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Douglas Gale's contribution to bargaining and markets☆

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1. Introduction

This short piece reviews some of the seminal contributions by Douglas Gale to the study of decentralized markets, both with symmetric information and with adverse selection. A key driver of Gale's interest in these themes was the aim to provide non cooperative foundations to competitive markets. The goal of this piece is not to provide a comprehensive survey, but to highlight some key insights and results in Gale's work in this area and to emphasize their relationship with the subsequent developments in the literature on decentralized markets and its various applications to OTC markets, labor markets, money and more.

2. Random search and bargaining

In a series of papers published in the mid 80's, Gale made very important contributions to the analysis of decentralized markets, where allocations are determined by search for counterparts and then by bargaining. The basic set-up is dynamic, as there are several dates in which meetings and trade can occur. Search is random, for two reasons: at any point in time an agent is matched with some probability with another, randomly selected agent. When this happens, the two agents bargain, under complete information: one of the two is randomly selected to make a trade proposal to the other agent, who then has to choose whether to accept, in which case the proposed trade occurs, or reject, in which case no trade occurs in that period. This setting, often referred to as a random search model, has been widely considered and applied in the following years. One important application is to labor markets (see Rogerson et al. (2005) for a survey of this large literature), another is to study money (originated by Kiyotaki and Wright (1989)), and a more recent one is to study Over-the-Counter (OTC) markets (see Hugonnier et al. (2025) for an overview of this work).

The main focus of Gale's work is the study of equilibrium allocations of large economies, with a continuum of agents, obtained in the limit, as search frictions vanish. The key question is: do equilibria in these economies converge to Walrasian equilibria? If they do, this would provide another justification of Walrasian equilibria and of the origin of prices in these equilibria. Moreover, the result would be obtained using trading protocols that, as Gale (2000) noticed, are similar to the ones observed in decentralized markets, and relying on equilibrium notions from non cooperative game theory. Gale's work was partly motivated by the negative result on convergence obtained by Rubinstein and Wolinsky (1985). This result was derived in a partial equilibrium set-up, considering a single market for an indivisible good, with two types of agents. The structure is as described above, with an additional feature: when a pair of agents agree to trade, they leave the market and are replaced by a new pair of identical agents, to retain the stationarity of the population. The frictionless limit is characterized by letting agents' discount factor approach 1. Gale (1987) considers a similar environment, though with several types of agents, and assumes a constant flow of potential entrants to the market in each period. At a stationary equilibrium the number of buyers and sellers entering the market must be the same, in the limit trade occurs at the same price and the types which enter are determined by this price. Gale shows that this is the competitive equilibrium price if we consider the demand and supply expressed by the agents who enter the market every period (instead of the one coming from the set of agents present in the market at any date), thus establishing a convergence result.

Gale (1986a,b) prove then an analogous result for a more general exchange economy, with an arbitrary number of divisible goods.

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Hence agents can trade several times before exiting the market and then consuming the amount of goods they have, as a result of their endowment and trades. In this work Gale works directly in the limit, by assuming that agents do not discount the future, and there is no entry after the initial date (thus the environment is non stationary). He shows that (under some regularity assumptions) the allocation obtained at any Subgame Perfect Equilibrium of the decentralized trading and bargaining game coincides with a Walrasian equilibrium allocation. A key step is that it is never optimal for an agent to stay in the market forever and that the decision to leave at some date, given the bundle acquired, is optimal when they anticipate that they will not be able to enter matches at any future date leading to beneficial trades. This allows then to pin down the utility gradient of this agent, which in turn determines the supporting price. Overall, these works by Gale provide a clear and convincing answer to the question stated at the beginning of the previous paragraph.

It is also useful to add that the recent applications of these models of decentralized trading to OTC markets has generated renewed attention for the study of equilibrium outcomes with vanishing search frictions. This situation is in fact particularly relevant for these markets. Rather than focusing on the properties of allocations and prices in the limit, Hugonnier et al. (2022) investigate the properties near the limit, where frictions are small but still generate misallocations, with different impact on different types of agents.

3. Directed search and asymmetric information

Gale also made very important contributions to the study of Walrasian equilibria with adverse selection, which again build on a decentralized market idea, as we will explain. At the time Gale worked on the topic, there was no readily available formulation of Walrasian equilibria with adverse selection, and an important part of the challenge was precisely coming up with such notion. A key element for this is the specification of the space of tradeable objects, which with asymmetric information is the space of tradeable contracts. In this respect, the approach pursued by Gale is rather different from the one followed by Prescott and Townsend (1984) in some earlier work for economies with moral hazard (and extended by Bisin and Gottardi (2006) to adverse selection settings). In contrast to these works, where the objective was to specify a sufficiently large space of contracts/mechanisms so that incentive efficient allocations could be decentralized as competitive equilibria, Gale (1992, 1996) consider an exogenously given space of contracts, hence defining agents' preferences over them. To help intuition, we can think of such contracts as specifying the quantity traded (in Gale (1992)), or the quantity and the price (in Gale (1996)).[1] The objective in this case is to show that Walrasian equilibria allow to characterize equilibrium outcomes, that they always exist, in contrast to the findings by Rothschild and Stiglitz (1976) following a strategic approach. The goal, as Gale writes, is to "emphasize the non-cooperative aspects of competitive equilibrium in a world of decentralized, anonymous trades" (Gale (1992, p. 230), highlighting also the tractability of this approach.

In Gale (1992) market clearing is ensured by prices, while in Gale (1996) by rationing, or probability of trade. At a competitive equilibrium, only some of the contracts will typically be traded. Hence for many contracts clearing occurs with zero trades (but still there is a price – or a probability – with which the agents, if they wanted to trade them, could do so). A key issue then arises in this construction: what determines beliefs regarding the type of the counterpart in each contract? This clearly matters in environments with adverse selection (Gale (1992) allows both for one-sided and two-sided private information). Such beliefs are pinned down by Bayes' rule for traded contracts. For non-traded ones Gale (1992) uses a refinement in the spirit of stability, requiring the robustness to any small perturbation. The competitive nature of the equilibrium and the fact that beliefs are not affected by the action of any trader (due to each trader being negligible relative to the size of the economy) ensures that an equilibrium always exist, in contrast to the findings of the works following a strategic approach. The refinement then allows to show that, when a single crossing condition is satisfied, the equilibrium allocation is unique and fully separating.

Gale's work is important as it lays the foundation for the competitive search approach to the analysis of markets with adverse selection (this is not, as explained above, the way in which Gale cast his analysis but, especially when the contract space is extended to include prices, as in Gale (1996), the analogy becomes clear). Such approach, developed by Guerrieri et al. (2010), has then been extensively used in the recent years to study decentralized markets, as OTC, characterized by the presence of adverse selection. In this approach, on one side of the markets there are principals, who post contracts they are willing to trade (including the specification of their price), on the other side agents, privately informed about their type, who choose one of the posted contracts they would like to trade (apply to). Market clearing is achieved via the queue length (buyer/seller ratio) associated to every market. Guerrieri et al. (2010) then also find that, under a different but related refinement, a unique competitive search equilibrium always exist and is fully separating.

Data availability

No data was used for the research described in the article.

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[1] This is motivated with an important observation (p. 209): "In economies with adverse selection or moral hazard, the distinction between commodities and prices breaks down, because a change in price frequently leads to a change in the characteristics of the commodity being traded".