Mechanism Design Theory and Sustainable Urban Form: A Proposed Priority for Collaborative Research

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Abstract

Recent news of the 2007 Nobel Prize in Economics has focused attention on a previously little-known area of economic science known as **mechanism design theory**.[1] It has been noted that this field holds promise for more sustainable forms of economic process, dealing with such urgent topics as climate change and resource depletion. Herein we consider the implications this field holds for the development of more efficient, higher-quality, more ecologically sustainable forms of urban settlement. We propose that to develop this potential, it will be important to pursue new collaborative forms of research between economists, urban planners and other disciplines. We note a particular opportunity for members of the urban reform movement known as The New Urbanism.

Mechanism Design and Economic Game Theory

It has been known for some time that markets work relatively efficiently to allocate resources based upon known information – Adam Smith's so-called "invisible hand" but do not work well to integrate so-called "externalities". These include environmental damages, services provided by ecological systems (purifying water for drinking, for example), long-term social costs, and other factors.

In addition it is now understood that human cognitive limits, asymmetric information and other forms of "bounded rationality" within market processes limit their efficiency and produce irrational outcomes.[2] This "bounded rationality" has important implications for the ability of markets to deliver ecologically sustainable results.

Mechanism design theory can correct these omissions by, in effect, "re-calibrating" the economic process to adjust to the new factors. It does so through the design of "mechanisms" such as combinations of taxes, credits and other rule-based processes that change the dynamic equilibrium of the market.

Game Theory and Economic Behavior

Mechanism design theory is in fact a form of game theory, that is, an understanding of the possible outcomes given a set of rules that, though they may be simple, may interact in a complex way (as, for example, the rules of Chess). Mechanism design theory asks, in effect, how can the rules of the game be changed so that the outcome is more like what we desire? We may want a game that does not continue on so long without a clear winner, or one that does not result in frequent stalemates, for example.

Game theory applies not only to ordinary games, but to any situation in which the outcome depends upon the actions of independent agents, following a set of shared rules, such as traders in a market. The theory describes the tendency of certain rules to produce certain classes of outcomes.

A famous example from game theory is the "prisoner's dilemma." In this example, two colleagues are charged with a crime, and questioned separately. The rules are set such that there are four possible outcomes. One, if Prisoner A confesses and also testifies against Prisoner B, and if Prisoner B does not confess and testify against Prisoner A, Prisoner B will get a harsh sentence and Prisoner A will get a light sentence. A second possible outcome is the converse: if Prisoner B testifies against Prisoner A but A stays silent, then Prisoner B will get the lighter sentence.

[2] These effects are becoming well understood, and have been the subject of their own recent Nobel Prizewinning work. See for example the 2001 award to George A. Akerlof, A. Michael Spence and Joseph E. Stiglitz for information asymmetry, or the 2002 award to Daniel Kahneman and Vernon L. Smith for prospect theory. One famous study showed that drivers will readily spend an extra $1 on gasoline to drive to a "big-box" store that saves them perhaps $.79 on paper towels – an illusory but nonetheless

behaviorally compelling bargain.

In the third possible outcome, if each testifies against the other, each will get a somewhat harsh sentence, but not as harsh as the maximum. But in the fourth outcome, if neither testifies against the other, they will both go free.

Here is the dilemma: not knowing what the other prisoner will do, what is the most logical choice for each prisoner? Clearly it would be best to say nothing and to have the other prisoner say nothing – then each will go free. But there is no way to be sure that the other prisoner will cooperate, in which case the most logical choice may be to hedge one's bets and to testify against the other. Then at least one will get less than the harshest sentence, and perhaps get a much-reduced sentence. Since both prisoners will tend to see this logic, each is very likely to testify against the other.

Hence the tendency under such a set of rules – such a "game" -- is toward a condition in which both will tend to testify, in order to optimize their benefit. This overall condition is known as the game's "Nash Equilibrium," in honor of the theorist who identified it, John Nash (whose biography was featured in the book and movie "A Beautiful Mind").

Note, in this example, that changing the rules could change the Nash Equilibrium of the game. For example, giving the prisoners the same punishment no matter what they say would likely result in their not saying anything about their comrade, as they would not be rewarded for doing so. Mechanism Design Theory, then, is the study of how such sets of rules – such "mechanisms" -- can be designed such that the trend toward the optimum for all players in the outcome of the game – its Nash Equilibrium - will change in a desired way.

Mechanism Design Theory – An Elementary Example

Mechanism Design Theory in the economic sphere seeks to change the rules of the economic game to shift the optimal outcome. Note that it does not in any way directly require that outcome. *Rather, it shifts the tendency of the game to favor that outcome.*

One can readily see that mechanism design theory, even when employed by government, is not the same as direct government regulation – as, for example, a simple tax on cigarettes, or ban on recreational drugs, to discourage their use. It is a more subtle strategy for altering by design the optimal tendency for rule-based outcomes of multiple economic interactions.

A simple example from a domestic environment will serve to illustrate a simple but effective designed mechanism. Consider two young children who have been given a piece of cake and directed to share it. It is not unlikely that they will fight over the cake, or that one child (the bigger one perhaps) will get a larger piece of cake.

To avoid this disparity, a parent may decide to try to direct the sharing of the cake, and may even intervene to cut the cake. This kind of action would be analogous to so-

called “top-down” government regulation.

But consider an alternative strategy. The parent simply establishes a simple pair of rules: one child will cut the cake in two, and the other will have the first pick of the two slices. Both children know these rules, and can think through their consequences. The first child, told to cut the cake, may want to have a larger slice, but now knows that is impossible; the second child, having the first choice, will simply pick the larger slice. Therefore the only reasonable choice for the first child, in order to maximize the benefit, is to cut the slice as close to evenly as the child possibly can. The second child, facing two very nearly even slices, happily chooses one. As if by magic, the children have cut and shared equal pieces of cake peacefully.

Thus the “rules of the game” have induced a fairer outcome than otherwise would occur, in a competition for limited and desirable resources. The normal tendency of the game to establish an optimum benefit for all players -- its “Nash Equilibrium” -- has been shifted by the new rules. The rules do not directly require a fair slicing; indeed, they are entirely silent on that issue. Rather, they create a set of conditions in which fair slicing is the most advantageous to all concerned. A mechanism has been designed that shifts the Nash Equilibrium of the cake-sharing game, such that both children are rewarded for participating in an even slicing.

The “Tragedy of the Commons” and Climate Change

In the environmental realm, one can observe a phenomenon closely related to the Prisoner’s Dilemma. The so-called “Tragedy of the Commons” refers to a hypothetical situation in which a group of villagers lives along a commons and shares a herd of cows. Each villager will be partially rewarded long-term for milking the cows and ensuring that they are well cared for. But if any one villager slaughters a cow, that villager will be disproportionately rewarded for the temporary meat that the cow will provide – even though the benefit to the one villager is not as great as the sum benefits would have been to all villagers over time. Each villager knows that the other villagers know this as well, and hence each is eager not to be left without any cows to milk, or to eat. Hence the cows are quickly and almost inevitably slaughtered. The Nash Equilibrium of the game almost compels the villagers to do so.

This phenomenon explains how, for example, Easter Islanders came to cut down the very last tree on their island centuries ago, surely knowing that these trees were essential for the canoes on which their fishing, and their livelihood, depended. How could such a seemingly illogical event have occurred? Yet clearly someone did cut down the last tree. That islander’s choice within the game as they understood it was not whether anyone was ever going to cut down the last tree, but merely whether it would be them, or someone else, who did so first. There was simply no logical structure in their interactions to suggest that the trees would be saved.

Similarly, we are all living on a “commons” of environmental resources, and we all gain a benefit from their maintenance over time. But there may be a far greater individual

benefit from a strategy to damage the environment to extract a perishable value, the mere existence of which strategy puts in jeopardy the larger strategy. This does indeed occur and is well understood in fields such as forestry, fishing and other industries.

As a result governments have long established legal protections for such resources. However, these are known to be crude, inefficient, and often politically not feasible – for the simple reason that the "tragedy of the commons" operates within the political sphere as much as any other. But a "mechanism design" might go a step further, and create a set of much subtler rules that change the logic of the process – for example, (cite example).

A similar "tragedy of the commons" is well understood in the case of environmental pollution, including the accumulation of greenhouse gases leading to climate change. While we may all gain enormous economic benefit in the end from a clean environment – and conversely, pay an enormous economic price for the consequences of pollution, such as climate change – the immediate transactions tend to offer the strongest economic rewards to those who pollute heavily, and they penalize – potentially with bankruptcy -those who don't. Again, we can create government regulations to mitigate this phenomenon, but they are often inefficient, and may not always be politically viable. Mechanism design theory offers us an important alternative strategy.

We now know that one of the major contributors to greenhouse gases is the pattern of land use and settlement efficiency. Sprawling, auto-dependent suburbs can contribute up to three times more greenhouse gases per household than the urban cores they surround.

A number of investigators have begun to look seriously at mechanisms that would serve to reduce greenhouse gases contributed by inefficient urban form. Models have been developed that show that certain "cocktails" of incentives and prices produce disproportionately effective results. Perhaps the best-known mechanism design is the cap-and-trade system for carbon trading. However, there are many possible mechanisms and work is accelerating in this promising field.

Mechanism design is also used to address developing-world economic development and economic justice issues. For example, the growing field of micro-finance uses mechanism design to analyze the patterns of incentives that are addressed in small communities. The processes can be customized for different communities with different cultural contexts.

Mechanism Design in Practice

A mechanism design problem may be said to have three inputs:

- A collective decision problem, e.g. the pattern of urban settlement, controlled by a collective of developers, citizens, regulators, technical experts, etc.;
- A measure of quality to evaluate a candidate solution -- for example, carbon emissions;
- A description of the resources, such as information and other assets held by the participants.

As economists Estelle Cantillon and Patrick Legros of VoxEU.org put it: "A mechanism specifies the set of messages that participants can use to transmit information and the decision that will be taken conditional on the messages that are sent. Once a mechanism is in place, participants effectively "play a game" where they send messages (e.g., a bid in an auction) as a function of their information. The goal is to find a mechanism with an equilibrium decision outcome (sometimes required to be unique) that is best according to the given measure of quality. The strength of mechanism design lies in its generality: any procedure, market-based or not, can be evaluated within a unified framework."[3]

As an example, let us suppose that one could assemble a group of stakeholders within a region, responsible for the real estate development, renovation, maintenance and regulation within that region. The group would include, say, developers, builders, planners, architects, government officials, citizens, and a range of technical experts, including climate scientists and emissions experts. Let us suppose that they agree to an overall level of greenhouse gas emissions (perhaps mandated at a higher level of government) and the means to measure it within their plans. The incentive they have is that they can develop their own flexible means of meeting the standard, rather than having it enforced in a rigid regulatory way.

The group then convenes in a workshop, and plays a series of simulations in which they "trade" the ability to emit greenhouse gases for other material benefits, such as reductions in systems development charges, tradable development rights, density bonuses, and other exchangeable assets. These rights are represented in some tradable currency, which can be ultimately converted to dollars to assess the resulting economic viability of a project. (For example, reductions in system development charges will have a quantifiable monetary value.) As they conduct this trading, they gradually assemble and refine a community development plan.

In this process of "gaming", the group may well find that the shape of the plan gradually changes; the mix of features shifts, and becomes more optimal with respect to greenhouse gas emissions. Other factors can be added as well: criteria that are judged to be either neutral, or complementary to the goal of greenhouse gas reduction. (For example, the promotion of walking and exercise might be an additional criterion.)

Moreover, as the process continues, the very structure of the game itself will likely change; its "Nash Equilibrium" will shift. The group may well find that it is possible in time to set a new and more ambitious greenhouse gas reduction cap, while preserving economic viability and other criteria.

Out of this process, the group may develop a politically viable proposal for meeting or even exceeding the reduction goal.

There are two notable consequences of such a process. First, it creates its own flexible system for achieving a pre-agreed goal, and one that allows maximum flexibility in

[3] This description courtesy VOX, Research-based policy and analysis, http://www.voxeu.eu/index.php?q=node/656

simultaneously meeting other goals (profit on development, or tax revenue, for example). Second, it is an entirely local system, generated from the local conditions, and not from a one-size-fits-all template.

The system can be set up such that it integrates with other local systems. For example, any credit of emissions could be traded with other communities within the larger political entity. Conceivably, credits could be "traded in" to "purchase" more regional infrastructure improvements, such as components of transit systems. Through this "investment", the community could receive further credits as a dividend of ongoing reductions.

This kind of linkage of credits to future reductions, we suggest, is an important unexplored territory. Similarly, linkage to environmental externalities may reap important dividends that could be ultimately monetized through such a system. It is possible that a kind of "futures" market could be established for such credits, or other debentures or financial vehicles, as a way of creating tradable present value from future benefits.

A notable feature of such a process is that it is already feasible as a workshop process in the format referred to as a "charrette". This process was developed by members of the New Urbanism movement, as a way to bring together multiple stakeholders for an intensive urban design process. The charrette (and its related formats in other countries[4]) is proving very useful for forging political consensus, and for developing evolutionary designs with better adaptation to local conditions. The charrette (whether by any other name) is arguably one of the most important contributions of the New Urbanism movement to modern best practice. Its application to this kind of process, we suggest, remains an important area of exploration and development.

The Role of the New Urbanism Movement and Its Allies

Many of the urban characteristics that are well known to reduce greenhouse gases are precisely those identified as principles of the New Urbanism reform movement – a movement that advocates more compact, efficient, transit-oriented urbanism. Hence within this project, academics and practitioners allied with the New Urbanism movement have an opportunity to play an important catalytic role. But to do so, they must be seen as intellectually scrupulous, and not mere lobbyists for a particular design philosophy or political position. They must be seen as more flexible in approach, and not mere handmaids to onerous regulatory schemes. This can best be effected, we suggest, through a series of larger alliances with those who may not be directly associated with The New Urbanism, but will readily grasp its alignment with these issues, and its potential usefulness in this effort. Those who are developing topics of mechanism design theory figure prominently in this group.

[4] See for example the Enquiry by Design process, or EbD, used by the Price's Foundation for the Built Environment in London. In most respects it is identical to the Charrette.

Therefore, we suggest that this is an important area for investigators sympathetic to the New Urbanism to pursue vigorously. We propose the following goals:

1 Place a new emphasis on this kind of project-based research, and develop a detailed strategy
2 Identify and develop funding sources
3 Identify potential collaborators and host one or more symposia
4 Develop pilot charrettes to test such ideas "on the ground"
5 Publish papers in peer-reviewed journals
6 Form strategic partnerships with government, academic and research centers
7 Consider funding small, catalytic research centers within, or overlapping, the New Urbanism movement.

An example of the latter is the so-called "Environmental Structure Research Group", a voluntary association of forty-two researchers and practitioners, around the broad topic of "structure-generating processes". They include physicists, mathematicians, biologists, ecologists, sociologists, economists, software engineers, and a number of prominent urban design practitioners, including Christopher Alexander and Andres Duany and others. They collaborate through symposia, emails and a Wiki site (www.aboutus.org/ESRG). Thus far they have held three symposia and written one collaborative paper, and there is ongoing discussion of a collaborative book project and other forms of collaboration. There has also been ongoing review and discussion of work to establish "neighborhood rebuilding centers" in New Orleans, as part of the Unified New Orleans team organized by Andres Duany.

Another such catalytic research center, closely related (in fact with two overlapping members), is the "Center for Advanced Transect Studies", formed by Andres Duany and Elizabeth Plater-Zyberk to take forward research into advanced coding strategies.

Also closely aligned, and providing useful network relationships, we suggest, are existing centers such as the Lincoln Institute for Land Use Studies, the National Center for Smart Growth, and the Victoria Transportation Policy Institute.

With a series of such centers collaborating effectively, cross-fertilization can trigger important progress in the field, and elevate both policy and practice to new levels.

A series of peer-reviewed journals can also facilitate such collaborative research. Notable among them is the new Journal of Urbanism, established to take forward just such inter-disciplinary collaborations.

Conclusion

The Nobel Prize-winning work in mechanism design theory offers a timely case in point about the opportunities ahead, and the need for more collaborative practice-based research in order to develop them effectively. The present changing climate (in more ways than one) offers daunting challenges, but also hopeful opportunities. To seize them, we

suggest, it will be necessary to make a step change in thinking and action on research. It will be necessary to develop a much more "joined-up" approach, and a much less politically factional, "not invented here" culture. For the New Urbanism in particular, we suggest, it will be necessary to recognize and to build upon the impressive gains made thus far, but also to recognize that the steeper grade ahead will require a different gait.