

# New Directions in Market Design

## Introduction

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## Introduction

The first FCC spectrum auction, designed with substantial input from academic economists and subsequently recognized with the 2020 Nobel Memorial Prize in Economic Sciences (awarded to Paul Milgrom and Robert Wilson “for improvements to auction theory and inventions of new auction formats”), took place thirty years ago in 1994. In the years since then, an extensive body of research has focused on improving auction design and many countries worldwide have followed the U.S. in using economic tools to design their spectrum auctions. The speed at which new insights moved from the research frontier to policy design was very short in the case of spectrum auctions. Some of the innovations that were applied in the 1994 FCC auction were developed just a decade earlier.

In parallel, in 1995 the National Residency Matching Program commissioned a report to develop a new clearinghouse algorithm for the medical match, with particular emphasis on outcomes for married couples. The recommendations of that report drew on some existing research, but also broke new conceptual ground in addressing multi-agent matching problems. The report’s recommendations were adopted by the medical profession in 1997 and have been widely viewed as very successful. This project was featured prominently in the 2012 Nobel Memorial Prize in Economic Sciences (awarded to Lloyd Shapley and Alvin Roth “for the theory of stable allocations and the practice of market design”). Just as in the case of the FCC spectrum auctions, collaboration between academics and practitioners was essential for developing practical solutions to market design problems.

In recognition of these two nearly-coincident 30-year anniversaries, the NBER’s Market Design Working Group organized a two-day conference in Washington, D.C., on May 11-12, 2023. The conference combined a retrospective assessment of key discoveries and advances in market design over the past three decades with prospective analyses of the most promising directions for future applications. One unique feature that made this conference special was extensive engagement both from academic researchers and from practitioners in a number of sectors of the economy: government, industry, and NGOs. The agenda of the conference, along with video recordings of many of the talks, is available at <https://www.nber.org/conferences/new-directions-market-design-spring-2023>.

This volume contains a selection of contributions based on the talks presented at the conference. These contributions provide different approaches and topic areas for market design research, illustrating both the wide variety of different applications that can benefit from the market design viewpoint as well as the broad diversity of methodological techniques.

We now briefly summarize the chapters in this book, drawing also on portions of the lectures.

### **Alvin Roth, Market Design and Maintenance**

From matching medical residents to saving lives through kidney exchanges, economists have evolved from theorists to hands-on market designers. In a chapter on the evolution of economists's involvement, Alvin Roth traces this transformation over the past quarter-century. Though markets have been designed since antiquity, economists' role as active architects is relatively modern. Three cases illustrate this evolution. The American medical residency matching system, established in the 1950s, required significant retooling in the 1990s to accommodate the surge of women doctors and couples seeking joint placements. Today, the system struggles under the weight of electronic applications, creating a new form of congestion. Proposals to introduce preference signals and caps on applications are being explored. The Economics PhD job market faces its own disorders. As interviews and offers become increasingly scattered across the calendar, the market risks "unraveling"—a phenomenon where hiring decisions are made prematurely, to the detriment of all. Without better coordination, the possibility of market breakdown looms. A third case is kidney exchange. Since America's first kidney swap in 2000, economists have helped craft increasingly sophisticated matching systems across hospital networks. Innovation has flourished: "donor chains", initiated by altruistic donors, have multiplied the number of life-saving transplants. Yet with diabetes driving up kidney failure rates, demand continues to outstrip supply. Cross-border exchanges offer hope, though regulatory and logistical hurdles persist. Roth observes, markets, like buildings, require constant maintenance.

### **Estelle Cantillon and Aurielle Slechten, Market Design for the Environment**

Can market forces be harnessed to save the planet? Estelle Cantillon and Aurielle Slechten examine the promise—and pitfalls—of environmental market design, with particular attention to carbon trading schemes and voluntary offset markets. The fundamental challenge is the familiar tragedy of the commons. Clean air, pristine waters and thriving ecosystems suffer from a market failure—their benefits are shared by all, but their costs are borne by none. Traditional remedies have evolved from simple auctions of resource rights to sophisticated cap-and-trade mechanisms and markets for ecosystem services. The European Union's Emissions Trading System serves as a case study. Europe's flagship carbon market has weathered storms of price volatility that have threatened to undermine investment in clean technology. The culprits include: overlapping green policies, financial speculation and rigid market architecture. Proposed solutions range from price floors to dynamic supply adjustments. Perhaps most intriguing are voluntary carbon markets, where companies seek to offset their environmental sins through emissions-reduction projects. According to Cantillon and Slechten, this nascent marketplace is plagued by credibility problems. "Greenwashing" scandals and dubious carbon credits have prompted calls for stricter oversight. The debate now centers on the tradeoffs between decentralized innovation or centralized regulation. Cantillon and Slechten argue that the success of environmental markets ultimately hinges on careful institutional design, but are optimistic about new opportunities thanks to technology.

## **Billy Ferguson and Paul Milgrom, Market Design for Surface Water**

Billy Ferguson and Paul Milgrom examine how market design could help solve humanity's mounting water crisis, using California's parched landscape as their laboratory. California's traditional response to water shortages—damming rivers and desalinating oceans—may be increasingly antiquated. However, water markets, which could allocate this precious resource more efficiently, remain stubbornly underdeveloped. The reasons are as complex as California's water-rights system itself. One is the "return flow" conundrum: irrigation water that seeps back into streams affects downstream users, creating externalities. The water rights system is also Byzantine, where rights are often held by irrigation districts rather than individual farmers, and measurement poses challenges. Drawing inspiration from America's successful spectrum auctions, Ferguson and Milgrom propose a novel approach: procurement auctions that would let farmers voluntarily swap their existing rights for more flexible ones. These new rights would permit water storage and borrowing—making them more attractive to trade than their ossified predecessors. Technology could grease the wheels. Satellite-based evapotranspiration monitoring promises greater transparency, while standardized hydrological models could prevent courtroom battles over water rights. A stricter definition of "beneficial use" might curtail water-intensive crops like alfalfa, which contribute little economic value. Australia's Murray-Darling Basin offers a glimpse of what's possible. There, water markets help farmers weather dry spells through efficient trading. Ferguson and Milgrom argue that by applying market design principles to water management—through voluntary rights conversion, better measurement, and robust legal frameworks—efficient, sustainable, and legally sound water markets can be created to address global water scarcity issues.

## **William Arnesen and Rachel Glennerster, Market Shaping to Combat Climate Change**

While carbon pricing garners headlines, William Arnesen and Rachel Glennerster argue that the thornier challenge lies in designing markets that drive the technological breakthroughs needed to decarbonize everything from concrete mixers to cargo ships. Arnesen and Glennerster think that traditional market design, with its focus on optimizing existing systems, falls short when confronting climate change. The reason is that the task requires reinventing how humanity heats buildings, moves goods and produces food. Innovation languishes, hobbled by market failures that carbon prices alone cannot fix. Inefficiencies and knowledge spillovers mean inventors capture only a fraction of their innovations' value. Arnesen and Glennerster divide the policy toolkit into "push" and "pull" mechanisms. The former, like research grants, subsidize inputs. The latter reward outputs through prizes or advance market commitments (AMCs). Success stories exist: a \$1.5 billion AMC helped deliver pneumococcal vaccines to developing countries. Replicating such triumphs for carbon removal is trickier, given the diversity of potential technologies and their uncertain costs. Arnesen and Glennerster discuss concrete production, which accounts for 8% of global emissions. The challenge in this case extends beyond energy use to the chemistry itself. Similarly, hydrogen fuel development stalls as complementary innovations from production to storage. Long-term government commitments could break such deadlocks. America's government purchases half the country's concrete—market power that could accelerate adoption of green alternatives. The challenge lies in providing the certainty that innovation requires. To accelerate decarbonization, Arnesen and Glennerster argue for an expanded view of market design focused on stimulating innovations and by addressing challenges such as complementary innovations, long-term commitments, and government procurement policies.

## **Mete Seref Ahunbay, Martin Bichler, Johannes Knorr, Challenging in Designing Electricity Spot Markets**

Electricity markets are not simple affairs of supply meeting demand. Mete Seref Ahunbay, Martin Bichler, and Johannes Knorr reveal that today's power markets are vast computational beasts, with their complexity multiplied by the fickle nature of wind and solar generation. Europe's day-ahead market alone, processing most of the continent's electricity consumption, resembles a giant mathematical optimization problem more than a traditional marketplace. America embraces nodal pricing, setting rates for each point in the grid, which is precise but computationally demanding. Europe opts for zonal pricing, with single prices per country or region, which is simpler but potentially less efficient. Institutional considerations are first-order. Power plants cannot switch on and off. Their start-up and shutdown costs create non-convexities. The AC optimal power flow problem is complex and require approximations, sometimes triggering price spikes. American markets emphasize efficiency, using "make-whole payments" to keep generators solvent. Europeans, via their PCR Euphemia algorithm, prefer avoiding such side payments, even at the cost of some efficiency. As markets shift from hourly to 15-minute settlements, the computational challenges intensify. Ahunbay, Bichler, and Knorr argue that multi-objective optimization could better balance efficiency against other goals. Further innovations in optimization and market design could also address the challenges posed by the increasing integration of renewable energy sources.

## **Kevin Leyton-Brown, Paul Milgrom, Neil Newman, and Ilya Segal, Artificial Intelligence and Market Design**

In their chapter, Kevin Leyton-Brown, Paul Milgrom, Neil Newman and Ilya Segal argue that AI—broadly defined as systems that improve with data or computing power—is transforming how markets function. The authors describe America's Federal Communications Commission's spectrum auction. The challenge involved persuading television broadcasters to surrender valuable airwaves for mobile networks while solving an NP-complete graph coloring puzzle to prevent signal interference. Traditional economic theory alone proved insufficient. A cocktail of AI techniques—from satisfiability solvers to algorithm configuration—helped to crack the computational conundrum. The resulting system balanced economic efficiency with computational feasibility, saving billions in auction costs. The authors see this as the prologue. AI promises to revolutionize everything from behavioral game theory to preference elicitation. More intriguingly, markets themselves must evolve to accommodate AI's peculiarities. How should AI services be priced? How can strategic manipulation of AI systems be prevented? As algorithms increasingly mediate economic activity, a host of interesting questions arise.

## **Tayfun Sönmez and Utku Ünver, Influencing Policy and Transforming Institutions: Lessons from Kidney/Liver Exchange**

Tayfun Sönmez and Utku Ünver argue that market designers could learn much from surgeons. By adopting "minimally invasive" techniques to repair failing allocation systems—nowhere more critically than in organ donation, Sönmez and Ünver believe that successful market design often requires delicate, targeted interventions rather than wholesale system overhauls. In kidney exchange programs, economists did not create new organ markets—they simply enhanced existing donation processes, working hand-in-glove with transplant surgeons and policymakers. Sönmez and Ünver recount how

this surgical approach to market design has proved remarkably effective. By respecting institutional frameworks and stakeholder objectives, economists have helped save lives without triggering ethical controversies or political backlash. The success extends beyond organs: from school choice to military assignments, minimal intervention has yielded maximal results. Yet challenges remain, particularly in expanding kidney exchanges globally. The transplant community's mixed reactions and fears about organ trafficking highlight the importance of careful stakeholder management. As liver exchange programs develop, similar sensitivities must be navigated. Sönmez and Ünver's lesson is that in market design, as in clinical medicine, a gentle touch rather than radical reform may be most effective.

### **Fanyin Zheng, Matching Hospital Resources with Patients in Needs**

Americans spend \$1.3 trillion annually on hospital care—a third of all healthcare expenditure. Fanyin Zheng addresses the need for improved allocation of hospital resources—such as ICU beds and operating rooms—to enhance efficiency and patient outcomes. Intensive care units and operating theatres—hospitals' most precious resources—often sit idle or overflow unpredictably. Physicians, focused on their immediate patients, display short-term thinking. Zheng argues the consequences are severe. Patients endure longer hospital stays and higher post-surgical complications, and costs spiral. The problem lies in systemic design flaws. Multiple decision-makers—doctors, administrators, policymakers—pursue different objectives with imperfect information. Real-time data and demand forecasting tools could help doctors make better decisions. Incentive structures could be redesigned to align physician behavior with hospital-wide efficiency goals. Artificial intelligence might smooth out the behavioral quirks that lead some doctors to hoard resources while others practice just-in-time medicine. But implementing such reforms requires delicate handling since physicians bristle at administrative oversight, administrators fear liability, and patients demand immediate care. Zheng describes how the challenge lies in designing markets that respect medical autonomy while promoting system-wide efficiency.

### **Derek Neal and Joseph Root, The Provision of Information and Incentives in School Assignment Mechanisms**

The elegant algorithms underlying school choice mechanisms may be solving the wrong problem. Derek Neal and Joseph Root emphasize that the challenge may not be simply preventing strategic manipulation of preferences, but in helping parents develop informed preferences in the first place. Parents face a dizzying array of options—each with its own teaching philosophy, academic results, and extracurricular offerings. Simple theory assumes they can rank these choices with complete knowledge of options. Reality proves messier. Many parents lack basic information about available schools, let alone the nuanced understanding needed to make optimal choices. The costs of gathering comprehensive school data—visiting campuses, interviewing teachers, analyzing test scores—often exceed the benefits for any individual family. As a result, parents make decisions based on incomplete information, rendering even perfectly designed assignment mechanisms suboptimal. Neal and Root argue simple interventions—standardized school quality reports, parent mentoring programs, school fairs—could yield great improvements within existing choice systems and call upon market designers to consider the design of information that participants bring to choice to be front-and-center in the design problem.