

JAYWALKING OR JOYWALKING: A GAME THEORY APPROACH TO POLICY-MAKING

SABRINA SCHÖNFELD

Senior Sophister

In a lively and thoroughly researched essay, Sabrina Schönfeld uses the phenomenon of jaywalking to compare standard rational choice theory and an alternative behavioural model with bounded rationality. She skilfully shows that policies which incorporate behavioural biases can lead to pareto-improvements and concludes by highlighting the fascinating potential of similar solutions in other policy areas. Her findings illustrate the importance of the underlying assumptions when applying rational choice theory in a policy-context.

Introduction

“If you do decide to step up and thumb your nose at Johnny Roadlaw like the natives, learn your chops on the beginners’ courses of Parnell Street and College Green before tackling the world-class black runs at the Stillorgan Dual Carriageway and Dame Street...”

(Kelleher, 2010)

The world that we live in keeps changing at a vertiginous pace. The challenge for policy-makers is to devise more effective forms of regulation that unburden rather than encumber the average person - regulation that produces results, laws that can be followed, and that will be effective. For this purpose, the discipline of economics has long been regarded as the ultimate tool to assist policy-makers to make the right choices, thereby improving the lives and wellbeing of the citizens and constituents. However, policies do not always lead to the desired outcomes.

To illustrate the importance of realistic assumptions that can help in the development of optimal policy, ideally resulting in pareto-improvements, this paper will discuss the case of jaywalking. This is a classic example demonstrating how a framework applying theoretically appropriate incentives and assumptions about actors’ preferences can result in very different outcomes, including inefficiencies and, occasionally, dangerous situations.

The reason why jaywalking is an ideal candidate to address the divergence between theoretical models and reality is that the sheer scale of the phenomenon cannot be justified by pointing to random deviations from the logic underpinning it.

In most countries, jaywalking is prohibited. The underlying reasons are multifarious - jaywalking affects the efficiency of the traffic system, results in externalities as it endangers other traffic participants, and constitutes a hazard to the individual's health. By standard economic theory, the threat of being hit by a car or collecting a fine should present a strong disincentive to jaywalk. The benefit of a minuscule time saving should not outweigh the possible high short- and long-run costs. However, observational evidence in most cities suggests that jaywalking is a common practice.

This begs the question, why is this the case? Using a behavioural game-theory approach¹, this paper will demonstrate the importance of realistic assumptions with regard to incentives and payoffs that influence the rational actor in the standard economic framework. Moreover, it will offer explanations as to why seeming deviations from the rationality principle may be more common than often implicitly assumed. The first section will provide a brief overview of the phenomenon of jaywalking, while the following section will discuss the standard rational choice theoretical model commonly underlying policy- and traffic design. The third section will then offer an alternative model with modified assumptions about the actors' preferences, and discuss how they are shaped, as well as present evidence that different approaches to policy design incorporating these insights can lead to better outcomes. The final section concludes.

My Street Is Your Street – from Public Space to Segregation

Until the 1930s, streets were considered public space, with pedestrians having the natural right of way. Automobiles were private property and merely tolerated on the condition that they did not interfere with the public rights of pedestrians. Automobile clubs and car manufacturers brought increasing pressure to bear on policy-makers (coining the term jaywalking along the way, inspired by the use of "Jay" as an insult for people from rural areas, who were unfamiliar with the rules of the high traffic cities). This led to the development of a legislative trend whereby automobiles gained greater rights of way than pedestrians (Norton, 2008).

Policy-makers and traffic engineers sought to make the flow of cars as efficient as possible, whilst improving public safety. This resulted in even further reductions in pedestrian rights and a move towards policies guided by the segregation principle that still prevails (Hamilton-Baillie, 2008). Although a relative reduction in the number of casualties has been observed in many countries, the problem of jaywalking and the associated

1. As Camerer (1997) outlines, "[b]ehavioral game theory aims to replace descriptively inaccurate modeling principles with more psychologically reasonable ones, expressed as parsimoniously and formally as possible." (p. 185).

loss of life have become no less urgent (Jost and Allsop, 2014). Perhaps the most common regulatory approach to jaywalking in conjunction with traffic signalling is criminalisation, the penalty for which is generally the imposition of fines. Nonetheless, jaywalking remains one of the most commonly committed regulatory offences across the globe.

For example, take the city of Dublin. Dubliners are renowned for their jaywalking skills and pride themselves on the ability to navigate the city's byzantine maze of traffic lights, roundabouts, one-way streets, and quality bus corridors with confidence. However, particularly in urban areas in Ireland, fatal accidents involving pedestrians and cyclists are a regular occurrence (Jost and Allsop, 2014). Traffic congestion remains high, in part due to sub-optimal road planning and high car dependency (McDonald and Nix, 2005, Wickham, 2006). To handle this situation, Dublin uses a sophisticated adaptive traffic system to regulate the flow of traffic through the capital. Its main objective is the optimisation of traffic flow, the avoidance of congestion and delay, with a focus on efficiency (Fellendorf, 1997). As is common elsewhere, jaywalking (as defined as crossing a roadway when the pedestrian crossing signal is red) is illegal and anyone caught jaywalking can be required to pay a fine pursuant to the Road Traffic (Traffic and Parking) Regulations (1997) as amended by the Road Traffic Act (2006). Moreover, a strategic plan is in place to continuously improve road safety for every participant (Road Safety Authority, 2010). Taking all of this into account, it is safe to conclude that considerable efforts are made to reduce the occurrence of jaywalking. Nonetheless, one needs only step outside to know that it remains a common practice to jaywalk on the streets of Dublin, as is the case in so many other cities in the world. This begs the question, why do Dubliners jaywalk despite these efforts? The following sections will demonstrate that the reasons for this are complex, but can be explained using a simple game-theoretical model.

The Classic Model

As outlined before, the sanctioning of pedestrians crossing the street when traffic regulations require them to stop is a common practice. The principle on which this is based is deterrence theory, coupled with rational choice theory, as O'Neill (2004) explains:

"This important link between deterrence and rational choice has become well-established in the legal literature and is the foundation of so-called optimal penalty theory. This theory posits that an appropriately constructed sanction will be no harsher than necessary to prevent the rational individual from engaging in criminal conduct."(p. 155)

Apart from penalties in the form of fines, not exercising due care can be equally costly for the pedestrian. As Baird et al. (1998) show in a game-theoretical set-up, in a regime of comparative negligence, each rational player has an incentive to exercise due care, re-

sulting in a stable Nash equilibrium. Using these insights about the incentives of the players, the following model illustrates the rationale that underlies common traffic policy design.

The players in the strategic game are the participants in traffic, with $N = \{1, 2, \dots, n\}$. Player i chooses from $a_i = \{\text{Go}, \text{Stop}\}$. The payoffs are such that $u_i(\text{Go}, \text{Stop}) > u_i(\text{Stop}, \text{Go}) > u_i(\text{Stop}, \text{Stop}) > u_i(\text{Go}, \text{Go})$. In this game, player 1 is the pedestrian and player 2 the motorist. The least preferred scenario, when both players go, is associated with a high potential cost, for example death, injury, damage or a penalty. Moreover, it is safe to assume that a situation in which both players stop has a lower payoff for the player than stopping when the other player moves. Even when relaxing this assumption to indifference, the best response would still be the same. Solving the game as illustrated in Figure 1, one finds that $[\text{Go}, \text{Stop}]$ and $[\text{Stop}, \text{Go}]$ are stable Nash equilibria, in which none of the players has an incentive to change their actions, given their expectations of the other player's action.

		Player 2	
		Go	Stop
Player 1	Go	-1, -1	4, 1
	Stop	1, 4	0, 0

Figure 1: Strategic game using standard assumptions. The payoff orderings for player 1 and player 2.

As this paper is interested in the pedestrian's decision-making of whether to go or stop when her crossing signal is red – the very definition of jaywalking – a more specific model is illustrated in Figure 2. This extensive form game allows the players to move sequentially. This captures the reality that a player may change her mind based on the actions taken by the other player. Assuming that the pedestrian's light is red, both players have to decide on their best strategy, while having full information on the other player's strategy. Again, negative payoffs are assigned to both players going at the same time. Similarly, it is explicitly assumed that player 1's payoff when she goes remains unchanged even if player 2 stops, due to the high opportunity cost as discussed above.

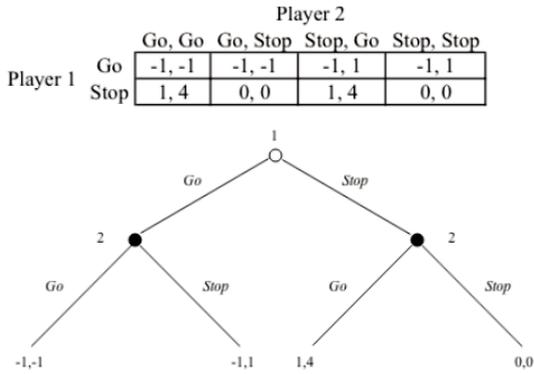


Figure 2: Extensive form game using standard assumptions. The payoff orderings for player 1 and player 2. Player 1 moves first.

Solving the game, there are two Nash equilibria, [Stop, (Go,Go)] and [Stop, (Stop,Go)]. The only subgame perfect equilibrium, however, is [Stop, (Stop, Go)], as player 2's strategy to go if the player 1 goes is a non-credible threat. This is consistent with the rational actor's preferences outlined before. Player 1's dominant strategy is to stop at the red light, whereas the motorist would choose to stop had the pedestrian chosen to go, and to go when the pedestrian stops, an outcome that is clearly desirable from the policy-makers' perspective.

However, as suggested before, the phenomenon of jaywalking highlights the fact that the assumptions about the pedestrians' preferences do not seem to reflect reality very well. Why this may be the case and how different preferences lead to a "bad" non-optimal Nash equilibrium is the content of the next section.

A Behavioural Game-theory Approach

Although the reasons for jaywalking depend on many different factors, common themes can be identified that give insights as to why actors do not act as predicted by the rational actor model presented in the last section. The key insight to understand why this is the case clearly lies in the preferences of the pedestrian, as she is the player deviating from the predicted actions. Therefore, the following game displayed in Figure 3 makes similar assumptions as the game in Figure 2, with one important exception. The payoff for player 1 when she goes and the motorist stops is assumed to be positive. The reasons why this may be the case will be discussed in the following section. The explicit assumption here is that the pedestrian is confident that she has sufficient time to pass the car without getting hit.

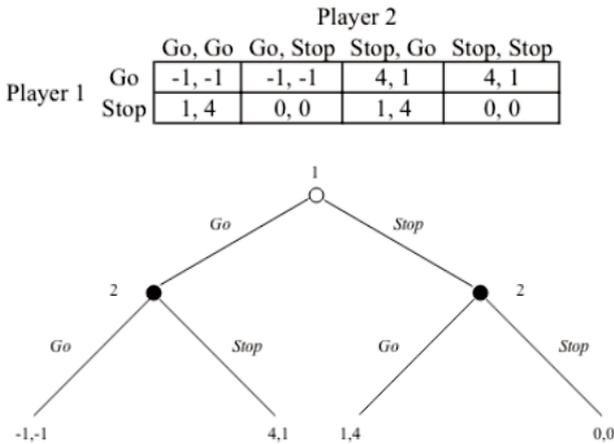


Figure 3: Extensive form game using modified assumptions. The payoff orderings for player 1 and player 2. Player 1 moves first.

Solving the model shows that the optimal strategy for the pedestrian will be to go, while the best response for the motorist is (Stop-Go). The two other Nash equilibria are, again, no subgame perfect equilibria, due to the non-credibility of the threats. In terms of the welfare outcome, however, this equilibrium is obviously not optimal. One of the possible negative outcomes is inefficiency in the traffic flow. The other, more dangerous one is injury. This is because the pedestrian's strategy is based on the expectation that a) the motorist will stop if necessary, and b) the probability of being hit by the car is low enough to not cause the pedestrian to stop. Moreover, what this stable equilibrium suggests is that such a payoff structure may lead to the establishment of a negative social norm, an issue that will be discussed in detail later. However, how realistic are these assumptions about the pedestrian's preferences? What would lead to a non-negative payoff structure like this?

A systematic review of existing research by Heinonen and Eck (2007) found that the reasons for jaywalking are often psychological, an unsurprising result. They argue that the physical environment in the form of a lack of crossing devices, midblock crosswalks, the poor timing of traffic signals, and the insufficient capacity of sidewalks impede pedestrians' willingness to adhere to traffic regulations, while the behaviour of pedestrians is another crucial factor. In their report they show that pedestrians' perception of risk, miscalculations of the probability of a collision, a tendency to follow the example set by others, and a general perception that the pace of urban life is faster can result in a lower willingness to stop and wait for traffic lights.

A vast literature on bounded rationality supports these insights. It is important to stress that the concept of bounded rationality does not refute the model of the rational actor in general, but rather is a helpful way to incorporate known biases and heuristics

into the model. That this is desirable for economic modelling has been compellingly argued by Conlisk (1996) and others (see for example Dawney and Shah (2005)). For example, legal scholars have begun to stress that bounded rationality must be taken into account when designing policies with punitive elements (O'Neill, 2004). With reference to the findings of Heinonen and Eck's report, the relevant heuristics that illustrate why the pedestrian's payoffs may be non-negative if she goes are the following.

Thaler (1981) discusses how dynamic inconsistencies through hyperbolic discounting - weighing present payoffs higher than future ones - and "rule of thumb" decisions can influence decision-making. In this case, the preference to jaywalk is highly influenced by the higher payoff associated with saving time. As Heinonen and Eck outlined, various studies have shown that pedestrian delays at signal-regulated crossings are a strong contributing factor to jaywalking. Moreover, Dawney and Shah (2005) note that "fundamental attribution error" - the false belief of control over situations - as well as habits need to be taken into consideration for optimal policy design. These biases, it can be argued, are equally applicable to the phenomenon of jaywalking.

Similarly, even if the pedestrian believes that the possible payoff may be negative, a case of herd behaviour may influence her decision of whether to jaywalk or not². This leads to the most plausible explanation as to why actors would choose to cross the street despite a red light - social norms. The role of social norms on individual decision-making has been well established in the literature (see for example Boyd and Richerson (2002)). As Conlisk (1996) observes, "[n]orms might be the cause of bounds on individualistic rationality. Or norms might be the effect of bounded rationality" (p. 677). Moreover, Posner (1997) comments that:

"[L]awyers think that the law is potentially significant as a shaper (not just an enforcer) of norms, much like education. The evidence for this conjecture is weak, and against it can be cited evidence that subgroups will often go their own way, adhering to norms that serve their special needs but violate the applicable legal norms, which may have been created without consideration for those needs." (p. 368)

Finally, a possible explanation may be provided by the observation that fairness considerations affect players' payoffs. Although this insight has been mainly gained by an experimental approach using ultimatum games³, it provides another important explanation as to why pedestrians may prefer to go rather than stop when the crossing signal is red. If

2. Banerjee and Duflo (2011), using a simple model, showed that herd behaviour can lead to such an outcome: "It then turns out that a likely consequence of people trying to use this information is what we call herd behavior - everyone doing what everyone else is doing, even when their private information suggests doing something quite different." (emphasis in original, p. 798)

3. See for example Korth (2009).

segregation, and in many cases an unequal distribution of waiting times, results in a perceived disadvantage for the pedestrian, this suggestion appears plausible.

So how can the pedestrians' preferences be changed to at least indifference between {Stop} and {Go}? The success of regulatory approaches that incorporated the insights about pedestrians' preferences discussed in the previous section is an indicator that a change in thinking with respect to incentives and preferences can result in considerable improvements. In other words, policy makers have successfully reverted the payoff structure from Figure 3 back to one similar to the one presented in Figure 2. For example, traffic engineers in many countries have placed an emphasis on reducing waiting times for pedestrians in order to reduce the incentive to jaywalk. That this is theoretically possible without causing delays for vehicle traffic has been established by a large number of researchers (Jason and Liotta, 1982, Ma and Zhang, 2008, Tianjiao et al., 2010, Vallyon and Turner, 2011). A prominent example of this approach, in combination with a strong social norm that punishes jaywalking in public⁴ as well as a strict enforcement system is Germany (Pucher and Dijkstra, 2003).

Another example is the concept of shared space, originating from Holland, and now in place in a growing number of countries. By removing traffic lights, signs and markings, participants are forced to interact with each other through signalling and eye contact. This concept has been largely successful, resulting in a highly efficient traffic flow and low accident rates (Hamilton-Baillie, 2008). The effectiveness of this approach may be surprising at first, given the complete lack of regulation. However, scholars such as Ostrom (2000) have argued that regulatory attempts may not necessarily lead to efficient outcomes:

"[i]t is possible that past policy initiatives to encourage collective action that were based primarily on externally changing payoff structures for rational egoists may have been misdirected - and perhaps even crowded out the formation of social norms that might have enhanced cooperative behavior in their own way. Increasing the authority of individuals to devise their own rules may well result in processes that allow social norms to evolve and thereby increase the probability of individuals better solving collective action problems" (p. 154).

Moreover, this approach similarly ensures an egalitarian character and circumvents the problems associated with the fairness considerations discussed earlier.

Other controlled experiments have shown that changing public behaviour is possible, and that the incorporation of these findings into policy-making including traffic system design may provide an opportunity to significantly improve pedestrian behaviour and

4. The role of third-party sanctions influencing social norms that lead to stable equilibria is well discussed. See for example Fehr and Fischbacher (2004).

consequently, public safety (Burger and Shelton, 2011, Cabinet Official Behavioural Insights Team, 2012). And while comparative studies relating to the change in pedestrians' preferences are still rare, these developments indicate that an approach aiming to model the actors' payoffs as realistically as possible rather than relying on standard theoretical assumptions is likely to be more fruitful in policy-making. Moving away from the illustrative example of jaywalking, this analysis using a simple behavioural game-theory model has highlighted the potential pareto-improvements that are achievable when the preferences modelled are based on behavioural structures that experimental and observational approaches suggest.

Conclusion

The above discussion has demonstrated the importance of the assumptions made about actors' preferences when using rational choice theory for policy design. A game-theoretical approach has been used to contrast the standard model with an alternative behavioural model using payoffs reflecting bounded rationality that may be the result of various heuristics and biases. The application of this model has been illustrated through the common phenomenon of jaywalking, and it has been argued that changes in policy-making that incorporated the issues relating to the assumptions discussed have led to pareto-improvements by successfully changing the payoff structure of the pedestrians in order to achieve optimal Nash equilibria. Finally, this paper has suggested that a similar approach to other applications in the area of policy design is likely to lead to further improvements.

References

- Applying behavioural insights to reduce fraud, error and debt. Cabinet Official Behavioural Insights Team. 2012.
- Baird, D. G., Gertner, R. H. & Picker, R. C. 1998. *Game theory and the law*, Harvard University Press.
- Banerjee, A. V. & Duflo, E. 2011. *Poor economics: A radical rethinking of the way to fight global poverty*, PublicAffairs Store.
- Boyd, R. & Richerson, P. J. 2002. Norms and Bounded Rationality. In: Gigerenzer, G. & Selten, R. (eds.) *Bounded rationality: The adaptive toolbox*. MIT Press.
- Burger, J. M. & Shelton, M. 2011. Changing everyday health behaviors through descriptive norm manipulations. *Social Influence*, 6, 69-77.
- Camerer, C. F. 1997. Progress in behavioral game theory. *The Journal of Economic Perspectives*, 167-188.
- Conlisk, J. 1996. Why bounded rationality? *Journal of Economic Literature*, 669-700.
- Dawney, E. & Shah, H. 2005. Behavioural economics: seven principles for policy-makers. In: NEF (ed.).
- Fehr, E. & Fischbacher, U. 2004. Third-party punishment and social norms. *Evolution and human behavior*, 25, 63-87.
- Fellendorf, M. 1997. *Public Transport Priority within SCATS - a simulation case study in Dublin*. Boston.
- Hamilton-Baillie, B. 2008. Shared Space: Reconciling People, Places and Traffic. *Built environment*, 34, 161-181.
- Heinonen, J. A. & Eck, J. E. 2007. Pedestrian Injuries and Fatalities. In: COPS (ed.). *Community Oriented Policing Services*.
- Jason, L. A. & Liotta, R. 1982. Pedestrian jaywalking under facilitating and nonfacilitating conditions. *Journal of Applied Behavior Analysis*, 15, 469.

Jost, G. & Allsop, R. 2014. Ranking EU Progress on Road Safety - 8th Road Safety Performance Index Report. European Transport Safety Council.

Kelleher, J. 2010. Dublin laws you can break today (Part One). Eleven Hundred Hours. [on-line], <http://www.eleventhundredhours.com/laws-you-can-break-today>

Korth, C. 2009. Game theory and fairness principles. Fairness in bargaining and markets. Springer Science & Business Media.

Ma, J. & Zhang, M. H. 2008. An Efficiency-Equity Solution to the Integrated Corridor Control Problem.

McDonald, F. & Nix, J. 2005. Chaos at the Crossroads, Gandon Books.

National Pedestrian Safety Action Plan, 2010 - 2014. [on-line], http://www.rsa.ie/Documents/RoadSafety/Leaflets/Leaf_booklets/pedestrian_safety_actionplan.pdf.

O'Neill, M. E. 2004. Irrationality and the Criminal Sanction. Supreme Court Economic Review, 139-180.

Ostrom, E. 2000. Collective Action and the Evolution of Social Norms. The Journal of Economic Perspectives, 14, 137-158.

Posner, R. A. 1997. Social norms and the law: An economic approach. The American economic review, 365-369.

Pucher, J. & Dijkstra, L. 2003. Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. American journal of public health, 93, 1509-1516.

Road Traffic Act. 2006.

Road Traffic (Traffic and Parking) Regulations. 1997.

Thaler, R. 1981. Some empirical evidence on dynamic inconsistency. Economics Letters, 8, 201-207.

Tianjiao, W., Jianping, W., Pengjun, Z. & McDonald, M. Study of pedestrians' gap acceptance behavior when they jaywalk outside crossing facilities. Intelligent Transportation Systems (ITSC), 2010 13th International IEEE Conference, 2010. 1295-1300.

Vallyon, C. & Turner, S. 2011. Reducing pedestrian delay at traffic signals. NZ Transport Agency research report 440. Beca Infrastructure.

Wickham, J. 2006. Gridlock: Dublin's transport crisis and the future of the city, Dublin, New Island.