The Competitor

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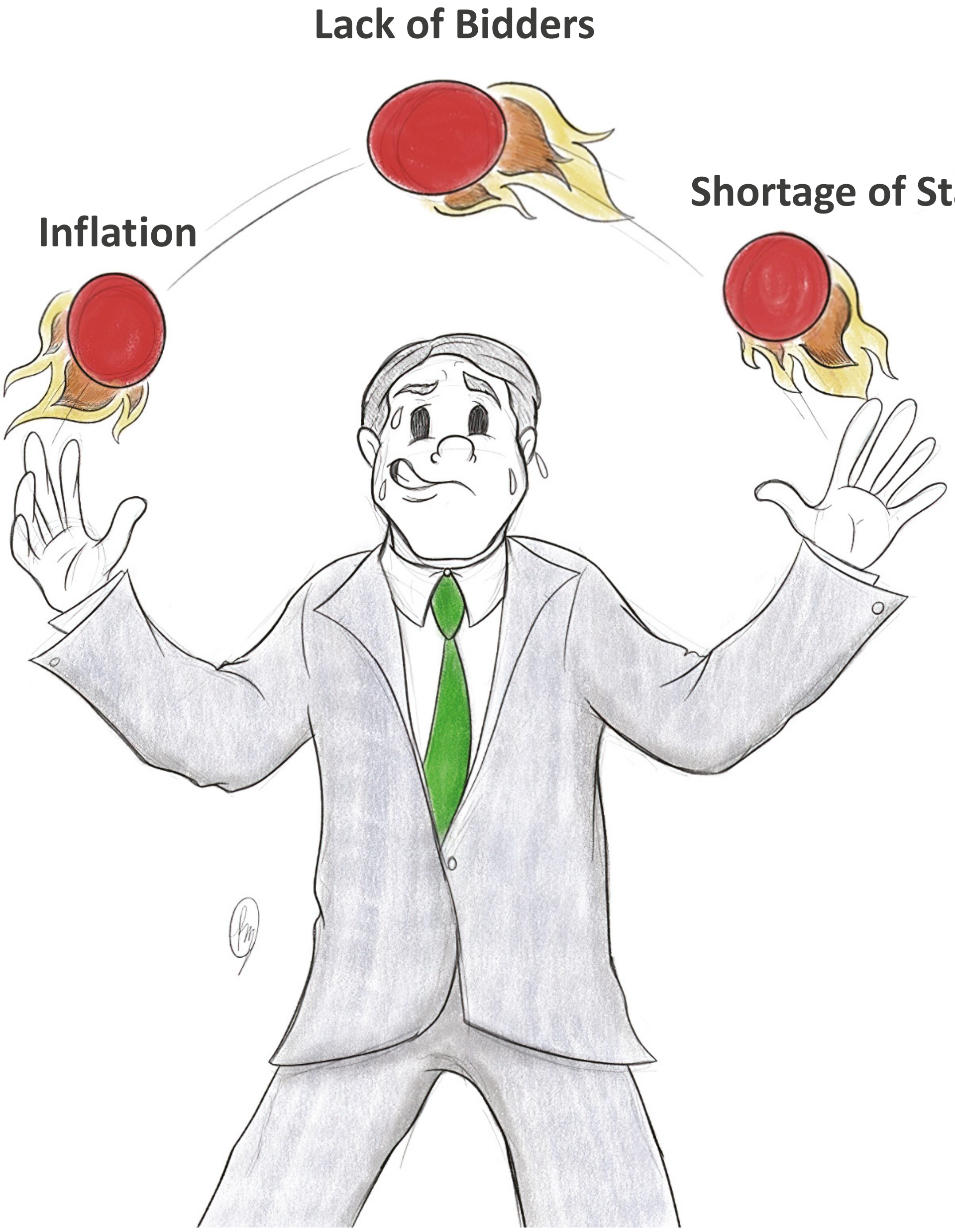

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Welcome to the first edition of our newsletter.

After being in the market with Competitio for more than three years now and having realized many exciting, complex, and challenging projects for our clients, we have noticed that it is often difficult to keep in touch. Especially intensive projects tend to absorb you.

To counteract this "disappearance", to stay in touch with you, and to keep you informed about current developments and projects, we have decided to publish this newsletter.

The last three years have been turbulent in many ways. The expansionary monetary policies and low inflation that we have become accustomed to since the financial crisis of 2008 seem to have come to an end for the time being. Skilled labor shortages, resource scarcity, and rising energy costs also lead to declining corporate production capacity.

Demographic trends will exacerbate the shortage of skilled workers. Sebastian Dettmer's book "The Great Workerlessness" clearly describes the relationships. Skilled immigration is certainly one possible solution, but it must be remembered that the countries from which the skilled workers come are, in part, facing similar demographic developments and courting the return of their skilled workers. A rational immigration policy is still a long way off.

The shortage of skilled workers and resources affects purchasing in two ways:

On the one hand, it is becoming increasingly difficult for purchasing to find bidders in sufficient numbers and with sufficient skills for intensive competition. As a result, the attractiveness of an RFX through volume aggregation and skillful bundling becomes particularly important. In addition, RFXs can be designed to encourage competition among bidders with different capabilities. Efficiency in project execution is also becoming increasingly important. In our interview with Gero von Grawert, we discuss, among other things, which strategies purchasing can use to strengthen competition.

On the other hand, purchasing itself is struggling with staff shortages. The use of artificial intelligence can counteract the lack of skilled workers. With the release of ChatGPT, the dramatic progress in artificial language intelligence became visible to everyone. The underlying technology of large language models is not entirely new but has been used by Competitio for several years, with purchasing applications.

Read more about how AI will change our working world in the article "Will AI make us obsolete?".

Text translation is one area where artificial intelligence has led to significant advances. Using applications such as DeepL or Google Translate, texts can be translated into the desired language within minutes. Even my book "Game Theory - Successful Negotiation in Purchasing", published in German in 2021, was translated into English using DeepL. Machine translation results are not yet good enough to be used without revision. But the whole translation process has become much more efficient with AI support.

The newsletter's next issue will also focus on possible artificial intelligence applications in purchasing. We will also talk to a professional ransom negotiator and explore what insights can be applied to other negotiations.

Christoph Pfeiffer

Game theory in times of scarce resources

Negotiation expert and game theorist Gero von Grawert has 25 years of experience optimizing price negotiations applying game, bargaining negotiation, and auction theory. He is founding partner of Competitio and a co-developer of the game theoretic negotiation concept GAIN. He has optimized a procurement volume exceeding €20 billion for industrial companies worldwide.

Melissa: Gero, how are you? What's on your mind right now?

Gero: Great, thank you. I've been working on projects under a lot of time pressure for a few weeks now. That's why it's stressful now. However, I still enjoy my job: I love challenging tasks for which I can develop creative new solutions with our clients. That's why I'm still passionate about it.

Melissa: Sounds good. What do you think are the most critical topics in purchasing now?

Gero: In the past we usually had enough suppliers competing for the business to award.

This has changed dramatically: Today, bidders' capacities are well utilized, and it is often challenging to attract enough competitors. Sometimes a tender does not receive a single bid. Often, only a few bidders respond or decline a request right away. This happens even for contracts worth tens of millions of dollars. The biggest challenge now is to manage the bidding markets that have emerged and to develop solutions for situations with weak competition.

Melissa: You've been working with a game-theoretic approach to negotiation for many years. Can you describe it?

Gero: Sure. Game theory has shown that the framework conditions and rules of awards and negotiations have a tremendous influence on their success: If you understand these relationships well, you can use this to your advantage - systematically and repeatedly. Purchasing has the great strategic advantage of being able to set these rules.

The core of the approach is to design awardings by applying game-theoretic insights in a way that maximizes the intensity of competition.

Among other things, we ask whether bundling makes sense and how to maximize competition in case it does.

Then we ask whether the pie should be divided, and if so, into how many slices of what size.

Using game theory, we can clearly answer these questions.

Being capable to measure the competitive intensities of different alternatives, we are able to develop the most competitive solutions. Based on the chosen solution, we then ask how best to negotiate it. The first task is called awarding design, the second negotiation design. In them, we determine the optimal formats and sequence of the negotiations.

First, we need to analyze and perfectly understand the specific competitive situation. Based on this, we use game-theoretic tools to develop the most competitive solutions for the awarding and negotiation design. In this way, we can significantly increase the success of contract awards.

Another aspect is contract design. This involves identifying risks, reducing them, and allocating them wisely between the parties. Risks in contractual relationships always have to be paid for in the end. If the buyer can bear the risk at a lower cost than the supplier, he should do so. This is often the case. For example, large buyers with their finance departments can bear foreign exchange risk much better than small suppliers.

Importantly, we constantly develop solutions to these challenges in close and creative collaboration with procurement, assessing and weighing the pros and cons of each measure.

Our game-theoretic approach, GAIN, creates maximum transparency, even and especially in very complex situations. GAIN works even better the more complex and difficult the award structure.

Since bidders for complex services often differ significantly, pure price competition usually does make sense. For this reason, we identify the relevant differences between the bidders and evaluate them in monetary terms. The subject of negotiation is then a so-called comparison price. It makes the differences perfectly comparable, takes them into account in the negotiation in a transparent and competitive manner, and ensures that the bidder with the best price-performance ratio from the buyer's point of view wins.

Melissa: If a buyer or purchasing manager is interested in the topic of game theory and hasn't had any previous exposure to the subject, what would you recommend as a place to start?

Gero: If he is interested in the theoretical background, he could read the books Christoph and I have written about it. If it's about specific tasks, it's best just talking to us: We could explain the approach and the expected results. And if he is interested, we then could think about together which of his tasks would be suitable for a pilot project.

Melissa: What are the criteria for eligibility?

Gero: There are three simple criteria. First, the contract must be of interest to the bidders, for example, because it is large in volume or because it is strategically important: perhaps a bidder wants to get its foot in the door with the company, or it wants to position itself with new technology. Second, there must be competition, i.e., at least two bidders who are acceptable from the perspective of critical stakeholders. Finally, the company must be willing to award the contract to the bidder with the best price-performance ratio: Whoever is the best according to the established rules must be 100% sure to get the contract. It's like the 100-meter dash: Whoever crosses the finish line first wins the gold medal. How hard would the sprinters try if they knew before the start that after they crossed the finish line, a panel of experts would meet to decide who gets the gold medal based on criteria that are not 100% clear to the runners?

Melissa: What do you think are the success factors for implementing game theory in a company? And what are the barriers?

Gero: The most important positive factors are interest and the willingness to try something new. Then the strategic decision for a pilot project should then be made by the business or purchasing management. If you leave it to a committee of your employees, you will not use game theory, because the buyers might not see us as experts with new perspectives, but rather as a threat to their reputation or even their jobs.

That's why it makes sense for the purchasing manager to position us from the outset as well-meaning supporters who bring new knowledge and new methods to the table. We are partners in the team, developing successful new approaches together with the buyers and trying to achieve something good for the company. We are not interested in who else is doing what or how many buyers there are.

Another important factor is that there must be enough time for project work before the negotiation. We need a certain amount of leeway to be able to design sensibly: If a job has to be done in a few days, it is not possible.

By the way, the area and the material group are irrelevant: Competition works according to the same principles everywhere, i.e. we can optimize all suitable awardings with applied game theory.

Melissa: In your 20 years of experience as a game theory purchasing consultant, what has been your most successful project?

Gero: The most successful project in percentage terms was a 72% price reduction. That was crazy but project and awarding task were rather simple. The biggest successes are the ones where we have a tough competitive situation, thoroughly understand it in all competitive aspects, and our tailored game-theoretic solutions generate intense competition that finally leads to a great result.

Melissa: Do you have an example?

Gero: We once negotiated with three bidders who knew each other well and knew that there were three of them. Unfortunately, they each had to get a piece of the pie. There was also a risk that they would coordinate. Through a unique design, to the surprise of our client, we were able to create intense competition and achieve savings of almost 25%.

Melissa: Do you apply the insights of game theory in your personal life?

Gero: Well, once in a while: I might get a bargain at a flea market. But in a one-on-one price negotiation, where I am a small buyer of no importance to the seller, game theory is of little use to me. The situation is rarely such that I can make up the rules and pit competitors against each other. But I have been able to help friends negotiate contracts. Thinking through the interests, possible courses of action, and "payoffs" of all parties involved and actively taking the first step has led to successful negotiations. However, I usually don't stand a chance against my wife and nine-year-old twins in negotiating situations…

Will AI make us obsolete?

CHRISTOPH PFEIFFER

Christoph Pfeiffer is a founding partner of Competitio Consulting. He focuses on the design of purchasing negotiations, data-driven cartel and fraud detection, and the development of AI applications with natural language processing. His book „Game Theory - Successful Negotiation in Purchasing" was published in 2021.

ChatGPT is a powerful demonstration of the power of artificial intelligence. It has surpassed one million users in the shortest time ever for an application. The application possibilities of large language models based on transformers are manifold. Reflexively, however, concerned reports also appeared. "Der Spiegel", a German weekly newsmagazine, writes about the "job destroyer ChatGPT".

A few comments on this:

First, the debate is reduced to ChatGPT. But ChatGPT is just one NLP language model among many. The revolution talked about here will certainly not happen through ChatGPT alone.

Second, the discussion often lacks a necessary distinction between complements and substitutes. Is artificial intelligence a complement that will increase our productivity, or will certain jobs be completely replaced by machines?

This also raises the question of whether it is a bad thing if certain jobs are eliminated. It wasn't that long ago that most people worked in agriculture. Tractors and other machines "destroyed" our jobs. But new jobs have been created, and we certainly don't seem to be running out of work - quite the opposite. The challenge remains to ensure that broad segments of the population have sufficient skills.

Third, fear is constantly stirred up in the media. Unfortunately, the way human attention works is that threat and fear are particularly interesting. This is perfectly logical from an evolutionary point of view, but it means that the media maximize their profits by constantly placing fear-inducing stories.

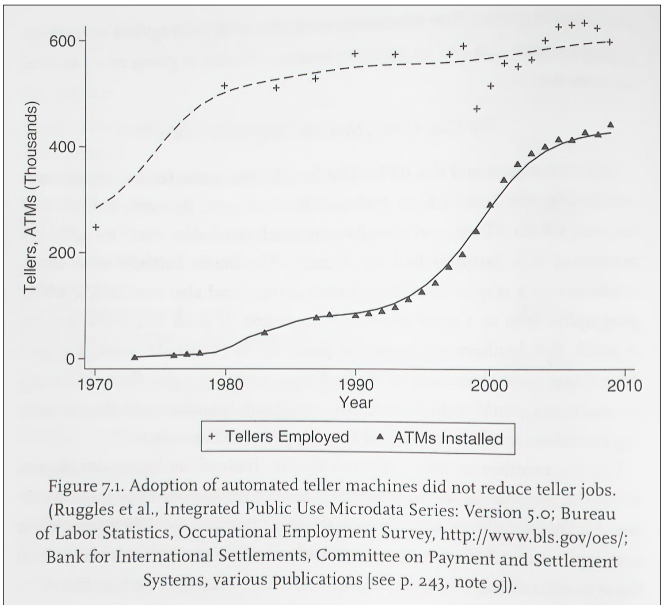

Figure 1: Evolution of the number of bank employees working at a counter and the number of ATMs. Source: James Bessen, 2015

History shows that when a new technology is introduced, whether it is a substitute, or a complement is often unclear. ATMs are a case in point. When they were first introduced, they were also seen as "job killers" for bank tellers.

But what happened? The number of tellers increased, as shown in the chart (top line). How did this happen?

Counting and dispensing money is a low-value-added activity for the bank. When machines perform these tasks, bank employees can focus on higher value-added activities, such as advising customers. In this way, ATMs have increased the productivity of bank employees. This has made it possible to open new bank branches that otherwise would not have been profitable.

Another example is the paperless office. With the proliferation of PCs, the paperless office became a buzzword. Do computers supplement or replace paper?

When asked in 1975 what the world would look like in twenty years, George E. Pake, then director of the Xerox Palo Alto Research Center (PARC), replied: "There is no doubt that in the next twenty years, there will be a revolution in the office [...] Technology will change the office as the airplane changed travel and television changed family life. I will be able to open documents on my screen at the touch of a button." He added, "I don't know how much more paper we're going to need in this world" (from Oberholzer-Gee, 2021).

Although most of the predictions came true, paper did not initially disappear from offices. On the contrary, paper consumption in American offices doubled between 1980 and 2000. Computers made it easier to print paper. It was not until 2000 that paper use per employee began to decline. It took

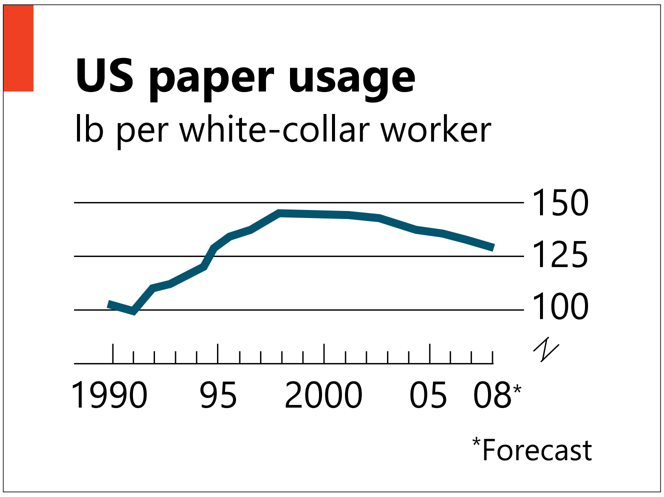

Figure 2: From The Economist, 2018

further technological advances, such as the proliferation of PDFs, and perhaps an awareness of the need to conserve paper, to reduce paper consumption (ibid).

The examples illustrate that, when a new technology is introduced, it is often unclear whether it will complement or replace existing processes. Second, the relationship may change over time. The computer began as a complement to paper, facilitating its processing, but gradually became a substitute as further technological advances made paper use increasingly obsolete. There is a fundamental tendency to initially see substitutes rather than complements. With certainty, the effects of new technology can only be assessed in retrospect (ibid.).

Consider autonomous driving. So far, progress in this area has been largely complementary. Taxi drivers are still in demand, unchanged by AI.

In other areas, especially where the output quality is less important, the technology is so mature that human labor is largely obsolete.

The quality of machine translation has improved to the point where translation agencies are no longer needed for everyday documents. Exceptions remain for very important or official documents.

In a recent project, we used large language models to summarize the results of an employee survey with approximately 30,000 responses in multiple languages. This resulted in about 230 different individual reports that gave managers a quick overview of the survey results in their area of responsibility.

In the context of increasing labor shortages, our biggest problem is not the rationalization of labor, but the question of how to maintain economic activity and industrial production. Further investment in automation and artificial intelligence is therefore inevitable. The right strategy for workers can only be to jump on the artificial intelligence bandwagon and increase their own productivity.

You don't need to know how to code. There are already many AI-based applications that do not require programming skills but can significantly increase your productivity if used correctly; one example is ChatGPT.

The next issue of the newsletter will focus on possible applications of artificial intelligence in purchasing.

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Automated cartel detection from purchasing data

Christoph Pfeiffer

Adam Smith already remarked in The Wealth of Nations (1776):

> *People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices.*

A cartel is an organized, often illegal, collaboration among competitors. Cartel organizations can increase profits by jointly fixing prices, dividing markets, or agreeing on a system of supply rotation. On average, cartels result in price increases of 22% to 25% for the buying companies. Government agencies have long sought to expose and punish cartels. Increasingly, private companies are trying to break up cartels themselves.

A data-driven, automated cartel screening has several benefits for companies:

1. The detection of cartels can lead to increased revenues from litigation, compensation payments and lower future prices.
2. AI-powered screening can deter cartel formation by suppliers when they are aware of the screening.
3. Automated screening increases efficiency and reduces manual workload.
4. Once automated screening has identified an alleged cartel, procurement can apply strategic and tactical approaches to mitigate the negative impact of cartels.

Cartel screening is based on indicators that measure specific elements of the bidding process.

For example, a commonly used indicator to detect cartels is the variance of bids over time. Several studies have shown that the variance of cartel bid prices is lower than usual. One explanation for this could be that coordination among cartel bidders leads to price convergence, as bidders align themselves with the coordinated bid of the designated winner.

Figure 3 shows that the coefficient of variation of submitted bids was significantly lower during the known cartel period 01.01.1999 - 31.03.2005 than in periods of normal competition.

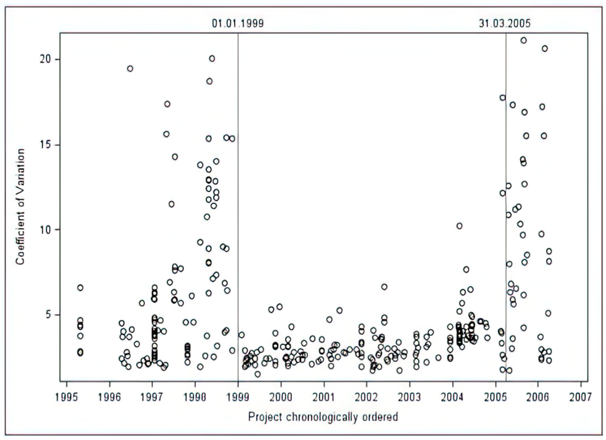


Figure 1: The Evolution of the Coefficient of Variation

Figure 3: Huber and Imhof (2018)

Most screening approaches are based on bid data. However, relying on multiple price based screens can lead to correlations between screenings. A spike from multiple correlated indicators does not have the same significance as a spike from uncorrelated indicators.

The statistical concept of correlation measures the extent to which pairs of variables move in a coordinated fashion. When indicators are highly correlated, additional indicators provide little additional information. Ideally, therefore, uncorrelated sources of information are sought. If several uncorrelated indicators simultaneously confirm the existence of a cartel, the analysis is more meaningful, and one has uncovered a cartel with a high probability.

Basically, a distinction can be made between behavioral, structural and other cartel screens.

For behavior-based screens, bids submitted as a First-Price Sealed Bid (FPSB) are the primary input. There are also specific screens for dynamic auctions.

Graph theory is a mathematical method for analyzing the structure of networks. Networks consist of nodes and vertices. For example, graph theory can be used to derive optimal routes for the traveling salesman problem; graph databases provide fast and intuitive querying.

Graph-theoretic cartel screening approaches are an underutilized complement to behavioral or industry-specific structural screens. They do not require price data and are, therefore less correlated with behavioral screens. Graph-theoretic antitrust screening typically requires only information on which suppliers bid together.

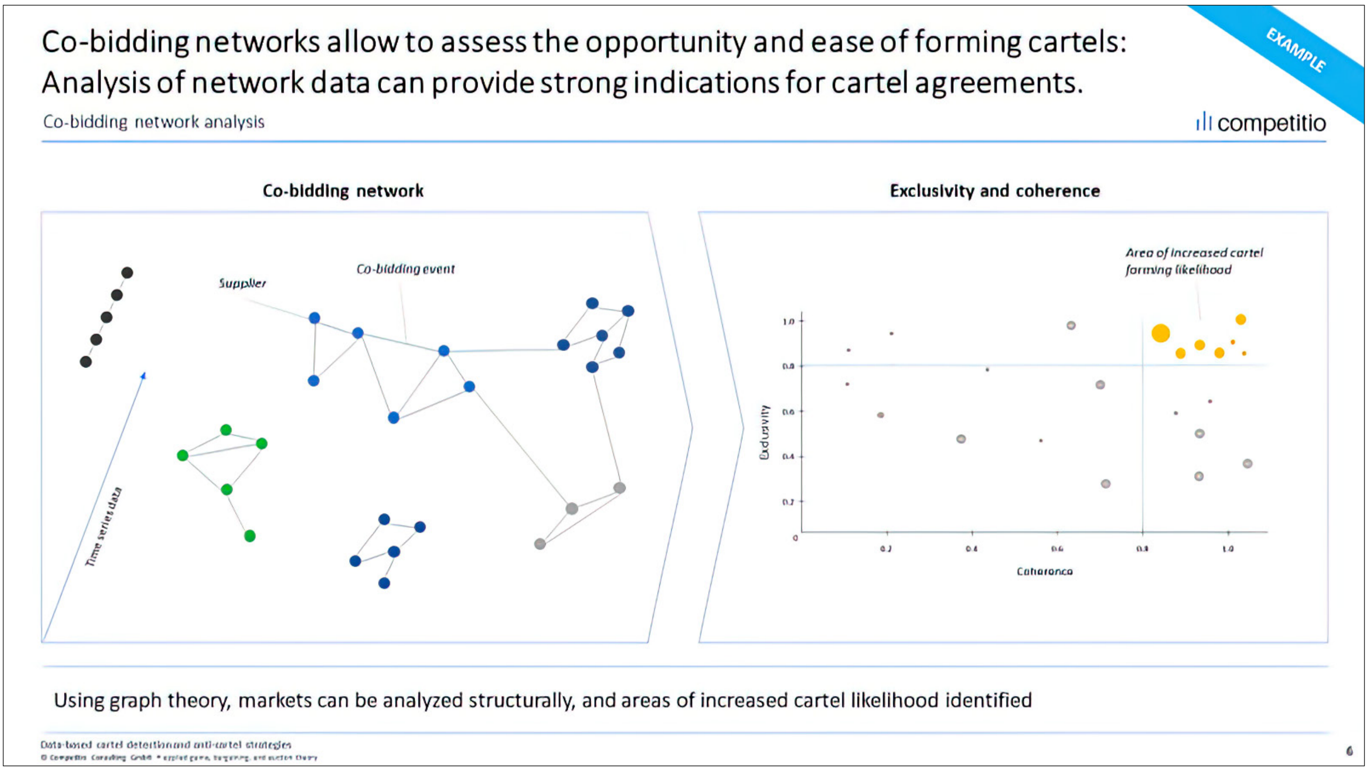
In 1980, Robert Axelrod began a tournament of game-theoretic algorithms that use competitive strategies in a prisoner's dilemma to analyze under what circumstances cooperation is likely. One of the main results of the study is that cooperation is more likely under adverse conditions (prisoner's dilemma) if two conditions are met:

1. **Repeated interaction:** Players interact repeatedly.
2. **Observability:** The behavior of the teammates is observable.

This result can be applied to cartel formation, which is a form of cooperation under more difficult conditions. Cartels are more likely when the same group of bidders repeatedly submit bids without changing their composition: From a cartel perspective, it is ideal if the same bidders are invited to bid repeatedly.

Johannes Wachs and János Kertész (2019) have developed a two-step graph-theoretic procedure to assess whether structural characteristics of the market are conducive to cartel formation.

In the first step, a community detection algorithm is used to identify groups of suppliers in a co-bid network. The co-bid



network shows all suppliers bidding on the same contracts.

In the second step, the identified groups/communities of bidders are evaluated based on coherence and exclusivity. A group has high coherence if the links between bidders are evenly distributed. It has high exclusivity if it has few or no links to suppliers outside its group. If both indicators are high, the likelihood of cartel formation is increased.

In practice, screening has proven to be effective. It has exceptionally high predictive power when combined with behavioral screening, as this approach combines multiple uncorrelated sources of information.

Graph theoretic analysis reveals the conditions conducive to cartel formation, but it does not reveal the cartel behavior itself. It is therefore ideally used as a complement to behavioral, time series, or other structural analyses.

Applying graph-theoretic analysis to procurement data requires data on contracts and all bidders who bid on that contract. Unlike other indicators, the type of negotiation and price data are irrelevant to the analysis; it does not matter whether bidders submitted their bids in an English, Dutch, or Hong Kong auction; whether the procurement department negotiated prices bilaterally; or whether you used advanced game-theoretic negotiation formats. Only the structural characteristics of the competition are relevant to the co-bid analysis.

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Effective procurement with combinatorial purchasing auctions

Christoph Pfeiffer

Bidders have no direct way to express their economies of scope or scale in traditional procurement and standard auction formats.

Combinatorial auctions allow bidders to communicate their costs and preferences more clearly, potentially benefiting buyers and suppliers. Combinatorial auctions have been shown to both reduce costs and increase the average supplier margin.

However, combinatorial auctions have a major drawback - their complexity. The number of possible combinations grows exponentially with the number of lots.

Exponential relationships are hard to understand intuitively. A bidder participating in a combinatorial auction for ten lots already has 1023 bidding possibilities. Analyzing more than a thousand combinations represents a significant complexity for a bidder. For the buyer, the difficulty is even more significant: with four bidders each submitting only 15 bids, the buyer would have to analyze more than a quintillion combinations (1.2×10^{18}) without further constraints, making brute force computation difficult. A computation time of one millisecond per possibility results in a total computation time of 38 million years.

To get a feel for combinatorial buying auctions, consider a simple example: a firm wants to buy three products, 1, 2, and 3. There are three bidders, A, B, and C, each of whom can bid on all three products.

In principle, bidders may submit bids for individual products and combinations of individual products. Unless otherwise restricted, bidders may submit bids for the following combinations:

- Individual lots: (1), (2), (3)
- Bundle of two lots: (1,2), (1,3), (3,2)
- a bundle of three lots corresponding to an offer of all products: (1,2,3).

So, there are 7 possible bids. This can also be calculated using the formula $2^n - 1$, where n is the number of lots. To enable unique bidding and evaluation, a bidding language must be defined. For example, bidder A could specify an individual price (P) for each product and offer a discount if he delivers all products. This bid vector could have the following form:

Bid_A= [(B = (1),P = 10),(B = (2),P = 8), (B = (3),P = 5),(B = (1,2,3),P = 20)]

However, another distinction is necessary: Can the buyer combine bids, or can only individual bids be used?

The bidding language is called an OR language if bids can be used in any combination. The bidding language is called an XOR language if bids can only be used individually.

The XOR language is more expressive, but it also makes bids longer. If the bidder wants to allow a simple, discount free combination of his single bids into bids of two, then he would have to state this explicitly:

Bid_(A_XOR)= [(B = (1),P = 10), (B = (2), P = 8), (B = (3),P = 5), (B = (1,2),P = 18),

(B = (1,3),P = 15), (B = (2,3),P = 13), (B = (1,2,3),P = 20)]

In practice, it is often easier for bidders to use OR language in conjunction with certain constraints, such as a maximum capacity and a maximum number of bids.

The Federal Communications Commission (FCC), which conducts spectrum auctions in the United States, initially rejected combinatorial auctions because of their complexity, computational uncertainty, and threshold issues. These concerns have since been addressed, and combinatorial auctions have become a standard tool of the FCC.

When implementing combinatorial auctions in practice, the following aspects, among others, must be considered (cf. Bichler, 2008):

Restrictions on bids: The mechanism can limit the number of bids or certain combinations to reduce complexity.

Design: The combinatorial auction can be designed as a single-round or iterative auction. An iterative auction can help bidders identify interesting combinations of bids.

Winner Determination Problem (WDP): The buyer must decide which combination of bids to select. Typically, the lowest cost combination is sought. However, other or additional criteria, such as a minimum number of bidders, may also be considered.

Ask prices: In RFXs with multiple rounds, bidders can ask what price they need to bid to be the leader in the next round, ceteris paribus. This can be an essential guide for bidders. However, calculating the ask price in a combinatorial auction is not trivial, since the bidder must not only offer the lowest price for that combination of bids, but the combination of bids must also be chosen a priori in the minimum cost combination.

Exposure problem: In a buy auction, you want to buy items 1 and 2. However, only individual bids can be submitted. If a bidder has positive economies of scope or scale for both items and includes them in his or her bids, but only wins one item, his or her bid was probably too low.

Combinatorial auctions solve this problem by allowing bidders to submit different prices for individual bids and combinations of bids. However, a similar exposure problem can occur in combinatorial auctions when the simple OR language is used. It may happen that a bidder bids on 1 and 2 separately, intending to supply only one of the two items, but ends up winning 1 and 2. This problem can be solved by using the (exclusive) XOR language. As mentioned earlier, a disadvantage of the XOR language is that it is longer and more complex because bidders must formulate their bids more precisely and thus submit a larger number of bids. Another solution to the combinatorial exposure problem is to allow dummy bids in the OR* language. Since items are only bought once, a bidder could ensure bid exclusivity by adding a dummy item to the bids, making them exclusive. For example, if he only wants to bid on product (1) or product (2) both exclusively, he could add a dummy bid D* to his bids: (1,D*) and (2,D*). Since each item is purchased only once, (1,D*) and (2,D*) cannot be combined because they contain the dummy good D*. The bidder has thus ensured the exclusivity of his bids without increasing the number of bids.

Threshold problem: Suppose three small bidders (A, B, C) and one large bidder (D) participate in an iterative combinatorial procurement auction for three positions (1, 2, 3). Bidder D can bid on all line items, while each of the smaller bidders can only bid on one line item due to capacity restrictions. Bidder D has a reserve price of 10 for all line items, and each of the smaller bidders has a reserve price of 3 for one line item. If Bidder D initially bids a price of 10 for (1,2,3), and the smaller bidders each bid a price of 4 for each line item, then coordination among the smaller bidders must occur to beat the larger bidder and achieve efficient allocation. Coordination among smaller bidders could be improved by providing feedback.

Cartels: Another critical issue is to avoid unwanted collusion among bidders. Cartels are organized cooperations between competitors and lead to significantly higher prices. It has been shown experimentally that combinatorial auctions make collaboration between bidders more complicated and thus reduce it. Cooperation is made difficult by the large number of possible combinations and the complexity of the WDP (see Lunander & Nilsson, 2004).

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