Technological Change and Market Design

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Abstract. Technological innovations lead to new market designs and new designs catalyze the emergence of new technologies. Building on examples drawn from recent advances in medical, electricity, car, computing, and data collection technologies, this note discusses the relationship between technological change and market design with an emphasis on new questions for market design theory.

Recent developments in market design have been largely driven by changes in technology, and new market designs catalyzed the emergence of new technologies as well as changes in legal and ethical environments. Consider, for instance, kidney exchange. The design of exchange (pairwise donation) markets was made possible by developments in transplantation technology, and legal and ethical resolutions that deemed kidney exchange not to violate the proscription against exchanging organs for valuable consideration (Roth, Sönmez, and Ünver 2004; 2005; 2007). Various important refinements and innovations then followed: organs are now being shipped via commercial flights (Butt et al. 2009) and altruistic kidney donations led to the introduction of donation chains (Roth et al. 2006, Rees et al. 2009). Kidney chains made possible for hospitals to issue vouchers for future kidney donations (Veale et al. 2017). The vouchers create the possibility of further innovations in designing the market and its underlying contractual structure (e.g. Sönmez, Ünver, and Yenmez

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2018). Other transplant markets are also developing in response to emerging technological possibilities, c.f. Bergstrom, Garratt, and Sheehan-Connor (2009) work on bone marrow transplants, and Ergin, Sonmez, and Unver (2017) on lung transplants.

The future will bring more instances of such a feedback loop between market design and technology developments and new technological developments will pose new market design questions. For instance, in California, new sources of electricity are already changing electricity markets. The supply of electricity from new sources such as solar and wind is much harder to forecast than the relatively predictable traditional electricity sources such as oil, coal, and nuclear. The electricity from these new sources flows into the grid at many entry points, rather than few big plants. Price patterns change: while in the past electricity was cheapest at night, this is no longer true in California where the price of electricity is lowest, and occasionally negative, mid-day because of the inflow of solar-source electricity to the grid. In addition, new demand for electricity comes from users of hybrid and electric cars. Without new market design, the current grid will not be able to balance supply and demand (Davis, 2014). Regulators and entrepreneurs are aware of this looming crisis, and are developing solutions such as balancing the supply and demand through the development of electricity storage, e.g. by enabling car batteries to trade with the grid (Davis, 2016).

There is a clear opening for economists to offer new market design solutions to the grid crisis. Even if the car-battery solution works in the near future, new designs might be needed when driverless cars become standard because the car-battery solution relies on the cars being connected to and trading with the grid most of the time. This assumption might fail in the presence of driverless cars and new market designs that their presence enables: the driverless cars that are in motion almost all the time will not be able to play substantial storage role unless new technology developments allow them to trade with the grid while there are in motion.

A related set of market design opportunities is being brought on by the development of technologies that allow sophisticated congestion charges for road use. Vickrey (1969) initiated the economic analysis of congestion charges (see also e.g. Arnott, de Palma, and Lindsey 1993), and technology might soon allow traffic optimization through more sophisticated price schemes than were possible in Vickrey's times.

The changes in electricity and transportation markets are just two examples of how technological changes destabilize some markets and make other markets possible, creating opportunities for market design. These new problems will be overlaid on classical challenges: despite some progress (e.g. Ausubel et al. 2014, Anderson, Holmberg, and Philpott 2013, and Pycia and Woodward 2016), we still do not understand equilibria in pay-as-bid auctions despite their important role in markets for electricity and other commodities.

Technological changes also generate new foundational questions for market design theory. Increases in computing power mean that in future markets—like in the electricity trading and transportation examples above—market participants might be able to perform more complex strategizing than seems reasonable to expect of them today. Increased strategic sophistication might both upend the rational for merely approximately strategy-proof mechanisms as well as weaken the case for fully strategy-proof or otherwise simple mechanism. In particular, the increase in market participants' ability to perform complex strategic calculations might enable market designs that lead to higher aggregate welfare than currently used simple designs. While a general analysis of such problems remains open, the first inroads were made in some special markets; see, for instance, the literature on possible welfare gains in school choice market that could be obtained by moving away from strategy-proof mechanisms (e.g. Bogomolnaia and Moulin 2001, Miralles 2008, Abdulkadiroglu, Che, and Yasuda 2011, Featherstone and Niederle 2016, Troyan 2012, Pycia 2011, Ashlagi and Shi 2015, He et al. 2018, Abdulkadiroglu, Agarwal, and Pathak 2017). The first inroads are also made into the analysis of sophisticated multiplayer games in which participants can offer contracts that depend on other's contracts (e.g. Peters and Severinov 1997, Peck 1997, Epstein and Peters 1999, Peters 2001, Martimort and Stole 2002, Calzolari and Pavan 2006, Pavan and Calzolari 2009, Peters and Szentes 2012). Technological and legal innovations might make such complex contracting arrangements feasible, and in some environments such complex mechanisms might be able to achieve substantial welfare gains. I conjecture that this might be the case particularly in settings in which externalities play substantial role.

The general impact of new technologies goes beyond the increased computational power. The current technology already makes it possible to collect unprecedented amounts of data about people, e.g. based on their online and offline behavior (see e.g. Taylor 2004). Leaving aside the question how to draw conclusions from rich, multi-dimensional data, the data abundance opens the possibility that many buyers might have little price-relevant information that would not be available to the sellers.

The technology also creates new types of data and new possibilities for mechanism design. In markets in which buyers (or other market participants) are physically present, the past behavior data might some day be supplemented by contemporaneous measurement of neurological and other bodily processes (e.g. eye movements). Recent extensive research in neuroeconomics demonstrated that such data correlate with buyers' valuations; for surveys see Rangel and Hare (2010) and Ruff and Fehr (2014). This correlation enables the use of new market mechanisms that rely on neurodata. For instance, the mechanism designer might be able to costlessly elicit a buyer's valuation by offering him or her fair bets on the neurodata that would be subsequently recorded: because the neurodata is hard for the buyer to control and correlated with the buyer's valuation, such bets might incentivize the buyer to reveal the valuation. Krajbich, Camerer, and Rangel (2017) make this theoretical point and test it experimentally. While such bets resemble and are inspired by Cremer and McLean (1988), here the bets do not rely on any assumptions on the behavior of agents other than the buyer. Furthermore, whenever the correlation between the neurodata and the valuation is strong, the offered bets might have realistic magnitude.

These new mechanisms are bound to lead to refinements in the legal and ethical environments in which they will be used, and the diminished role of individuals' private information will increase the importance of resale markets and regulation. In these tasks, the new technologies, and the neurodata in particular, might turn out to be useful in allowing the society to refine our normative welfare concepts. Indeed, we already see the first explorations of welfare concepts that are motivated by the availability of neurodata and other non-choice data (see e.g. Salant and Rubinstein 2008, Bernheim and Rangel 2009, and Fehr and Rangel 2011).

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