Markets and Coordination

by Preston McAfee[1] and Simon Wilkie[2]

One of the most contentious political debates can be summarized by:

Left: Markets are not delivering the results people need. Let the government run it.
Right: Markets created the giant increase in living standards we enjoy. Leave the market alone.

Both positions are right – and wrong. Yes, market forces created the vast wealth of the western nations, and China shows what market forces can accomplish in two generations. At the same time, the way markets operate doesn't necessarily produce the greatest good for the greatest number, and in some cases, such as pollution, laissez faire markets produce terrible outcomes.

Market Design is a way of having your cake and eating it, too. Market design involves harnessing and directing market forces to produce socially desirable outcomes. It responds to *Left* by accepting that an unregulated market may produce undesirable outcomes, and adjusts the rules of competition to improve the outcome. It responds to *Right* by embracing market forces.

Market Design for digital transactions permeates the ten key challenges for the digital economy posed by the Luohan Academy, an open research institute founded by Alibaba.[3] These questions encompass inclusive, strong and sustainable growth using new digital technologies.

The market design approach is familiar in government procurement. Governments don't typically make roads, computers, French fries, or warships: governments buy these things. Typically, governments will create specifications and take bids for the specified products. Similarly, governments used to issue licenses to use the radio spectrum by hearings, essentially having the government decide who is the most desirable. Now many governments use auctions to allocate the spectrum, with constraints that respect things markets get wrong (interference, need for tied channels, social purposes like diversity), thereby harnessing market forces to produce better outcomes than either government hearings or an unrestricted market would produce.

The key insight, perhaps, is that "let the market decide" involves dozens of choices which affect the kinds of market outcomes that arise. Market design is the study of how to make those choices in such a way as to improve the outcomes that arise. A sharp example arises in the design of Ant Financial. Alipay, the payment arm of Ant Financial, employs big data and cloud computing for fraud detection, based on observed information flows. It achieves a fraud-loss rate of less than 5/10,000,000, well below the 0.2% level seen in the world's leading payment agencies, due to the management of information flows.

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[3] https://www.yicaiglobal.com/news/alibaba-luohan-academy-poses-10-questions-on-the-digital-economy; accessed Oct 31, 2019.

Market design is a form of applied economics, bearing the relationship to traditional economics that engineering bears to physics. The main goal of market design is to design "the rules of the game" governing how people interact in a market relationship, and what information they are required to report, to achieve various objectives like efficiency, equity, revenue, and broad participation. Market design uses a mixed set of techniques – game theory, economic theory, laboratory and online experiments, psychology, behavioral economics, analysis of existing markets, and interviews with market participants – to figure out what rules are likely to work, and subject candidate designs to empirical stress tests.

Market design has worked in a quite diverse set of circumstances. Over $100 billion in spectrum has been allocated via the simultaneous ascending auction, designed by three economists to improve on spectrum auctions, a design that now has stood a quarter century test of time.

There are many successful examples of market design which didn't organically evolve but rather were handcrafted and intentionally implemented. Twenty thousand physicians are matched to residencies in the US and UK using a variant of the Gale-Shapley algorithm, implemented via a large computer program. Professors Al Roth and Lloyd Shapley won the Nobel Prize for this work. A related mechanism matches New York and Boston children to public schools. Market design methods have been fruitfully applied in such diverse settings as electricity auctions, airport security, sales of mineral resources, matching MBA students to classes, packing experiments in the space shuttle, allocating water rights, reclaiming poorly-used TV spectrum, scheduling railroads, and improving financial markets. While applications of market design tend to be handcrafted by expensive consultants, the technology is a resounding and accepted success.

Market design generally performs best as a decision support system helping the government to meet its needs and inform them of the consequences of choices. The combination of automated data, especially from Internet of Things devices, and machine learning processing like video processing, open a wider array of market design technologies, and indeed create the possibility of new markets like those pioneered by Alibaba, Uber and AirBnB.

The evolution of Taobao's rating system[4] provides an instructive example of practical market design. Over fifteen years, Taobao increased the information – both complexity and context – provided to market participants. It acted to prevent collusion and exploit social networking. Feedback loops involving user engagement, product returns and algorithms that detect ratings manipulations led to a system that maximizes the gains from trade. Taobao made dozens of choices to optimize the marketplace.

What follows is a discussion of seven specific technologies and issues that can be addressed with market design. These range from well-established, proven technologies (Auctions, School Assignment, Removing Subsidies) to emerging consensus with working examples (Security Force Deployment, Traffic) to novel solutions that require validation and testing (Crowd Control, Worker Retraining). By influencing incentives, market design can help with most problems faced by the public sector, and be transformative in many.

[4] Section 4.2.3 from "Digital Technology and Inclusive Growth," Luohan Academy, 2018.

Auctions

Auctions represent a price discovery methodology. As a result, they are valuable whenever prices or costs are uncertain. If a government is buying a competitively supplied product, like catsup or wheat, it can buy it from the market. In almost all other circumstances, it should run a procurement auction. Similarly, if the government is selling something whose value varies or is unknown, like off-shore oil drilling rights, radio spectrum, airport landing rights, pollution permits, import quota rights, timber on public lands, water, electricity, or confiscated stolen goods, the right method of selling is an auction. Auctions should be used whenever a resource is in fixed supply, like airport landing rights, to efficiently allocate shortages.

A common misunderstanding is that auctions should be used only when the goal is to obtain the best price. But modern auctions are actually a nimble tool that can accommodate many other social objectives, like favoring domestic or minority-owned suppliers, favoring sustainable development, penalizing suppliers who pollute excessively, sharing risk, and generally meeting other non-monetary goals.

There are many choices in designing an auction appropriate to the problem at hand and the application should determine the choice. Auctions can be sealed-bid or ascending; auctions can be priced with the best or second-best bid; multiple goods can be sold simultaneously or sequentially or involve bundles; auctions can favor or disfavor particular bidders and may offer bidder credits; auctions can share risk between buyer and seller; auctions can have forward markets; auctions can involve withdrawal penalties.[5]

Auctions with favoritism provide a mechanism for using market forces to accomplish social objectives. For example, consider the common goal of favoring a particular group – domestic workers, women- or minority-owned business, or companies using green technologies. Historically the means of favoring such groups is a "set aside": some portion of procurement or government activity is earmarked only for such groups. A superior method is actually to favor the target group in all activities. For example, the target group might obtain a bidder credit, which works like a handicap in golf. When the government is buying services, a bidder credit means the government pays more than the stated price when buying from the target group. Thus, a 15% bidder credit means a \$100 bid produces a \$115 payment for targeted bidders, permitting a higher cost targeted bidder to compete effectively with a more efficient competitor. The advantage here is that all auctions are open to all bidders; in contrast, set-asides usually involve the worst services being set-aside. Moreover, like a handicap in golf, the advantage given the targeted group makes the auction more competitive, forcing better bids from the non-targeted group.

Auctions come with another advantage in the public sector – they are more transparent than most alternatives like comparative hearings or administrative assignment. Thus. they are seen as fair

[5] A useful discussion of the spectrum auctions, which discusses the pros and cons of many of these choices, can be found at The Greatest Auction in History, *Better Living Through Economics*, ed: John Siegfried, Harvard University Press, 2009.

compared to most alternatives. Using bidder credits to favor groups, for example, makes the cost of the program transparent.

School Assignment

Sophisticated computer matching systems have been used in assigning school children to public schools in Boston and New York City. These matching systems have parents rank schools for their kids, and the schools rank the children, and then perform an assignment that maximizes the quality of matching given the constraints, which include both the space in the schools and the commuting distance. Parents' desire to locate siblings at the same school can be respected. Economists and computer scientists now have extensive experience in matching mechanisms, which can be usefully employed to improve classroom and other assignments.

School assignment technology is especially valuable when assigning subsidies to students for colleges, where the subsidies can be tied both the quality of the education and the social value of the education – is the student meeting social needs of the country, which might be engineering, medicine or philosophy.

Removing Subsidies: Water, Electricity

Subsidized prices have two effects: they represent a wealth transfer and they reduce the apparent cost of the subsidized good. For example, if water costs $20 per 1000 cubic feet (KCF), but the customer is charged $7, they receive a subsidy of $13 per KCF and presumably use more water than they would at a price of $20.

In this example, suppose that at a price of $20, a household uses 10 KCF, while at a price of $7, they use 18 KCF. In this case, 8 KCF are wasted in the sense that the value the household derives is less than the cost. We know this because the household was not willing to buy the water at $20 but were willing to buy the water at $7, so the value is somewhere between $7 and $20 and in particular less than $20. One of the goals of removing subsidies is to eliminate that waste.

Consider increasing the price directly to $20, but combining that with a payment. If the payment is $13 × 18, the household is better off, because they can still afford to buy the water they used to buy when the price was $7, since they receive the difference between what the water costs now and what it used to cost. But we know the household won't spend all of the subsidy on water because the cost of consuming additional water is now higher.

A key aspect of the subsidy is that it is independent of current water usage. Thus, if we have two families who both used 18 KCF before, and one uses 5 KCF after the price increase and the other uses 15 KCF after, both get the same subsidy of $13 × 18, which is what it would cost them to buy the earlier consumption level at the new prices. Thus, the nature of the system eliminates the incentive to use extra water to get a better subsidy after the fact.

This strategy – removing the subsidy while making a lump sum payment to mitigate the financial impact of the subsidy's removal – is the best strategy to turn off subsidies without undue harm on the citizens. There are a couple of wrinkles to be considered.

First, if citizens are aware of the policy, they will want to increase usage today to increase tomorrow's subsidy. There are two ways to combat this perverse incentive. One is to establish a baseline quantity in the past, prior to contemplation of the policy. The other is to use an average, e.g. an average based on household size and property size, so that the subsidy doesn't depend on individual behavior.

Second, the subsidy should probably have a limited duration rather than be an indefinite entitlement. For example, it might be reduced by 20% each year after the first year, so that it disappears after six years. At that point, the household would be treated like any other with its income and so on.

Security Force Deployment

Designing the rules for market transactions is one type of market design, but so is using game theory and better technology to accomplish tasks more efficiently. For example, humans tend to fall into patterns, and police forces are no exception. Over time, police will tend to "walk a beat" or drive in a predictable pattern. Patterns are exploitable; an attacking enemy can wait for the police to pass, assured that they won't return for an hour or more, providing a safe window for misbehavior.

Police should randomize deployment; however, people aren't very good at randomizing. Even a simple randomizing app improves security deployment. Two aspects of the security problem make it important to use centralized, sophisticated software to deploy security forces. First, it is important to coordinate across security forces. For example, in airport security, it is undesirable for all the forces to appear in the same location, which may happen with individual randomization. It is important for optimal deployment to use to the total force efficiently. Second, while optimal deployment is random, it is not uniform; more attractive targets should be defended with higher probability. The attractiveness of targets can be established through a variety of means; to prevent poaching in Uganda, the presence of slaughtered animals, reports of poachers and animal movements, including GPS on some target animals, provide a wealth of data for predicting poacher behavior with machine intelligence. There is a well-developed game theory behind police and security force deployment.

There are great successes in predictive policing in Los Angeles, both in regular police deployment and in TSA deployment at LAX, as well as preventing poaching in Uganda and Indonesia. The potential gain of combining market design with big data analytics is enormous. For example, Microsoft Research has shown that by using data and optimizing, New York City could have achieved the same level of targeted crime reduction as the controversial "stop and frisk" policy without bias and an astonishing 94% reduction in interventions.

Traffic

It has been estimated that Americans waste over $1 trillion stuck in traffic; that is, people spend enough time stopped or slowed in traffic that, with the time valued at their wages, drivers lose $1 trillion. This represents about 6% of GDP lost in traffic, a proportion that probably holds approximately true around the world, suggesting that the loss around the world is nearly $5T.

And yet, highways in Singapore – a very crowded country indeed – run at 65 km/hr at the peak of rush hour. Singaporeans lose *much less* time in rush hour. Why? Because they use dynamic pricing on the highways. It costs more to enter the highway when more people want to use it.

Highways have a maximum capacity. When more cars try to enter the highway than its capacity, crowding rises and people get nervous. When people get nervous, they slow down for safety, which reduces the throughput of the highway, which reduces the capacity of the highway. They key to maximizing the carrying capacity of highways and to keeping speeds up is to limit entry to the highway to its capacity. Singapore does that with dynamic pricing – when too many people try to enter, Singapore increases the price to deter some of them.

The cost of driving on highways is not just gasoline, pollution and wear and tear on the roads and car. There is also an externality – an additional driver slows down other drivers. Congestion is a real cost that, like pollution, should be priced. Congestion costs are minimal until the highway is fairly crowded, at which point the costs skyrocket. There is an incorrect perception that the "freeway ought to be free." When freeways are crowded, they ought to be priced.

Devices have gotten cheap enough that we can replicate Singapore's solution throughout the developed world. A $50 device – a fraction of a percent of the cheapest automobile – or even a phone app would permit dynamic pricing not just on highways but on all streets, with a price posted that reflects the risk of traffic jams. People would quickly adjust, carpooling, taking public transportation or adjusting the timing of trips that can be adjusted, to mitigate what will likely be substantial charges in many metro areas (prices in London can be £20, yet traffic remains terrible, suggesting that the price is too low).

Pricing congestion will, of course, have a substantial impact on the poor. The likely high prices of traffic mean that substantial revenue will be raised by efficient pricing. This money can be used to increase the frequency and convenience of public transport, much to the social advantage – the improvement in alternatives to driving will actually lower the price of driving as more people substitute away from driving. Overall, pricing the roads and using the money raised to provide alternative transport can make all members of society better off, indeed, make them better off by over a trillion dollars.

The market design approach to public transport is to procure transport from private firms, rather than operate it as a city agency.

Crowd Control

Crowds create problems. People are crushed by abrupt movements, and thick crowds inhibit police movement, which in turn makes crowds attractive environments for pickpockets and criminal gangs. People in crowds with health issues – either caused by the crowd or not – have little to no ability to obtain care. Crowds are probably unavoidable: New Year's Eve, political demonstrations, the Pope's Christmas mass, the Hajj in Mecca, outdoor concerts, sporting events, the Arba'een Pilgrimage, Sabarimala, Mardi Gras, and funerals of beloved leaders routinely produce enormous crowds.

New technology can mitigate the risk of crowds and introduce new options for crowd control. First, fixed location video and drones permit new data sources; machine intelligence can be employed to identify and surface video that needs to be examined by humans. Second, such data then permits methods of reducing the density – slowing the flow into a funeral viewing, for example, or redirecting part of the flow. Making an alternative path attractive can also slow the flow into a crowded area, for example providing free trinkets can divert part of a group moving into an overcrowded area. The key to mitigating the harm of crowds is to identify incipient problems prior to their emergence, and divert people – either by slowing their entry or offering an alternative – to reduce peak density.

Second, identifying and prosecuting crimes can reduce the incentive of criminals to enter crowds in the first place. With extensive video, machine intelligence can be trained to find pickpockets and catch them in the act, especially if cameras can be re-aimed. Third, health problems can be identified more rapidly. It will still prove difficult to provide care quickly, but in some cases, just asking people to help by loudspeaker, e.g. stopping a concert and asking people to let an ambulance through, or dropping medicine via drone, may help.

The major challenges of crowd control are absorbing and analyzing a large volume of video signals, which will require machine intelligence, and developing methods of diverting portions of the crowd. In some cases, one strategy might involve overflow areas that are opened as needed.

Worker Retraining

The number of workers displaced by foreign competition or technological advances is increasing. Developed countries have responded by setting aside funds to retrain workers, but the experience with worker retraining is mixed at best. How can worker retraining funds be used to maximal effectiveness?

The problem of worker retraining is a combination of two separate problems – skill acquisition and employer needs – that admit a common solution. An important aspect of market design is to produce credible information from employers to guide retraining decisions.

One strategy is to create an electronic market, where employers can bid for an employee. Of course, a labor market normally involves employers bidding for employees with wages and job characteristics; the difference in the retraining market is that the employer is going to hire the worker immediately, but bid for the amount of subsidy needed to hire the worker. So, for example, an auto plant might hire a worker at $20/hour but require a subsidy of $7 per hour for six months and would require for the worker to take a twelve week, half-time class. The employment contract would be for a minimum of a year, unless the worker violated the contract. The goal of the market design is to bring the employer into the equation, so that (i) the worker gets skills valued by at least one employer, and (ii) the worker has a viable job at the end of the process. Such a market would blend an apprentice program with worker retraining.

The beauty of such a market for retraining is that it can operate in parallel to the existing system; it does not need to replace the existing system. That way, workers can opt for standard retraining if they don't receive an acceptable offer through the new market. The ability to influence the training of incoming workers and the existence of subsidies insures that retrained workers will be competitive with other methods of acquiring workers.

There are still many problems to be solved to create a retraining market. The market can be tuned to spend funds efficiently, making retraining funds accomplish more. Search algorithms can be built to facilitate matching. Companies and workers face a matching problem: which workers are best matched to which employers? But even addressing the informational problem – letting companies bid and workers choose the bid they like best – would go a long way to improving the use of retraining funds.

Conclusion

Market design is a strategy to improve welfare by harnessing market forces to solve social problems. While it has already had great successes, market design can be used in many more situations. It belongs in every politician's toolkit.