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Bunching on the Autobahn? Speeding responses to a 'notched' penalty scheme[☆]

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ABSTRACT

This paper studies drivers' responses to a 'notched' penalty scheme in which speeding penalties are stepwise and discontinuously increasing in speed. We present survey evidence suggesting that drivers in Germany are well aware of the notched penalty structure. Based on a simple analytical framework, we analyze the impact of the notches on drivers' optimal speed choices. The model's predictions are confronted with data on more than 150,000 speeding tickets from the Autobahn and 290,000 speed measures from a traffic monitoring system. The data provide evidence on modest levels of bunching, despite several frictions working against it. We analyze the normative implications and assess the scope for welfare gains from moving from a simple, notched penalty scheme to a more complex but less salient Pigouvian scheme.

1. Introduction

The economics of externality-correcting interventions typically focuses on smooth, Pigouvian incentive schemes. It is quite common, however, for such subsidies, taxes, or penalty schemes to include 'kinks' or 'notches' (Slemrod, 2013; Kleven, 2016). In North America and some continental European countries, for instance, vehicles are subject to a tax that is a step function of a car's fuel economy or CO_2 emission level (Sallee and Slemrod, 2012; D'Haultfœuille et al., 2016). Notches are also ubiquitous in many domains of law enforcement. Fines and penalties often change discontinuously with small variations in the 'nuances' of a legal violation. Compared to minor fraud, theft, or tax evasion, major cases are punished in very different ways — and the differences between minor and major are commonly defined along cutoffs in a continuous metric of damage (Rasmusen, 1995). A further example is driving under the influence, which triggers a penalty that discontinuously increases at certain cutoff levels of blood alcohol content (Hansen, 2015). Similarly, many countries use penalties for speeding which are stepwise increasing in the speed level (Goncalves and Mello, 2017).

From a Pigouvian perspective, such notched taxes or enforcement schemes seem puzzling. Given that the underlying externalities are typically smooth functions of a given action, corrective interventions should build on smooth incentives, too. The marginal cost imposed by a Pigouvian scheme should reflect the marginal social cost of the action — and it is unclear why the latter should discontinuously change at certain cutoffs (such as, e.g., speeding at 30 mph above the limit). Admittedly, the exact marginal externality may depend on a vast number of factors.[1] A 'correct' Pigouvian solution would thus become quite complex. A high level of complexity, in turn, might hamper – in this case *desired* – behavioral responses to the policy (e.g., Abeler and Jäger, 2015). Notched Pigouvian schemes could, therefore, represent constrained approximations to the optimal penalties that account for decision makers' limitations in their attention, awareness, or cognition (Altmann et al., 2017; Ericson, 2011; Taubinsky and Rees-Jones, 2017). The simplicity of, e.g., stepwise increasing penalty schemes might assure its salience and individuals' awareness about the scheme (Chetty et al., 2009; Finkelstein, 2009). In the presence of externalities, the salience gains related to simplicity could then dominate the welfare costs from deviating from the correct Pigouvian scheme.

We examine this idea in the context of speed limit enforcement in Germany, where drivers are confronted with a notched – and, as we are

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[1] Consider, e.g., the marginal accident risks associated with a marginal increase in speeding under different weather, road, traffic and car conditions.

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going to show, quite salient – penalty scheme. The core of our analysis exploits detailed data on more than 150,000 speeding tickets recorded on the German Autobahn. In addition, we examine complementary data on 290,000 (non-ticketed) speed measures from single-lane roads. Like in many other countries, fines and other penalties jump discontinuously at several speed levels. Hence, drivers face numerous 'notches' in the penalty structure.

To set the stage for our analysis, we first introduce a simple analytical framework in the spirit of Kleven and Waseem (2013) and study the effect of the penalty notches on drivers' optimal speed choices. The analysis, which differs in several ways from a deterministic taxation framework, highlights conditions under which drivers bunch at different notches. Before examining bunching responses, we present evidence from a survey that assesses whether drivers know and understand the penalty scheme's structure. The survey reveals that respondents are quite knowledgeable about the scheme's stepwise shape, its discontinuous jumps and the location of the cutoffs. This finding is by no means trivial and – potentially due to the penalty scheme's simplicity – different from studies documenting limited knowledge (e.g., Chetty et al., 2013) and misconceptions of non-linear or non-convex budget sets (De Bartolome, 1995, Liebman and Zeckhauser, 2004; Feldman et al., 2016).[2] At the same time, the survey indicates considerable heterogeneity across drivers, suggesting that bunching might not be very sharp. Variation in the speed indicated by speedometers as well as ambiguities regarding the computation of the fine-relevant speed measure might further limit the scope for bunching.

Studying the distribution of measured speed, we do find bunching for some of the notches in the penalty scheme. Disproportionately more drivers are speeding exactly at (or slightly below) certain cutoffs of the penalty scheme. Quantitatively, however, the observed bunching mass is quite small and – similar to findings in several tax bunching studies (Saez, 2010; Chetty et al., 2011; Bastani and Selin, 2014) – varies considerably along the speed distribution.[3] Given the optimization frictions noted above, it is not too surprising that we do not detect massive bunching responses. The fact that we do find some evidence on bunching indicates that at least some drivers do respond despite the frictions they face. By exploring a reform of the penalty system we provide further evidence on behavioral responses. The reform increased the size of several notches, without shifting their location. Our results indicate that some speeders responded to the reform by avoiding speed ranges which triggered significantly higher penalties after the reform. Overall, the data suggest that the reform produced a sizable shift in the speeding distribution, with a 25% drop in the fraction of vehicles driving more than 20 km /h above the limit.

Based on our empirical results we finally get back to the analytical framework and derive an upper bound on the 'salience gap' — the maximum difference in salience between a notched and a more complex Pigouvian penalty scheme, for which the latter scheme would be superior to the notched one. Our results suggest that if at most 12% of drivers turn inattentive after switching from a notched to a smooth Pigouvian scheme, the hypothetical reform would be welfare enhancing. For a higher salience gap, the notched approximation would be superior to a Pigouvian scheme that is poorly understood by drivers.

Our study relates to several strands of research. First, we contribute to the law and economics of speeding and speed control.[4] One million lives are lost worldwide each year due to motor vehicle accidents (Peden et al., 2004), with speeding being a major contributor to the number of traffic fatalities. It is therefore important to advance our understanding of speed control policies. Several quasi-experimental studies document the impact of police enforcement (DeAngelo and Hansen, 2014), speed limits (van Bentham, 2015) and speeding tickets (Dusek and Traxler, 2017) on travel speed, accidents, fatalities and air pollution externalities. The present study differs from these contributions since it analyzes drivers' responses to the specific *structure* of speeding penalties. By focusing on an electronic (i.e., automated) enforcement system, our study also differs from Goncalves and Mello (2017), who study racial bias in police officers' (not drivers') responses to similar notches.

Conceptually, our paper closely relates to the work by Sallee and Slemrod (2012), who study automakers' responses to notches in the (fuel economy based) taxation of automobiles. They offer an interesting welfare discussion, in which they quantify the welfare loss due to the inaccurate incentives of a notched scheme. Our analysis contributes to this discussion by (i) explicitly modeling the benefit of a notched scheme being more salient and by (ii) empirically approximating the tradeoff between these costs and benefits. In this vein, we also offer a new perspective on related welfare discussions of notched schemes (e.g., Blinder and Rosen, 1985; Gillitzer et al., 2017).

In terms of methods, we use tools from public finance to analyze behavioral responses to law enforcement (Kleven, 2016). Applying the bunching framework to speeding responses, our analysis clarifies several key differences between the law enforcement and the taxation context. In our application, bunching is proportional to *expected* notches — the discontinuous increase in penalties weighted with the detection probability. Hence, there are two policy parameters that jointly determine the incentive to choose a corner solution: the jump in penalties at a given speed (analogous to, e.g., increases in average tax rates at certain income levels) and the risk of punishment. This latter dimension, which is not present in most taxation studies but crucial if one explores notches in law enforcement, impedes the translation of bunching mass into behavioral response elasticities. The reason is that objective variation in law enforcement and subjective priors about detection risks (speed controls) essentially add an additional layer of heterogeneity. Without common knowledge about the enforcement parameters (or subjective risk assessment data), notches in penalty schemes cannot readily be used to identify behavioral elasticities.[5]

The rest of the paper is structured as follows. Section 2 describes the institutional framework for speeding in Germany. Section 3 presents evidence from our survey on drivers' knowledge of the penalty scheme's structure. Section 4 introduces a simple model of speeding and discusses several predictions. After presenting the data (Section 5), we turn to the empirical analysis of the different speed measurement data (Section 6). Section 7 offers a welfare comparison between a notched and a smooth penalty scheme and Section 8 concludes.

2. Institutional background

Despite common prejudices about German highways being the great dream of speeders, there are speed limits on more than 85% of the 13,000 km of Autobahn. Speed limits are primarily imposed for safety reasons: high speed is the leading cause of roughly 4000 annual traffic deaths and 400,000 annual traffic injuries in Germany. For most of the accidents, speeding is the chief cause.[6]

The enforcement of speed limits is based on permanently installed and on mobile speed cameras, which are set up by an officer for a few

[2] Further evidence is discussed in Congdon et al. (2011; Ch. 2).

[3] Using the data that cover the full distribution of measured speed (rather than the distribution conditional on receiving a speeding ticket), for instance, we find no evidence on bunching at the speed limit itself. Moreover, in both sets of data, we observe no bunching at very high speed level cutoffs. Drivers in this speed range might either have a very 'sharp' preference for speeding or they might expect very low detection probabilities. In either case, such drivers seem fairly insensitive to the penalty notches.

[4] For early, theoretical contributions in this field see, e.g., Jondrow et al. (1983), Lave (1985), and Graves et al. (1993).

[5] A further, more technical difference to the taxation literature is related to the close proximity of potential bunching points. In our context, it is reasonable to consider drivers who are indifferent about speeding 20 or 25 km/h above the limit. Our analysis therefore considers the joint influence of multiple, potentially inter-related notches on behavior — a point which advances and generalizes the theoretical bunching literature.

[6] See *Deutsches Statistisches Bundesamt* (2017; *Fachserie 8/7, Verkehr*).