions of firms within the complex industry value-chain network, which we hypothesize may work to the advantage of large, elite, downstream firms.

In order to integrate detailed micro-level mechanisms of the complex industrial network with our previous findings at a macro-level, we employ innovations both in theory and in quantitative analytical techniques to probe the large interfirm trade-relationship data among suppliers and their prime buyers in the Ohta regional cluster. Examples of the outcomes of these new methods include the ability to pinpoint and numerically inventory the monopsony buyers, and to examine the different ways that firms are positioned in the network hierarchy according to different conceptions and measures of hierarchical roles.

Kranton and Minehart's general network economic modeling, although discussed exclusively from the buyer's point of view, is directly relevant to our study of the industrial district and includes issues of monopsony. They consider how links or exchange ties in the production-chain market involve not only the costs and benefits of linkage but strategic incentives by end-producers to "share" a single supplier whose greater volume allows them to achieve economies of scale and to lower the prices received by those suppliers. While this might result in a network configuration for that resembles a supplier having "monopoly" over both buyers benefiting from these economies of scale, what Kranton and Minehart are saying is that such "sharing" occurs as a result of a production-chain hierarchy organized from the top down, where particular buyers create the market for the product, creating a dependency on the part of the single supplier. An alternative view is that suppliers will try to achieve economies of scale, and the monopolistic supplier is in a better position to do so, lowering its prices while increasing its

profits. And having lowered prices, the monopolistic supplier is able to lock-in those buyers. Kranton and Minehart neglect this latter possibility, possibly because they tend to presume an over-arching instrumentality of end-producers.⁵

In our previous work, we assumed that triadic substructures within the network consisting of multiple suppliers with single buyers were evidence of monopsonies that might force suppliers to lower their prices, but this evidence was ambiguous because of overlapping triads. We can now articulate more accurately, without raising the methodological problems of a triad census, those network configurations that would affect the power of monopsonists to reduce prices.⁶

DATA AND HYPOTHESES

Ohta Industrial District and Data

We study here again a complex web of supplier/prime buyer relationships among manufacturing firms within or linked as buyers to Ohta, which is one of 23 special wards in the most populated part of Tokyo, within one of the two largest regional industrial clusters in Japan. At the time of the survey (1994-95), over 7,000 SMEs were engaged in a variety of manufacturing processing activities, parts, components, and modules production, and the subsequent assembling work by hubs and large original equipment manufacturers, composing the complex web of regional interfirm linkages. (Our study's OEMs are mostly in Tokyo, but many are outside Ohta proper). A majority of the SMEs had the size of a typical family household, or even smaller, in terms of the number of employees. The regional cluster has been well known as a so-called machine-tools industry where the SMEs functioned as suppliers for leading Japanese OEMs in other applied industries.⁷

Among the 7,000-plus manufacturing firms in the "industrial district" of Ohta, a majority of firms were specialized in their own areas of processing activities. In particular, many firms were engaged in various metal-cutting processes. At the same time, a minority were suppliers of parts and components in areas such as automobile production, aerospace technologies, computer-related products, electrical and electronic equipment and devices, general industrial and precision machinery, jigs and tools, and shipbuilding, among other areas. Only 10%-20% of these suppliers had product lines of their own brands (Seki and Kato 1990).

⁵ Our results show 209 single-supplier buyers compared to 480 single-buyer suppliers for the connected firms within Ohta. Because any of these 209 may result either from buyers "sharing" suppliers or monopolistic suppliers locking-in buyers, we do not investigate monopoly here, nor do we have complete data to do so. Study of monopsony in these production chains may have a better potential for identifying pricing effects.

⁶ In monopoly, monopsony and other situations where there are only one or two parties to one side of a transaction, it is recognized that there is an asymmetric advantage in the relative *power* to affect prices. The case where firm A is the only supplier to B and B the only buyer for A involves neither monopoly advantage nor a monopsony advantage: it is only that B has no other supplier and A no other buyer (A could have another supplier and/or B another buyer, which would simply make a directed chain but still offer neither party a structural advantage, even if the chain was part of a cycle).

⁷ We do not differentiate such terms as "OEMs," "end producers," and "top firms in the hierarchy of supplier-prime buyer relations" throughout our discussion. Literally speaking, an OEM is original equipment manufacturer, or a firm that produces end-products, which are purchased by the consumers possibly under different brand names. Practically, however, it is extremely difficult to identify the actual OEMs behind the top brand names, as each brand consists of so many different products manufactured by different OEMs. In the case of the complex production-chain market, any large prime buyer as an organizing hub can be an OEM for another prime buyer. Most large prime buyers are probably OEMs for other large prime buyers that have reputable brand equity. Therefore, we rather call these organizing buyer/suppliers OEMs.

To conduct the present network analysis, name-generating data from *Akusesu Data* (Ohta-ku Sangyo Shinko Kyokai 1997a; Ohta-ku Sangyo Shinko Kyokai 1997b) were used. The dataset encompasses approximately 70% of all manufacturing establishments in operation in the Ohta ward during the years of 1994-95. The questionnaire employed asked each of the roughly 7,000 SMEs located in Ohta-ward to list up to three names of their prime buyers. Among the 5,111 respondent firms in Ohta, i.e., those in our dataset, 2,710 firms (53%) listed a total of 4,077 other firms as their prime buyers. The other 2,401 firms (47%) listed no prime buyers. Of the SMEs that responded with the names of their prime buyers, 501 firms (9.8%) listed only one; 530 firms (10.4%) only two; and 1,679 firms (32.9%) listed three.⁸ Of the 4,077 prime buyers listed, 841 were supplier/prime buyers located in Ohta and 3,236 (80%) were prime buyers outside Ohta. The total number of firms in the network dataset, including named buyers, was 8,347.⁹

Hypotheses Derived from Principles of Market Exchange and Network Economics

Two hypotheses follow from a general economic axiom of competitive pricing, which we label under **Axiom A (Multiple independent decision-making)**: *Competitive equilibrium pricing emerges from economic networks in which each player has independent alternative choices, and there are many (more than one or two) parties to each transaction.* **Corollary A'**: *A monopsony is expected to have the power to lower prices of supply, while a monopoly is able to raise prices,*¹⁰ unless: (a) buyer and supplier are part of a vertical organization/integration, or (b) their link is part of a “sharing” of suppliers organized collaboratively by the buyers to their own cost-sharing advantage (e.g., as discussed by Kranton and Minehart). Accordingly, we posit Hypotheses 1A and 1B for effects of competitive/noncompetitive links and Hypothesis 2 for diffusion of effects.

⁸ Many of our observed “prime buyer” links in the Ohta network could be long term contracts but in any case, given statements such as having only one or two buyers, we assume that the acquisition of more buyers is in some way difficult or problematic.

⁹ The term “prime buyers,” or “Tokuisaki” in Japanese, used for our dataset, should generally be much more exclusive and narrower than listing “all buyers”. At the same time, the limit of up to three prime buyers, imposed on all 5,111 respondents, will be less than the numbers of all prime buyers that otherwise could have been listed in Ohta, especially by large suppliers. As the percentage of firms with 30 or more employees in 1990, however, was less than 4.6% in the industrial district, and approximately 80% of the firms in Ohta had nine or fewer employees (Whittaker 1997), the impact of the restriction to up to three on the number of total prime buyers should not be that great. According to our statistical estimate, an average number for all buyers per firm might be as high as 6-8, while the subset of prime buyers are estimated at less than two per firm, had free listing been allowed (Nakano and White 2006a). In this study, although we use a restricted sample of 981 Ohta firms that form the largest connected component (within Ohta), we study the distribution of total number of buyers. As shown in the tabulation below, the firms with three or more buyers within their component from 33% for the total sample of 5,111 firms to 31% in the largest component of all firms, to only 5% for the 981 firm Ohta component, but rise to 62% in the Ohta component for all buyers named, including those from outside.

| Outdegree Cluster | 981 Ohta Component | | | | 4500 Component | | All 5111 Interviewed | |
|-------------------|--------------------|-------|------------|------------|----------------|------------|----------------------|--|
| | Freq | Freq% | All Buyers | Freq | Freq% | Freq | Freq% | |
| 0 | 254 firms | 25.9% | 114 | 2383 firms | 54.0% | 2401 firms | 47.2% | |
| 1 | 480 firms | 48.9% | 102 | 294 firms | 6.5% | 501 firms | 9.8% | |
| 2 | 198 firms | 20.2% | 157 | 397 firms | 8.8% | 530 firms | 10.4% | |
| 3 | 49 firms | 5.0% | 608 | 1426 firms | 31.7% | 1679 firms | 32.9% | |

¹⁰ With lesser degrees of potential noncompetitive price-altering power, the same is true for duopsonies and duopolies, and possibly for oligopsonies and oligopolies.

Hypothesis 1A (Competitive market links). In the absence of constraints on link formation, all buyers will attempt to link to two or more sellers and all sellers to two or more buyers.

The principle here is that by creating links to multiple alters for purchase and sale, firms may acquire through choice the advantages of competitive prices and price equilibrium. *They are less likely to acquire these advantages as the number of independent alternative choices of buyers (non-vertically integrated sellers) is drastically reduced* (e.g., to a few, two, and one). To the extent that competitive market links obtain in an exchange network, economic theory holds that competitive pricing equilibrium obtains, a prediction that experimental economists have tested extensively and that holds true under a variety of differently-constructed markets.

Our empirical markets, however, are not those of idealized perfect competition, where every producer has many alternative choices of buyers and may choose the buyer that offers the best price. So too for the idealized buyer with choices that include finding a seller that minimizes their transaction costs, with the result that all must sell a homogeneous good at the same price in order to sell at all. In this idealized market, all of the producers and all the suppliers for a homogeneous product look the same.

In the industrial district production chains that we study, however, what we observe is how many firms are actual (named) prime buyers and how such prime buyers as are named may be assumed to “mostly” clear the market of demands by buyers. We do not know how many possible buyers were considered by suppliers and rejected because their price offers were too low. This is very different, however, than the idealized conditions for perfect competition where all of the producers and all the suppliers for a homogeneous good look the same, so why have more than one? When we observe that a supplier names only one prime buyer, we take this to mean that over an indefinite period of time and many transactions the supplier is not entertaining purchases from other buyers. The supplier is “locked in” in some way to the single buyer. There is here a possibility that they have no choice of an alternative buyer and that they may be selling for a lower price that might have been available elsewhere. This is all we can assert about an observed monopsony.¹¹ We are not saying that there are not potential buyers available with better offers. If our empirical markets rely on a world of monopolists, monopsonists, duopolists..., however, cannot we ask: How far from competitive prices will these prices be? But in this world of small numbers there are no standard solutions, and the prices of perfect competition cannot be determined. We can only talk about factors that may raise or lower them.

Hypothesis 1B (Noncompetitive market links). *To recapitulate other aspects of Corollary A': Monopsony buyers are able to lower prices, while monopoly suppliers are able to raise them.*¹²

¹¹ Since we do observe a vastly greater proportion of monopsonies occurring lower in the production hierarchy, to anticipate our results, we need to consider alternatives to the hypothesis that these monopsonies might occur *without* pricing advantages for the monopsony buyers. It may be possible that more suppliers are in monopsony relations with single buyers simply because (1) they have a small volume that is easily absorbed by this buyer and (2) there is no alternative buyer offering a better price. As for (1), we should find suppliers high up in the supply-chain hierarchy that have few products, even if they are more complex, so there is no reason to regard small volumes as an explanation for monopsony to occur lower down in the hierarchy. And as for (2), why would there be more alternative buyers offering a better price the higher in the hierarchy when there are in fact fewer buyers at each higher level? So where we observe monopsony more frequently in the lower runs of the hierarchy, it is also possible that their options are foreclosed in some way by the buyer, by a long term contract, or by their situation, and that the buyer enjoys the possible pricing advantages of monopsony.

¹² Suppliers with single buyers (i.e. the appearance of monopoly) are also common in vertical integration where one firm owns a number of suppliers or organizes in supplier chains that lead to a common upstream producer. This may result in prices set by buyers, or offer other advantages to the firms organizing integration such as reduction in taxes.

The same is true to a lesser extent for duopsony/duopoly, and, less so, for oligopsony/oligopoly.

Given these two hypotheses, derived from Axiom A, we can examine the extent to which the number and position of monopsonists and monopolists may potentially affect the structure of prices within the network, relative to the model of Kranton and Minehart. We can deduce the factors that may raise or lower prices within the network on the basis of characteristics of the related market structures, making use of Axiom A. In any case, having actual prices paid in an exchange network would not *in itself* provide evidence as to departures from competitive prices without knowing actual supply, demand and costs, and even then equilibrium theory offers no answer. The monopsony buyer occupies the superior position in the dictator game (Bolton, Katok, Zwick 1998): take it or leave it, that's the price paid. In many cultures, however, people do allocate a non-zero share of the dictator game endowment to the responder (Henrich, et al. 2004).

Hypothesis 2 (Lateral effects of noncompetitive price-setting potential: “competitive disadvantage”). When some suppliers and buyers are disadvantaged by noncompetitive price-affecting power due to effects of restrictive market links these effects and disadvantages—and noncompetitive pricing—tend to diffuse through competition between structurally equivalent suppliers and buyers to those who are disadvantaged.

Plott (personal communication) pointed out that our Hypothesis 2 is stated in terms of a market with homogeneous goods that will have “one price” in the competitive model. Throughout our analysis, nonhomogeneity of goods will err on the conservative side in attributing monopoly or monopsony links. That is, we count monopsony as present only once when all of a seller's products are going to a single buyer.¹³ In general, if we “thinned” the observed network to reflect transactions for a single good (ignoring vertical integration/organization, which also tend to give buyers in a production hierarchy more potential price-affecting power), there would be more monopoly and monopsony links, not fewer.¹⁴

Hypotheses Derived from Principles of Social Exchange and Network Sociology

This section considers hypotheses that question the assumption of network economics that the formation and dropping of links depends on the independent optimization of pairwise interactions. We begin with alternative questions: Are links formed or dropped on the basis of the relative cost and benefits of specific links? Are firms free to do so? Do their pairwise decisions on what links to utilize or drop shape the network of market links? Or, does link-formation itself involve influences that are not pairwise but emerge from an exchange network of buyers and sellers and

¹³ Because we measure the number of monopsonies by reported number of prime buyers (which does not reflect choice among a larger number of alternative buyers), our findings can suggest only the *possibility* of pricing advantages. Further understanding of alternatives would require further empirical investigation. Because the Ohta production hierarchies tend to be organized from the top down, by and for end-producers, and often by their elite suppliers, small suppliers are very likely to be constrained to sell within these top-down hierarchies and are at a distinct disadvantage in terms of free choice of buyers. We have data on firm size (number of employees, capitalization) that would be useful to relate in a subsequent study to our present findings.

¹⁴ In the Ohta network a variety of goods flow from the upstream small suppliers to the downstream large OEMs through production chains where values are added at each of the linked but different stages of manufacturing, in a series of the divisions of labor organized by hubs. Thus, the exchanges capture critically important flows of goods and services in the aggregate, as the relationships between suppliers and their prime buyers are embedded in the role structure of the complex production-chain market.

how they are hierarchically embedded in the complex value-chain of the production-chain market? Do the relative positions of buyers and suppliers in exchange networks affect price formation? Or affect cost of links? The sociological view can be expressed as a core axiom about market formations from which several more hypotheses will follow.¹⁵ By the end of our analysis we will try to answer some of these questions, bearing in mind that the links in our empirical network consist of those few “prime buyers” that each firm identifies as its current outlets for sales, allowing optimal pricing choices when alternative prime buyers are distinguished.

A general sociological axiom is proposed regarding the effect of link formation on price-affecting power, **Axiom B (Positional and institutional role structures)**: *The price structures that are generated within exchange and production-chain networks are constrained not only by network properties (as in Corollary A) but by social (positional and institutional) role structures that deal with problems of coordination, communication, and problem-solving. Hence the processes of tie formation result from interactions among players with nonindependent choices. Thus, even if ties involve economic exchanges, they are also “social.”* **Corollary B'**: *The structure of social networks may reflect formal institutional, economic, and emergent hierarchical roles.*

One aspect of the institutional role structures that may work to alter tie-formation in organizations and exchange networks, which can range from firms to whole production hierarchies, and which almost invariably have a hierarchical component, is that they operate as in Harrison White's principle of optimizing in part on *survival*: i.e., that firms and whole market networks invest in certain orientations (often upstream *or* downstream, but not often both, for example) that avoid the kind of “Knightian uncertainty” (Knight 1921) that would put them or their industry out of business. An institution, firm, or corporate organization does not simply shape its link-formation pairwise but in ways that insure robustness of the larger organizational network or their position in it (or position in a price/quality *profile* of firms).¹⁶ This contrasts with Kranton and Minehart's (2001) definition of *efficient* link patterns as “those where the cost of any additional link is more than balanced by the expected gains [perhaps better stated as net revenue for a given output] from exchange.” They did so from the local standpoint of the partners forming a link to enhance the expected gains from the altered context of exchange that is thereby created. This ignores the role structures that may operate within interorganizational networks to reshape link structure.

Exchange transactions in a production hierarchy, for example, are executed as part of a value-chain where each in a series of linked exchange transactions adds value to goods or services at subsequent stages. To optimize added value it is not only the quality and character of

¹⁵ Economic sociologists tend to focus upon structural constraints and institutional pressures on decision-making processes of embedded players while economists construct and test models primarily on the assumption of rational actors, so as to explain market pricing mechanisms. In our discussions, we aim to partially bridge this gap by articulating the actual, relational properties from social network analysis in relation to potential pricing effects.

¹⁶ Jorion (2007:3-4), for example, finds in his studies of financial market transactions: “Fair play works against the agent's self-interest as it distracts him from winning at all costs, but it implements unspoken rules ensuring the maintenance of the game. Talking of economic exchange, one speaks of the “invisible hand” as deriving from the agents on the market “selfishly pursuing their sole interest.” “But traders need to cooperate towards the preservation of the benefits deriving from their trading relationship: sellers seek to ensure therefore the existence of buyers, and buyers that of sellers. Trying to win is one thing, making sure that the game goes on is another one that requires equally effort and dedication. There is therefore in these competitive situations, out of necessity, both antagonism AND solidarity; striving to the common good amounts to self-interest AND solidarity, not self-interest INSTEAD of solidarity. Effectively thus, traders never follow their ‘sole interest’: they follow both their own interest and the interest of the game as such; they collaborate with their adversaries for the superior cause of the pursuit of the game.”

the product passed along by a supplier but how this product *fits into the uses made of it* to create value when incorporated into other products further downstream in production chains.¹⁷ That is, other firms or organizations in the production hierarchy have an interest in engaging in distributed coordination, communication, and problem-solving through role structures that alter the processes of tie formation.

Thus, although Kranton and Minehart (2001) provide us with a useful starting point for a game-theoretic seller-buyer model for study of the relationships of suppliers to prime buyers in a complex production-chain market, their model fails to take into account the effect of *aggregate-oriented* behavior, *trading positions* and *complex roles* of exchange partners in production-chain markets. These may be due to organizational network coordination or institutional design, including those that Harrison White's (2002a) *Market from Networks* models suggest. These designs and coordinations may take into account: (1) perceptions of profiles within the vertically-oriented, serial-manufacturing exchange network in which contributions of adding value to stages in the production sequence may motivate reconfiguring linkages other than one's own in the exchange network, beyond those of partners or potential partners; and (2) the influence of role structures on the foundations of the division of labor, such as flexible specialization theory posits (Piore and Sabel 1984), among technologically specialized small- and medium-size enterprises (SMEs) or among dedicated suppliers organized by hubs.

Kranton and Minehart's (2001) economic framework, then, represents an under-socialized perception in which link-formation processes can be defined independently of the surroundings of a larger network in which each exchange transaction is an embedded part of the value-chain. It lacks the notion of actors' positions in production- and value-chain markets, problems of coordination and problem-solving communication, and moves made to optimize organizational networks, whether by experimental tinkering or overall planning (Dodds, Watts, Sabel 2003). In order to open up a range of questions other than buyer-side economics, we need to expand the questions asked in our empirical study.

Sociologically, *we expect suppliers that are low in a production hierarchy to be the most likely to accept a single monopsony buyer for their products or services*. There are, however, two different measures of rank in a hierarchy, and they have different implications. The first relates to network cohesion, evolution of complex niches, and thus hierarchical power. The second relates to status in a way that relates to how much depth has been acquired working up from the position of a novice entering at the lowest level, as if successive suppliers added from below were what pushed a firm up the hierarchy. Each of these two concepts should affect link formation and price-affecting power in different ways.

If relations in a graph are strictly oriented (non-reciprocal), such as those between buyer and supplier, and chains of these oriented relations do not form cycles, as in a production hierarchy, the conditions are fulfilled for a directed acyclic graph (DAG). The DAG is a generic definition of hierarchy. Elements in such a graph are partially ordered in the vertical dimension, reflecting the condition that if there are no cycles then all directed chains can be regarded as running in the same direction, "top" to "bottom," for each directed chain. How to assign numbered levels to each element in a DAG is not uniquely defined, however, because chains are of different length and intersect in different places. Assignment of elements to numbered levels is merely

¹⁷ How this is done will vary by industry. For the biotechnical industry, see Powell, White, Koput and Owen-Smith (2005). For individual organizational networks, Dodds, Watts, and Sobel (2003) develop a generative model that might be easily expanded as well to cover the distributed coordination, communication, and problem-solving that takes place within the decision-making organizational semilattices (Friedell 1967) of industrial hierarchies.

constrained by partial ordering. Different ways of assigning levels may be sociologically useful if they reflect basic aspects of the roles of the elements – in our case, industrial firms – in the hierarchy. The following hypotheses relate to the two most common ways of defining hierarchical positions, one of which is a unique minimal longest-chain levels (MLcL) assignment and the other a maximally cohesive level (CoSL) assignment that is not strictly unique. Accordingly, we defined these two hierarchical properties separately in order to posit two additional hypotheses that specify possible effects of role structure.

Minimum longest-chain levels (MLcL). When any two chains in a DAG intersect, they define a unique longest chain length. Over all intersections, this gives a longest-chain length for the DAG as a whole. Each element in a chain is assigned a series of numbers, always starting from 1 for the lowest element, and adding one for each upward level unless there is an intersection with another chain, at which point the larger of two numbers (“height from bottom”) is assigned. Numbering is unique and never exceeds the height of the longest vertical chain.¹⁸ Lower levels in this hierarchy are a potential sociological indicator of the newness or immaturity of a firm as supplier.

Hypothesis 3: Effects of minimum longest-chain levels (MLcL) as a hierarchical role structure. In this kind of hierarchy we expect a structural bias for more monopsony to occur in the very lowest rung of the MLcL hierarchy because the lowest rung is the most immature in the sense of not being supplied by others and hence is the most vulnerable to monopsony. It is also the rung that might be most vulnerable to the dictatorship game in accepting the least feasible offer made as an acceptance of low status.

Cohesive sequence levels (CoSL). Cohesive sequence levels derive position or role in a hierarchy from keeping elements together so as to maximize vertical cohesion, i.e., vertical closeness. Connected firms are pulled together vertically as closely as possible—with sequential numbering—without violating the partial order, even if the overall number of levels in the hierarchy is increased. Firms derive their roles from their minimal vertical closeness to one another, i.e., their positions minimize vertical distance between firms directly above or below one another. Ideally, a buyer and supplier pair will differ only by one level, i.e., they are either in adjacent levels or pushed into more distant levels only if there is an intermediary. If $A \rightarrow C$ are a supplier-buyer pair the chain $A \rightarrow B \rightarrow C$ forces A and C to be further separated. Intersecting chains are handled differently than in MLcL: with upward branches as the intersection points in the local network patterns of V, Y, X, for example, the junction points do not have to be pushed down to their lowest level but are placed at their most cohesive (and often highest) level. CoSL assignments are usually very limited as to how levels can be assigned.¹⁹

Sociologically, CoSL roles in production hierarchies reflect how, as production chains evolve, they might minimize cohesive distances (i.e., cohesive placement of links does not often connect to a supplier already two or more levels down a supplier chain). This allows older firms to

¹⁸ In Pajek (De Nooy, Mrvar and Batagelj 2005) the MLcL assignment is done with /Net/Partitions/Depth/Acyclic.

¹⁹ The CoSL assignment in Pajek is done with /Net/Partitions/Depth/Genealogical. Determine layers / generations – y coordinates. Pseudocode from Andrej Mrvar: – delete all tree subgraphs; – determine all first and last vertices; – determine all longest paths among first and last vertices; – determine the levels of vertices along the longest paths; – normalize the levels; – extend levels to the entire [DAG or] genealogy. This gives more than the minimum number of levels. A third option, “Nuclear depth Levels” (NdL), not programmed in Pajek, consists of moving each node in the MLcL assignment up to a level just under their lowest buyer (“parent”). This gives a useful role structure within the minimum number of levels but the sum of distances between pairs along ordered chains is not minimized.

“climb” the hierarchy by bringing in or positioning themselves higher up relative to the length of their supply chains. Because their supplier distances are as compact as possible, other firms can share their “upper” suppliers and push themselves and their supply chain beyond the limits of the longest chain lengths in the network. A good example is Tokimec Inc., founded in 1896, which now sits atop a compact hierarchy of six levels. Most of the manufacturer’s primary (one level down) and secondary (two levels down) suppliers could be arbitrarily pushed down to a minimum level given the partial ordering of their suppliers (as in MLcL), but the cohesive ranking principle keeps them higher in the hierarchy, at levels five and four. This has allowed other firms to build upward from these suppliers, reflecting the greater experience and sophistication of their shared suppliers with Tokimec. Sociologically, higher levels in the MLcL hierarchy may reflect “sophistication” in drawing on the suppliers of others located cohesively higher in the hierarchy.

Hypothesis 4: Consequences of cohesive sequence levels (CoSL) as a hierarchical role structure. For the CoSL measure of hierarchy we expect a structural bias for *less* monopsony at higher levels and more monopsony at lower but not always in the lowest levels of the cohesively sequential processing roles. Higher positions measure “sophistication” of firms in the cohesive neighborhoods of the hierarchy. While some higher CoSL levels may be at the lowest level in the MLcL hierarchy, their status in a higher CoSL level might make them less vulnerable to the dictatorship game dilemma of accepting the least feasible offer made as an acceptance of low status.

FINDINGS

Of the 7,000+ firms in operation in the Ohta ward in 1994-95, recall that 5,111 were interviewed.²⁰ The data we analyze here, however, constitute the largest interconnected sample of 981 firms within Ohta.²¹ This sample allows us to construct a representative hierarchy of firms in Ohta based on the largest number of its connected firms. In each of the following 981-firm graphs, we show the attribute of each firm’s *total number of buyers, in and outside Ohta*.

Cohesively sequential levels (CoSL hierarchical processing) role structure

Figure 1 shows the cohesively sequential processing structure hierarchy, from left to right, formed by the links connecting Ohta firms. Buyers and their suppliers are at separate levels and the total of all vertical supply-chain distances (i.e., difference in levels; eight levels) between pairs of firms is minimized. The colors and sizes of the firms correspond to their numbers of prime buyer in the total connected hierarchy of 4500 firms, inside and outside Ohta. At level 6 of this hierarchy, the upper-right firm and its suppliers are separated from the rest to show one of the larger 6-chain hierarchies of a large firm. The firm is our previous example of Tokimec Inc.,

²⁰ Data collected on 4,364 of these include number of employees, date of incorporation, capitalization, and three primary activity areas: finished products, manufacturing processes, and parts.

²¹ Of the 5,111 Ohta firms interviewed, 2,710 named one to three prime buyers, whether in or outside Ohta, making 4,077 firms named, 3,236 of which were not from Ohta. The largest interconnected component of supplier chains within Ohta consisted of 981 firms. These 981 Ohta firms, analyzed here, exclude other firms from Ohta in the largest component of 4,500 firms that included those connected to these 981 through naming of common non-Ohta firms. We carry over as an attribute of each of the 981 internally-connected firms in Ohta the number of buyers that they named both in and outside Ohta, and it is these numbers that allow us to identify monopsony.

Fig. 2: The Ohta component of 981 firms with levels reduced to single nodes, showing number of links between cohesively sequential levels that are one, two, or three levels lower

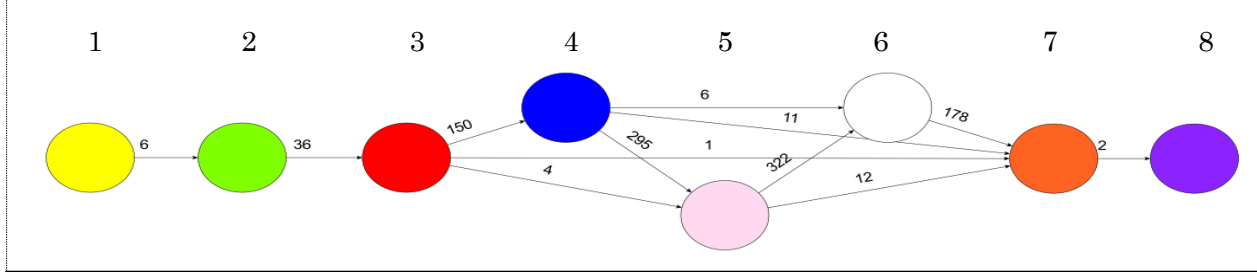


Table 1 shows the number of buyers of each type in Figure 1, and the number of links from level to level for cohesively sequential levels 1 (low) to 8 (high). The numbers in the matrix shown in the rightmost columns labeled 7 to 1 show the same numbers of supplier-buyer links between levels as in Figure 2. Of the 1023 dyads in the network, all but 45, or 95.6%, are between adjacent levels. The compactness of the hierarchy when viewed by cohesive sequence levels, as shown here, is discussed in the CoSL definition and hypothesis 4.

| total reporting | 3 buyers | 2 buyers | 1 buyer | Zero buyers | C.Seq. Level | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|-----------------|----------|----------|---------|-------------|--------------|---|-----|-----|-----|-----|----|---|
| 1 | 0 | 0 | 0 | 1 | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46 | 23 | 1 | 4 | 18 | 7 | | 178 | 12 | 11 | 1 | 0 | 0 |
| 228 | 133 | 33 | 22 | 40 | 6 | | | 322 | 6 | | 0 | 0 |
| 318 | 191 | 54 | 41 | 32 | 5 | | | | 295 | 4 | 0 | 0 |
| 238 | 158 | 42 | 21 | 17 | 4 | | | | | 150 | 0 | 0 |
| 119 | 85 | 18 | 10 | 6 | 3 | | | | | | 36 | 0 |
| 26 | 14 | 8 | 4 | 0 | 2 | | | | | | | 6 |
| 5 | 4 | 1 | 0 | n.a. | Low=1 | | | | | | | |
| 0.993 | 0.977 | 0.972 | 0.962 | 0.916 | 0.936 | | | | | | | |

Table 1: Number of buyers and number of links for nodes at cohesively sequential levels 1=low to 8=high, with single-factor correlates for the six leftmost variables in the bottom row. Firms at the lowest level cannot have zero buyers (coded n.a.) since they must be connected to others.

The six variables on the left of the table fit a single factor covariance model computed with Principal Component Analysis (D. White 1990), excluding level 8 with one buyer. The last row in Table 1 shows the component correlations with the common factor. There is 92.1% common variance with the factor, and no second factor. Link frequencies in the diagonal (in yellow) and total link frequency for each level form a second factor, but also fit a single factor model with factor correlations of .85 and .87 if cohesively sequential levels 7-8 are excluded. Generally, number of nodes and of links expand for levels 1-5 in successively smaller multiples, and then these numbers shrink successively in levels 6-8. There is, then, a great deal of coherent role structure in the cohesively sequential production-chain processing hierarchy, reflecting the compactness of processing relations among firms in supplier-buyer production sequences.

As measured by single-factor structure of correlations among the raw frequencies by level of monopsony, duopsony, no buyers, or three or more buyers, there is little difference between their relative frequencies. But when the distribution of number of buyers is *percentaged*, relative to number of firms reporting buyers at each level (excluding level 8, with only one firm), the

correlation across CoSL levels between percent monopsony and percent three+ buyers is strongly negative ($r=-0.785$, $p=0.04$). This supports the existence of a structural bias for a higher proportion of monopsony to occur lower in the cohesively sequential processing role hierarchy, consistent with Hypothesis 4.

Minimum longest-chain level (MLcL) hierarchical role structure

If monopsonies tend to occur lower in the cohesively sequential processing role hierarchy, why is there so much monopsony for firms (coded yellow) in Figure 1 in levels 3-6 and so few in levels 7-8 where there are many firms? These highest levels are somewhat sparsely populated but another complex nonlinear factor is operative: the MLcL role structure. In an MLcL hierarchy, all the nodes with no suppliers are placed at the bottom of the hierarchy, and successive levels are added where a firm is pushed up exclusively by the length of supplier chains from below. What the lowest MLcL position represents is a lowest level of participation or low-order new entrant into the hierarchy. The CoSL hierarchy in Figure 3, with color codes for MLcL positions 1-6 for firms placed identically as in Figure 1, allows us to assess how much the CoSL and the MLcL hierarchies differ. Firms colored yellow are those at the lowest entry-level in the MLcL hierarchy. They constitute all of level 1 of the cohesively sequential hierarchy, and are still numerous up to level 6, thinning out at CoSL levels 6-8. Number of buyers is still shown by size of nodes.

Fig. 3: The eight production-chain CoSL (cohesively sequential) hierarchical roles in the Ohta hierarchy of 981 firms, as in Fig. 1, recolored to show MLcL hierarchical levels (yellow=level 1, green=level 2, red=level 3, blue=level 4, pink=5, with Tokimec coded white for level 6). The eight CoSL levels in this figure collapse into a 6-level MLcL hierarchy if firms are aligned by their MLcL color, as shown in Figure 4.

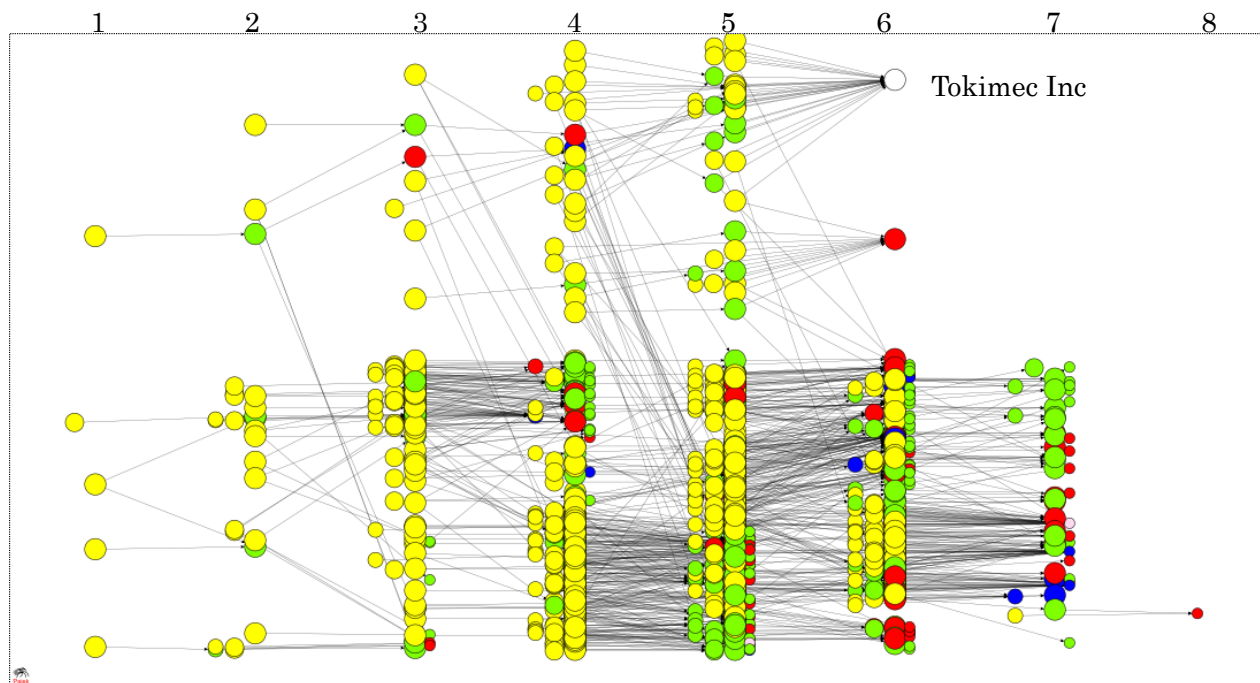


Table 2 summarizes the Figure 3 data on number of buyers classified by MLcL positions and

These results point to the conclusion that (1) the cohesively sequential levels (CoSLs) that position nodes to create more levels in the industrial sequence hierarchy do so in a manner consistent with Hypothesis 4 (higher level positions in the supplier chains having fewer monopsonies and duopolies), and (2) membership in the lowest two MLcL positions, those of *entry-level* and newcomer positions in the hierarchy, create a greater likelihood of susceptibility to monopsony and duopsony, consistent with Hypothesis 3.

Both variables (but mostly the CoSL hierarchy) contribute to the small amount (7%) of variance that can be accounted for in number of buyers per level. This is significant relative to the null hypothesis across all firms but not a large percentage of variance explained. It is the greater likelihood for monopsony to occur relative to three plus buyers at the aggregate level, lower down in the CoSL role hierarchy, that provides the evidence for structural bias, but the MLcL position variance helps to explain how monopsony bias distributes across the cohesively sequential processing levels. Table 2 shows, from the perspective of MLcL positions, that monopsony occurs at the bottom of the hierarchy, a position that serves to pass such price advantages as exist up the MLcL hierarchy.

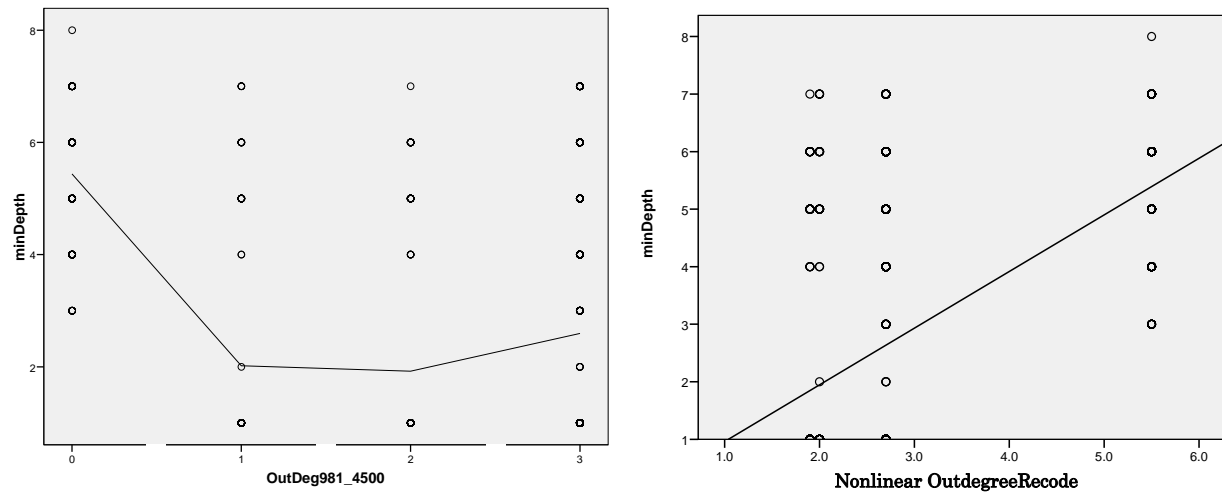
The leftmost graph in Figure 5 shows the relation between the number of buyers on the x axis (0=no buyer, 1=monopsony, ...) and on the y axis an 8-level hierarchy variable, minDepth, which is CoSL depth substituting 1 from the MLcL hierarchy where it occurs. The same y axis is shown in the graph to the right but with number of buyers on the x axis reordered with monopsony and duopsony to the left, three or more buyers at the center, and zero buyers to the right. Covariances between CoSL and MLcL instead of minDepth with the recoded outdegree x axis variable are 4% and 17%, respectively, while covariance of recoded outdegree with minDepth is 21%. This small increment in variance partly reflects the contrast between end-producers high in the hierarchy and the monopsonies and duopsonies at the lower end. There is thus some slight interaction of the two distinct hierarchical role measures that affect monopsony and duopsony, with MLcL having the much larger effect. The 4% contribution of CoSL depth is a small contribution to variance but reflects how suppliers pushed up in the CoSL hierarchy by virtue of sharing a sophisticated supplier of an elite firm might attract more buyers. One of Tokimec's level 5 suppliers, as shown in Figure 1, gives this advantage to Yamatake-Honeywell Co., Ltd., headquartered in Ohta.

The potential of monopsonies (and duopsonies) to create noncompetitive pricing is amplified in two ways: First, horizontally, by homophily, or diffusion of noncompetitive pricing to their same-level competitors, who are more likely to offer price-breaks at lower than true competitive prices in order to attract buyers if the two are engaged in similar manufacturing processes.²³ Second, vertically, noncompetitive price-breaks will be passed upward to benefit producers higher in the hierarchy, and vertical amplification may occur if monopsonies (duopsonies) occur in vertical chains or are convergent from multiple suppliers.²⁴

²³ When two suppliers have comparably high levels of engineering technologies and manufacturing skills as well as resources, the two firms can also be potential competitors to become suppliers of a single buyer, even if they are in fact engaged in different manufacturing processes.

²⁴ This can be checked in a later phase of research when we examine the supplier chains of particular end producers in relation to their specialties.

Fig. 5. Covariance for number of buyers with hierarchical role positions.



LIMITATIONS OF THE STUDY

Two of the limitations of this study are that 1) the network data collected from suppliers were only for their prime buyers, from zero to three, but not four and beyond, and 2) we included the named buyers *outside* Ohta to give more grist for our network analysis, although suppliers in the main adjoining districts to which these buyers belonged were not interviewed. The lack of data from suppliers in the adjoining industrial districts made it impossible to do complete network statistics and controls in fitting models to test a variety of hypotheses about structural effects in the production-chain network.²⁵ This second limitation, however, did not preclude testing and calibrating the ordered levels in the main part of the production hierarchy and determining the MLcL hierarchy structure, which was not an artifact of data collection. The first limitation, that of naming up to three buyers, did not prevent us from identifying the occurrence of buyer monopsonies, since these are direct reports in single interviews, namely, that certain suppliers reported one and only one prime buyer. Hence the main conclusions of this study ought to hold up in spite of the limitations on data collection. In this paper, however, it should be remembered that we have not been looking at actual pricing or structural effects on price formation per se, but only at systematic structural indicators for the heightened possibility of such effects.²⁶

²⁵ We would argue that the real “network entity” in this study was at the multi-district level, as demonstrated in footnote 9 where we examine the effects of deleting the buyers outside Ohta (mostly in the adjacent wards and district). The defect of not having supplier reports from adjacent wards or districts *did not affect our main conclusions about hierarchy and monopsony*, particularly when the levels of hierarchy in our Ohta 981 firm largest component sample has the same number of labels as the largest component of firms in the total sample. The problem of not being able to detect *all the structure features of the multi-district network* would have been easily remedied if data from the larger region had been collected at the same time. But use of the total number of firms named as buyers, from Ohta and elsewhere, has provided *sufficient aggregation* to reach the proper unit of study.

²⁶ We envision future research focusing on the roles of firms embedded in the complex production-chain market, in relation to the present positional analysis of monopsony configurations, where we take into account firm size (number of employers, capitalization) and primary activity areas (finished products, manufacturing processes, and parts).

CONCLUSIONS

Analytic concepts and methods of both network sociology and network economics are needed to uncover preconditions for empirical market-link formations (monopolies, monopsonies, duopolies, oligopolies, et cetera) that are inconsistent with competitive prices.²⁷ Such analyses generalize to a classical set of concerns with noncompetitive price formation. Here we have shown how these analytical tools can uncover structural factors that may influence price formation in a complex network context. The novelty of the present study allows us to expand the applicability of modeling of roles in network hierarchies to a more general level that includes industrial production hierarchies,²⁸ and link these models through the methods of this study to Harrison White's (2002a) theory of *Markets from Networks*. Coupling these various analytical tools and concepts, as applied to the large, manufacturing regional cluster in Tokyo, we see that the structure of links in these markets has a systemic potential to affect price formation. Concepts and measures of sociological roles in hierarchical networks may help to account for the distributed structure of potentially noncompetitive prices.

We used two models for measuring the role-positions of suppliers in production-chain hierarchies that were useful in examining the occurrence of monopsony and duopoly. One, measuring cohesive production sequencing levels within the hierarchy, emphasizes compact neighborhoods of supplier-buyer links, where suppliers are brought up to the most proximal level to that of their buyers in these supplier chains. This model reflects assumptions about greater sophistication at higher levels of the production chains, and lesser susceptibility to effects of monopsony. A buyer or producer that shares a "sophisticated" supplier with a manufacturer high up in terms of supplier chains builds on that supplier's cohesive sophistication ("close" to the producer even if lacking its own deep chains of suppliers below). This measure, in keeping cohesive neighborhoods together, may push the total number of levels higher than the minimum levels required to model the hierarchy, which need only be as deep as its longest supply chain. A second minimal measure of role-levels assigns firms with no suppliers to the bottom rung of the hierarchy. This, however, is where one would expect a supplier to have minimal immunity from monopsony bias implemented by a buyer above them. Our findings support the hypotheses that the lower in the supply-chain hierarchy, as measured by one or a combination of these two types of hierarchical roles, the greater the proportion of suppliers with but a single buyer (monopsonies) compared to those having multiple buyers, and similarly for duopsonies.

The potential of monopsonies (duopsonies) to create noncompetitive pricing is amplified in two ways. First, horizontally, by diffusion of noncompetitive pricing to same-level competitors, which are more likely in consequence to reduce prices to attract buyers. Second, vertically, through noncompetitive price-breaks passed downstream to benefit producers high in the production hierarchy. Vertical amplification may be greater if monopsonies (duopsonies) occur lower down in more deeply vertical chains or to the extent that deep supplier chains are more convergent in passing pricing advantages to end producers.

Results of studies of this sort, for interfirm hierarchies in regional clusters generally, are likely to show that the concept of competitive prices cannot be simply the automatic outcome of locally independent decision processes as classically defined for competitive markets governed only by

²⁷ Conversely, one could study how price equilibria that are competitively, socially or otherwise optimal are enhanced by certain types of configurations in exchange networks, a goal of network economics.

²⁸ Although we use here some contrastive models related to hierarchical role structure, we can also envision using such network-analytic sociological role models as developed by Reichardt and White (2007) for overlapping and hierarchical role models or network organization models as developed by Dodds, Watts, and Sabel (2003).

supply and demand. Our conclusions challenge what have become major assumptions of more standard studies of network economics, namely, the axiom that link formation is economically bounded, i.e., governed by independent decisions of the two parties, and the problematic view that economics alone as a discipline could provide a complete and general theory of market link formation, without incorporating major elements of network sociology. If we are required to consider production-chain markets in terms of hierarchical roles (or perhaps as organizational networks in the manner of Dodd et al. 2003) in order to understand structural effects of monopsony that may affect prices, we are in the domains of social networks and distributed-organization theory. Our approach puts a focus on institutional and relational constraints upon instrumental rationality of role or structurally equivalent players. Further, since there is no standard economic model for equilibrium prices deriving from monopsony or monopoly, economics will need greater reliance on the sociological side in examining potential network effects on pricing, with further elaboration of methods and primary data analyses. Network sociology seen in this broader perspective becomes central to the study of markets and price formation.

This type of conclusion was reached independently by Harrison White (2002a, 2002b) in his theory and analyses of socially constructed modern production-chain markets with a set of detailed models of link and price formations that are complementary to our own. One of his central models is that sellers of similar products position themselves vis-à-vis judgments of where they fit in a price-quality profile. In this paper we developed different concepts and measures as to how firms are positioned. Further work would be needed, for example, on those market niches that are low in a production hierarchy and how they may contribute to supports for lower pricing in the upper end-producer levels than would be available otherwise from supplier networks that conform more fully to the conditions for competitive pricing.

New perspectives on potential structural effects on price formation can help to explain how and why the network structures that evolved in industrial manufacture of goods and services in production-chain market hierarchies may involve structural effects on the potential to affect prices. Our model addresses the question of how it is, as in the case of Ohta, for example, that processing activities and parts and components manufacturing organized by the “elite” buyers for the top OEMs, while executed by numerous other SMEs lower in Ohta hierarchy, leave so many low-level suppliers potentially subject to monopsony and duopsony and to a potential reduction in supplier prices.

These results are consistent with our earlier findings (Nakano and D. White 2006b) of a structural divide capable of recursively generating unequal distributions of wealth, not on the basis of firm size but by status ordering among firms in the “elite core” and the rest. Greater monopsony and duopsony in the lower tiers of the hierarchy are consistent with the divide between the larger firms and the majority of the SMEs that resemble the sizes of family households in terms of the number of employees.

Although price equilibrium is virtually never stably realized in complex economies, economics as a discipline is commonly premised on an assumption that an empirical tendency toward competitive equilibrium pricing also works toward optimum benefits to all players in an economy. Structural effects of network configurations in markets, however, i.e., scarcity of alternatives in exchange, may act to create noncompetitive pricing advantages. Specific structural inequalities such as monopsony, as for suppliers at the lowest levels of supplier chains, may weigh heavily in an exchange hierarchy when pricing disadvantages below become added benefits flowing up. These unequal benefits, where pricing advantages to buyers low in the production-chain hierarchy are ones that flow up to buyers above, are further amplified when

noncompetitive pricing diffuses to suppliers whose asking prices are lowered by competition with other suppliers that are more directly subjected to pricing disadvantages due to monopsony.

To understand how to study the structural foundations of price formation in complex economic systems, which has been a goal of this paper, further intellectual alliances are needed between network economics and network sociology. The kinds of findings shown in this study will require further analysis and discussion to develop deeper comparative and dynamical understandings of the effects of network properties of production-chain hierarchies. Operating at many levels in a market, the study of the potential effects of network structure on pricing opens up a range of considerations about amplifying or neutralizing effects of prices as their effects are transmitted across and through production chains.

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