Electronic Commerce and Market Mechanisms
A Game-theoretic Approach

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Abstract

This paper takes the view that providers of electronic markets are to be considered as economic actors in a strategic game played with potential buyers and sellers. The crucial assumption clearly concerns the choice of instruments that a market provider is considered to have at hand. Contrary to large parts of mainstream economic theory, which assume a simple perfect auction market setting guaranteeing price flexibility and actual trade taking place only in situations where supply equals demand, the position taken here emphasizes that market mechanisms can be very diverse and trade outside of equilibrium is essential. To operationalize these core assumptions the instrument of the market provider is modeled as the choice of market mechanisms that is provided.

Keywords: market mechanism, market negotiation, electronic market and negotiation

1. Introduction

From a history of thought perspective it is an interesting phenomenon that mainstream economic theory still is concentrating on the study of perfect auction markets. Though it is clear that such markets, where trade takes place only when price changes have already equilibrated supply and demand, are much easier to incorporate into a formal model, it is a fact that most markets in everyday economic life do not work in a comparable way. As Takayama [3] already mentioned a long time ago, trade out of equilibrium is not a negligible issue but usually will undermine the emergence of equilibrium prices. More recently the issues of mechanism design have attracted the attention of microeconomic theorists working in the field of bargaining. The most famous, early contribution evidently came from Vickrey [5], who pointed out that a certain type of auction design – the so-called Vickrey auction - has the property that participants are induced to bid with their true reservation prices. Of course, truthful bidding is an objective of a design that itself must be somehow economically justified – and as experience shows so-called 'English auctions' with their much cruder mechanism but clear advantages for the seller are much more common. So even within the world of auction markets the last word in mechanism design surely has not been spoken yet.

With respect to electronic markets these topics gain further importance. Not only can in some cases auction markets be implemented to replace traditional market mechanisms – implying consequences in their design due to the possibilities of automated trading (compare [4]). There also appears the possibility of new market providers who can build up their set of available market mechanisms from scratch. Taking this new instrument of electronic market providers seriously leads to a changed view of what a future market economy actually will be:

It will not be characterized by sellers and buyers working on the background of anonymously defined markets – or even perfectly competitive markets. To provide market mechanisms will be a proper, entrepreneurial activity in its own right! This development was not possible before the wake of electronic commerce because only with the enlargement of information processing facilities and the detachment of bargaining from geographic locations the implications of market mechanism design became visible. Indeed it now seems to be mainly the time dimension, which is only partially bridged by the current global monetary credit system, that limits further growth of market provision.

What follows focuses on the modest goal to use a simple game-theoretic setting to demonstrate how a 3-person game of a market provider, a seller and a buyer could look like. Though the argument easily could have been formulated on a much more general formal level it is didactically more convincing to work with a specific example. Readers interested in necessary conditions for shapes of functions if certain issues are meant to hold must wait for further elaboration. The example given here shall present the general intuition and shall introduce a certain way how to treat the problem.

2. The Model

Assume that a market provider plans to establish an electronic market place for a well defined homogenous commodity that is sold in a given unit, i.e. its price is its only characteristic. There are two different market mechanisms she can provide: a fix-price mechanism and a negotiation mechanism.

The fix-price mechanism is defined as the following simple procedure. The seller (buyer) announces its reservation price, i.e. the lowest (highest) price for which the commodity can be sold (bought). If both parties use the fix-price mechanism, then for each price offer of the seller it is checked if there is an offer of a buyer whose reservation price is at least as high. If this is the case, then the deal is struck. Simultaneously for each offer of a buyer deals with sellers with reservation prices equal or lower than the offer are made. In a sense this mechanism is an extreme counterposition to equilibrium mechanisms. Here every trade usually favours one of the two parties, being below (buyer) or above (seller) its reservation price.

Assume further that reservation prices of the seller are normally distributed with mean 100 and variance 10 and that only integer prices from 50 to 200 are admitted. Similarly let the buyer's reservation prices be normally distributed with mean 150 and variance 20. Diagram 1 shows how the probabities of the two sets of reservation prices and the probabilities of prices reached with the fix-price mechanism for both parties look like.

To use the fix-price mechanism a market participent does not need any strategic capacity, all it needs is to know its own reservation price. Quite the opposite is assumed in the negotiation mechanism. In this case it is assumed that seller and buyer are acting according to the hyper-rationale bargaining model developed by Rubinstein [2]. In this model the price at which the deal is made depends on the relative cost that a further round of negotiation incurs on the bargaining parties. Who has higher negotiation cost will need the deal more urgently and will be forced to accept a more unfavourable price. More precisely, the price reached, P_N, is given by

$$P_N = P_S + (P_B - P_S) \cdot \frac{\delta_S \cdot (1 - \delta_B)}{1 - \delta_S \cdot \delta_B}$$

with P_S and P_B being the respective reservation price of seller and buyer δ_S and δ_B being their respective discount factor. For the seller δ_S is assumed to be 0,99, meaning a loss of 1% of price for each round of negotiation. The buyer is assumed to be more impatient expressed by a discount factor δ_B of 0,97. An interesting property of Rubinstein's result is that it does not impose any limit on the length of negotiations. Assuming a certain reservation price with which the buyer starts the negotiation procedure for any given reservation price of the buyer the price P_N can be computed. With the same assumptions on the distributions of reservation prices diagram 2 shows the probabilities of prices reached if both parties negotiate according to the Rubinstein model.

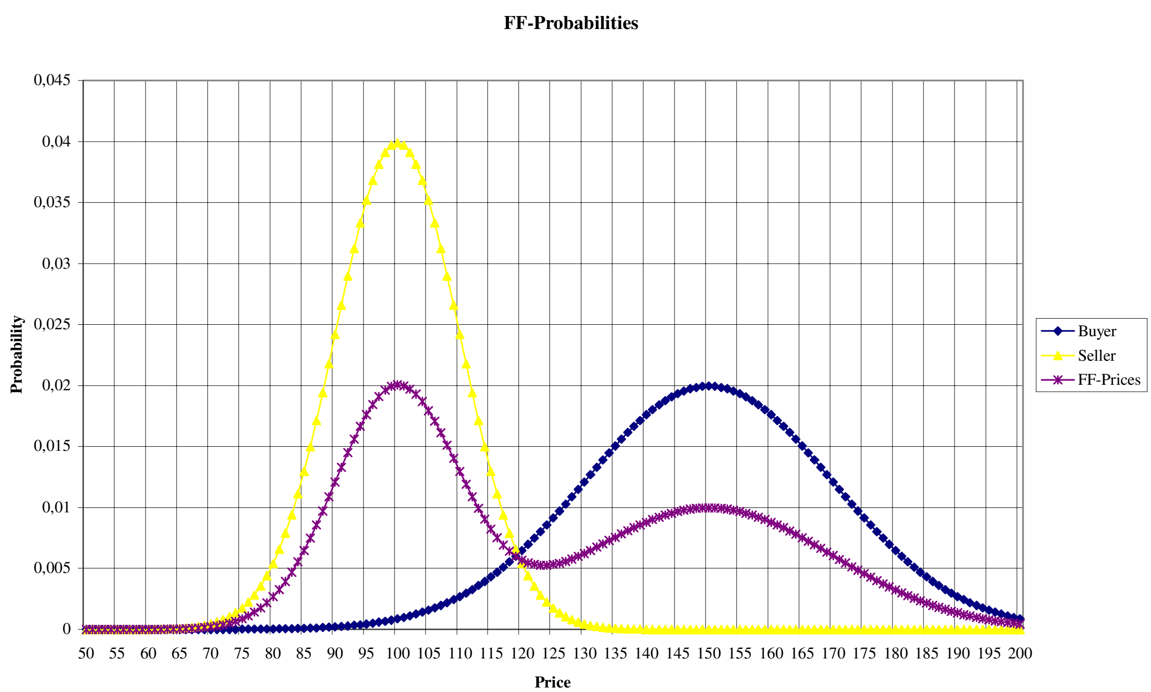

Figure 1. Price probabilities of the fix-price mechanism

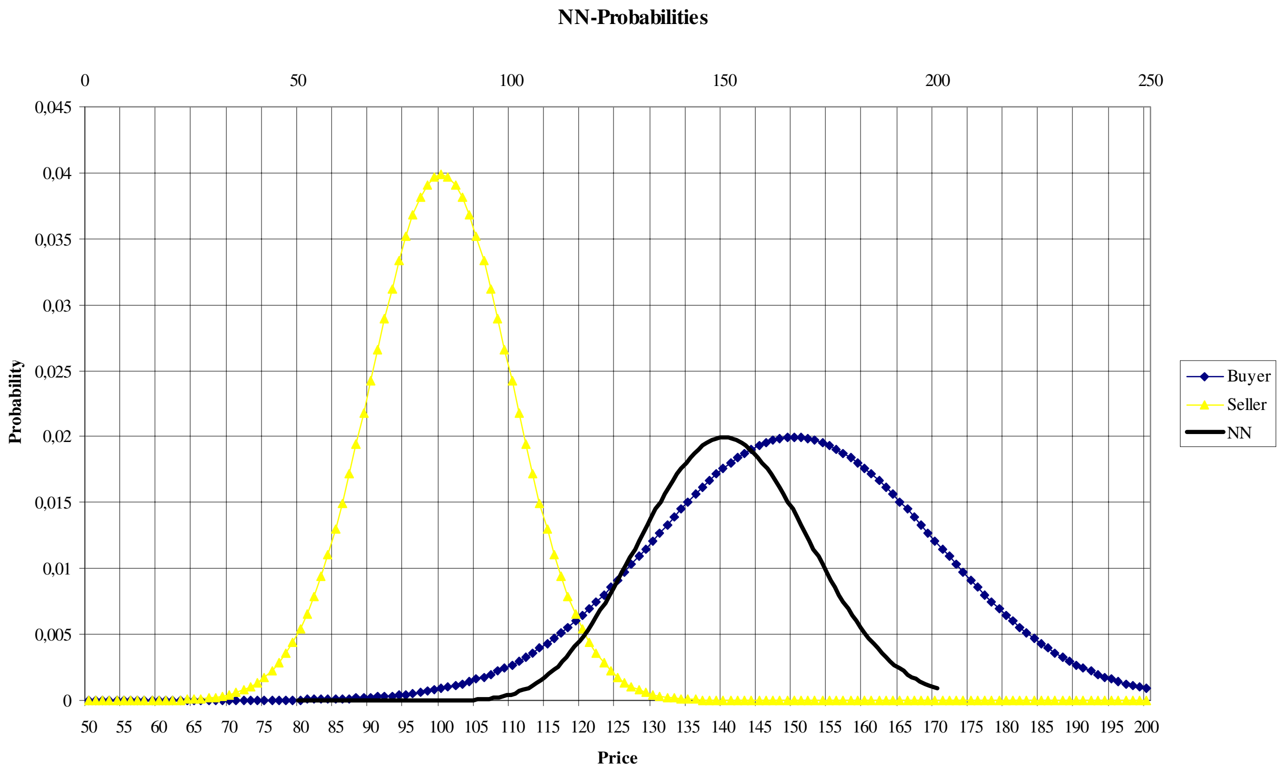

Figure 2. Price probabilities of the negotiation mechanism

With these two procedures at hand a market provider can choose to prescribe either the one or the other to be used by her customers. Of course a market that gives the customers the possibilty to choose the procedure they want to use would be even more attractive. But if this is made possible it might happen that one party chooses fix-price, while the other one chooses negotiation. So it has to be defined what happens in these cases.

If the buyer chooses fix-price and the seller wants to negotiate, label this case BFSN, it is assumed that the seller starts of with a price 10 units higher than its reservation price, expecting some approachment in a bargaining process. In a second round some sellers will be content with a price 5 units above their reservation price, but a certain share of them, given by the so-called frustration rate, will react frustrated to the fact that buyers stick to their fixed prices - they will leave the market. In the example the frustration rate is assumed to be 40%.

The other asymmetric case, the seller uses fix-price and the buyer wants to negotiate – call it BNSF, is constructed analogously. Now a price 5 units below the reservation price is the best the seller can get and the frustration rate again is 40%.

Having four possible matches of individual mechanisms, the market provider indeed has five different choices. She can either prescribe one of the four or let the seller and buyer choose their respective mechanism on their own. The game tree of this game thus looks as shown below in figure 3.

Assume further that buyer and seller make their choice without knowing from each other – this can easily be guaranteed by a market provider in an electronic market. And it will be done if it is advantageous for her. This is represented by the inserted information space of the buyer in diagram 3 – when making her choice the buyer does not know what the seller did.

At the leaves of the game tree the vectors of utilities of the players have to be inserted. To do so utility functions of the market provider, the seller and the buyer have to be assumed.

The market provider's utility is assumed to depend linearly on three elements: the success rate (the rate of deals made), the mean price reached (e.g. a share of this price is kept) and the average number of negotiation rounds supported. In the example let us first assume that the factors in front of element one and three are equal one, the factor of mean price reached is 0,3.

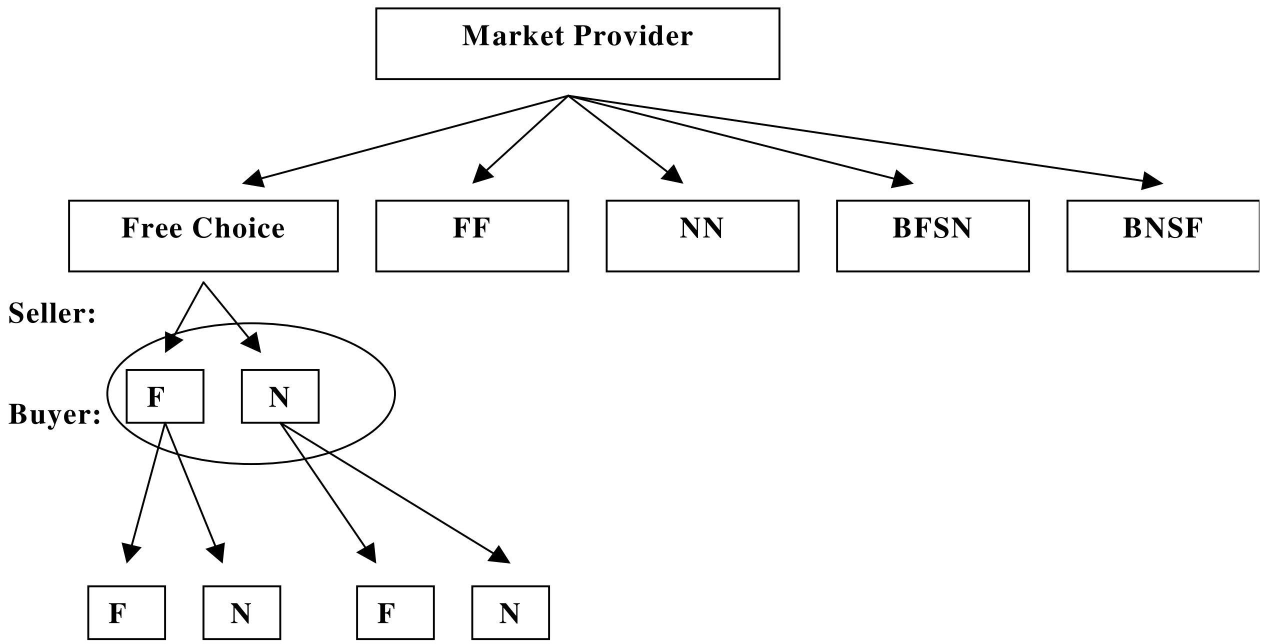

Figure 3. The game tree

The utility function of the seller and of the buyer look the same. They consist of two elements: A Cobb-Douglas function with expected price success and expected standard deviation of this success and a term to be subtracted that describes the cost of negotiation. Expected price success is the difference between reservation price and expected price. The cost of negotiation consist of the money paid to the market provider as negotiation cost and a term describing the (non-linear) opportunity cost of the time spent for negotiating. In the first example slight risk-aversity (elasticity of standard deviation of –0,2) of both market parties is assumed, opportunity cost of sellers are somewhat faster increasing than those of buyers.

3. Some Results

For the assumptions just made the subgame played by seller and buyer looks as shown in table 1. There is a single Nash equilibrium in the bilateral negotiation case. For the seller negotiation dominates fix-price anyway. Although the overall utility of the bilateral fix-price mechanism, the sum of utilities, is superior to the Nash equilibrium, it is not a Pareto improvement. Entering utilities in the game tree shows that in this case bilateral negotiation is the best outcome for the market provider too. Note that it has been assumed that a voluntarily chosen outcome is always better than its 'forced' equivalent. The amended game tree is shown in figure 4.

A modest upward shift in the opportunity cost of sellers would alter the subgame between seller and buyer dramatically, compare table 2. Now this subgame is a prisoners' dilemma, both players would be better off if they could shift to the bilateral fix-price mechanism. But for both players this Pareto optimum is unstable. An analogue situation emerges if the market provider has enough market power to increase negotiation fees, at least for the seller. This would increase her utility by forcing the other two in the prisoners' dilemma situation. Of course such solutions imply that the market provider is in a position to undermine binding commitments between seller and buyer.

The following two sets of changes show that this type of analysis opens up a wide variety of empirically relevant findings.

Table 1. The subgame

			Buyer			
		Fix Price		Negotiate		
Seller	Fix Price	11,73	13,73	-0,06	29,17	
	Negotiate	26,42	-0,15	**12,60**	**0,15**	
Market Provider's Utility		FF:	103,97			
		BFSN:	61,25			
		BNSF:	61,82			
		NN:	106,55			

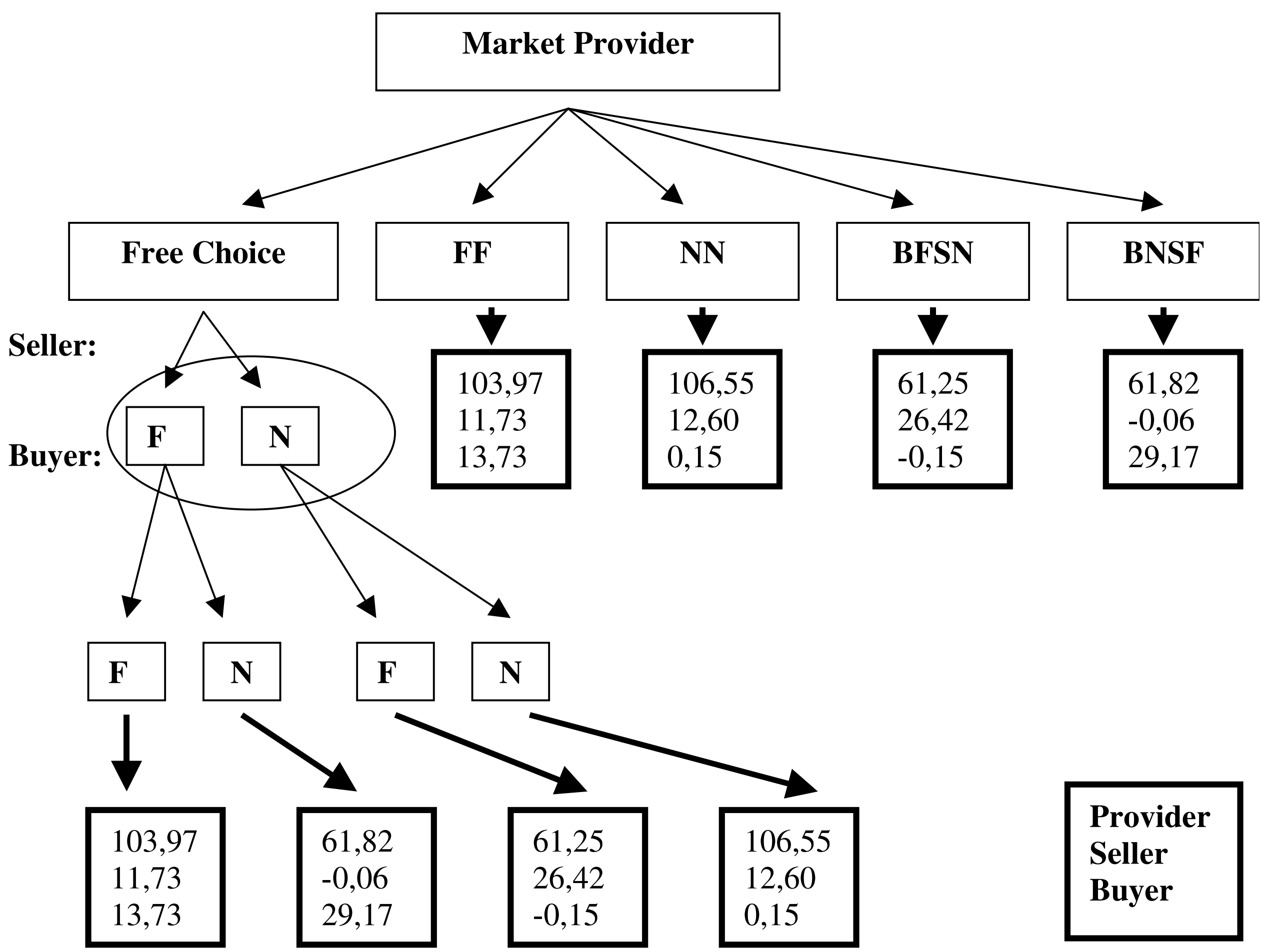

Figure 4. Payoffs inserted

Table 2. A prisoners' dilemma

			Buyer			
		Fix Price		Negotiate		
Seller	Fix Price	11,73	13,73	-0,06	29,17	
	Negotiate	25,98	-0,15	**11,32**	**0,15**	
Market Provider's Utility		FF:	103,97			
		BFSN:	61,25			
		BNSF:	61,82			
		NN:	106,55			

Let us first increase the standard deviations of reservation prices of the seller (from 10 to 40) and from the buyer (from 20 to 50). As table 3 shows, there now is no Nash equilibrium! Only two of the outcomes, BFSN and BNSF, show positive utilities for both players, in each of the other two regimes one of them would not enter the market. The market provider probably should enforce regime BNSF, where her utility is higher than in BFSN. Letting the game circle around the four outcomes might at first sight be another promising strategy. If it remains in each position for the same time the average utility for the market provider would increase remarkably (up to 51,81). But in this case there would be a periodic outflow of customers in the cases where their utilities turn out to be negative. So only when a market provider expects a permanent strong attraction of new customers she will be willing to take that risk.

Finally let us simply increase the mean value of the seller’s reservation price from 100 to 130. As can be seen in table 4 there is no cell in the payoff matrix where both utilities are positive. This means that for the given prices charged by the market provider (given the characteristics of seller and buyer) there will be no possibility to establish this market at all!

These examples should demonstrate that the presented model, despite its simple structure, can produce extremely interesting answers to fundamental questions concerning the implementation of electronic markets.

Table 3. Increased reservation price dispersion

			Buyer			
		Fix Price		Negotiate		
Seller	Fix Price	-9,00	32,17	**0,13**	**23,46**	
	Negotiate	24,55	0,25	-19,73	26,04	
Market Provider's Utility		FF:	60,59			
		BFSN:	39,84			
		BNSF:	44,33			
		NN:	62,45			

Table 4. Higher mean reservation price of the seller

			Buyer			
		Fix Price		Negotiate		
Seller	Fix Price	-7,51	17,68	-0,75	10,17	
	Negotiate	12,76	-3,40	**-13,30**	**6,99**	
Market Provider's Utility		FF:	77,99			
		BFSN:	50,85			
		BNSF:	54,37			
		NN:	89,72			

Conclusion

The overly simple model described above clearly calls for a number of extensions. On the one hand a more general and rigid mathematical treatment should replace the more eclectic approach chosen in this paper. It is clear that restricting the set and scope of instruments available to economic agents in such a strong and rather specific way has its price: the results derived are only valid for the setting chosen. On the other hand it is an evident advantage of more specific formulations to enable the formulation of mechanisms that mathematically are difficult to grasp while their algorithmic description is rather simple.

Using more, in particular more empirically grounded market mechanisms would enhance the acceptance of models like this in the business community. But at the same time it surely will make game theoretic treatment extremely difficult. Remember also that unexpected combinations of mechanisms must always be taken care of – this increases the number of supplementary assumptions exponentially.

Whatever extension of the basic setting is envisaged, one general result has an excellent chance to survive: The model can be used to describe a wide variety of situations by simple changes of some exogenous variables. Moreover the chosen 3-person game setting in most cases will produce the same result for small exogenous parameter shocks – the set of equilibrium strategies will not change for marginal changes in payoffs. But if an exogenous parameter shock reaches a critical size, then the whole situation suddenly becomes completely different. Of course, this is a general property of game theoretic models of this kind.

For future market providers there is the important implication that they should collect the best information they can get concerning what entered this model as exogenous variable. As emphasized in another paper [1], and not mentioned here, this should include expectations of customers. Then they should choose their market mechanisms carefully – perhaps a simulation tool like the one developed in the course of writing this paper could help. As game theory teaches, the rules of a game are themeselves the most important ingredient of successful economic behavior - the party that is able to establish or, at least, to modify these rules in an intelligent way will win in the long-run. These rule sets might well include a certain scope freedom of choice given to other players - (at least partial) knowledge of the relevant probability distributions characterizing the opponents will be essential to guide the design of favourable rule sets. This means that there is a lot of empirical field work to be done. But there is a lot of data already collected and waiting to be evaluated too. Empirically working scientists should meet model building theorists more often - it would pay.

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