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ECONOMICS

Simple market models fail the test

An analysis of energy markets with prices that vary according to demand finds that this market design unexpectedly serves to amplify, rather than dampen, fluctuations in power use.

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From the dynamic pricing of electricity to congestion-based road tolls, simple market models lie hidden within much of our current thinking about government, regulation and policy. However, this sort of market thinking can easily go wrong, as exemplified by Krause *et al.*[1] in *Physical Review E*. The authors find that variable energy prices that are designed to adapt demand to supply, and thereby dampen fluctuations in power use, in fact amplify these fluctuations.

Variable pricing in power markets and other market models is based on what the eighteenth-century economist Adam Smith called the "invisible hand" — the idea that market competition efficiently allocates resources according to need. This idea was mathematically codified by the start of the twentieth century by working out what self-interested, rational individuals would do in response to different price, usage and market conditions, and what effect this would have on prices and demand.

Subsequent criticism of the 'rational' part of this model has given rise to what is now known as behavioural economics. However, human limitations on rationality — which simply means that individuals know their goals and act to achieve them — typically only bias the market response, and do not invalidate the simple market model. In fact, there are far more serious problems concealed within the rational-individual market model. The two biggest limitations are: the focus on how the average behaviour of independent actors (often assumed to have a normal distribution) determines where the market eventually settles (reaches equilibrium); and the idea that people act independently. If we applied these assumptions to a classroom in which all the students copy answers from each other, and half the students have perfect scores but half have failed, we would declare the class a success because the average grade is a pass.

Krause *et al*. demonstrate what can go wrong when we apply this average and equilibrium thinking to a situation such as a power market, in which people's needs and the external situation vary hour by hour and day by day, so averages and long-term behaviour do not capture the full picture. The energy-market model discussed by the authors is similar to that of proposed US policy to vary price by demand, with the intention that individuals will shift activities that use a lot of energy (such as air conditioning or heating) to low-demand, cheaper times of day. The goal of the policy is to smooth demand over time, allowing the power company to use more-efficient and cleaner energy sources.

The authors find that this sort of market thinking is too simplistic. They show that when there are unusual events, such as an especially hot day or a snowstorm, people's actions become synchronized, with everyone turning up the air conditioning or the heating at the same time, as soon as the price drops (Fig. 1). As a consequence, rather than smoothing demand as expected, the market will cause huge spikes in demand that completely swamp the electricity grid, decoupling price and demand, and potentially causing power failures and even damaging the grid itself. Interestingly, this same synchronization process is thought to be the source of 'flash crashes' that have been observed in financial markets, in which markets shed huge amounts of value in a few seconds as high-frequency trading algorithms become synchronized[2].

In addition to issues arising from a focus on averages and long-term behaviour, the assumption that people act independently can cause other problems. Obviously, people do not act independently — they talk to one another and learn from each other. Not only is their behaviour sometimes synchronized as a response to changing external conditions, as discussed by Krause and colleagues, but also people actively make their actions more similar by trying to copy the successful actions of others. These peer-to-peer interactions drive the evolution of culture, norms and even the law. In the context of market-like situations, however, people learning from each other can lead to financial bubbles, political upheavals and health fads[3,4]. Such undesirable outcomes are particularly likely when there are large, rapid changes in the environment, or when the communication links between people are particularly strong and influential.

The advent of social media and the crowdsourcing of news has made it much easier for people to learn from each other, and the pace, inclusiveness and influence of social learning

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Figure 1 | Synchronization spikes. Power markets with variable pricing are designed to shift individuals' power consumption to low-demand times of day. But Krause and colleagues' modelling[1] suggests that synchronized consumer behaviour may result in amplified spikes in demand.

and opinion change have increased dramatically. The paradoxical consequence of this technological move towards greater transparency, democratization and engagement is that fads, political turmoil and bubbles are more common than ever before. Because so many institutions are based on some sort of simple market model, the limitations of this way of thinking have become increasingly clear[5,6].

What can we do about this problem of overly simple market-based policies? It took half a century for policymakers and the public to understand the simple market model's connection between price and demand. I don't think we can wait another 50 years for people to move to a more sophisticated way of thinking that accounts for synchronization and connections between people.

Fortunately, we can simulate situations and visualize the results on today's ubiquitous digital devices. If we make computational modelling of social behaviour a standard part of policy debate, as Krause and colleagues have done, we can hope to markedly accelerate a transition towards better and more robust social policy. Scientists, policymakers and science-funding agencies should make this sort of computational social-science modelling a regular part of their portfolio. ■

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