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Forecasting the impact of the viral ‘Kia Boys’ social media trend on car thefts to 2050[☆]

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ABSTRACT

In 2022, Hyundai Sonatas became the most frequently stolen car model in Los Angeles, mirroring a nationwide trend. The sudden popularity of this mid-sized sedan among car thieves has, according to some, been linked to the viral spread of videos on TikTok and YouTube that showcased a security vulnerability that made certain Kia and Hyundai models easy to steal. These videos later acquired the moniker ‘Kia Boys’ or ‘Kia Challenge.’ In this work, we show that the surge in Hyundai Sonata thefts in Los Angeles was only weakly tied to the ‘Kia Boys’ trend, having begun much earlier during COVID-19 pandemic lockdowns. Any lasting effects of the viral social media trend were fully absorbed into offline car theft dynamics by the time social media interest peaked in 2022. We use historical data on Honda Civics and Toyota Camrys, car models popular among pre-social media generations of car thieves, to develop a model for the offline temporal and spatial evolution of theft preferences. The model suggests that the effects of the ‘Kia Boys’ vulnerability are likely to persist for decades, irrespective of the role social media played in its inception, and that these effects will be increasingly concentrated in low-income communities over time.

1. Introduction

Car theft remains a significant challenge for most US metropolitan areas, though it rarely makes the news (Farrell, 2025; Tapp & Coen, 2024). For example, among 9639 articles in *The New York Times* in 2019 that contained the keyword “crime”, fewer than 0.2% ($n = 18$) mention “car/auto/vehicle theft” or “stolen car/vehicle”. The recent surge in thefts of Kia and Hyundai car models is a stark exception (Casey & Dohr, 2022; Endale, 2022; Morrison, 2023). Widespread media reporting, starting in June 2022, raised an alarm about videos posted on TikTok and YouTube under labels such as the ‘Kia Boys’ and the ‘Kia Challenge’ that showed how to exploit a unique mechanical vulnerability that made several Kia and Hyundai car models easy to steal with little more than a USB key. In this study, we examine the recent surge in thefts of Hyundai Sonatas in Los Angeles, CA, which became the top-ranked stolen car, and use a comparative model, based on previous generations of top-ranked stolen cars, to forecast the temporal and spatial impact of the ‘Kia Boys’ vulnerability through 2050. The results suggest not

☆ The numerical results presented in this manuscript were reproduced by the reproducibility team on 13 July 2026.

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The numerical results presented in this manuscript were reproduced by the reproducibility team on 13 July 2026. However, minor differences were observed in the Optima column of Table 4. These differences may arise across different operating systems due to parallelisation and numerical precision.

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only that the role of online social media in generating this offline harm is more nuanced than popularly portrayed but also that ignoring key offline mechanisms to focus on unique online processes would lead to a substantial mischaracterization of the dynamical system over the long term. Model-based forecasts suggest that thefts of the vulnerable Hyundai and Kia models in Los Angeles will remain elevated over baseline levels through at least 2042, dropping to negligible levels between 2043 and 2050 largely because vulnerable vehicles will have become rare due to scrapping. The long-term impact will vary across the city, however. Higher-income areas of Los Angeles will have forgotten about the 'Kia Boys' vulnerability as older, at-risk cars are traded in for newer ones. Lower-income areas of the city will continue to absorb vulnerable cars as they change hands in the used market before moving toward eventual scrapping.

The remainder of this paper is organized as follows. In Section 2, we provide historical background on vehicle anti-theft technologies and the origin of the 'Kia Boys' social media meme or trend. Section 3 introduces our data and the mathematical model used for long-term theft forecasting. Section 4 presents results, focusing on the trajectory of the Hyundai Sonata as it became the top-ranked stolen car in Los Angeles, and then on historical analogs for popular targets among Los Angeles' car thieves. We conclude with a discussion of the role of online and offline dynamics in the rise of the 'Kia Boys' phenomenon.

2. Background

2.1. Vehicle anti-theft technology

Many modern cars include a range of anti-theft technologies designed to thwart common methods car thieves use to gain entry to and start a vehicle without the correct key (Farrell, 2025). In addition to ubiquitous audible alarms, many cars now include keyless entry systems, locking steering wheels, chip-based engine immobilizers, or pushbutton ignition systems. Part marking and GPS-based vehicle tracking systems are additional technologies used to deter offenders and to aid in investigation and recovery if a vehicle has been stolen. Engine immobilizers have been the most successful of these anti-theft technologies (Brown, 2015; Kriven & Ziersch, 2007; Sallybanks & Brown, 1999). Engine immobilizers were first widely deployed in the U.S. car market in the 1990s, following Congressional approval of the 1984 Motor Vehicle Theft Law Enforcement Act (MVTLA) (42 U.S.C. §14171) and its expansion under the 1992 Anti-Car Theft Act (ACTA) (H.R. 4542, revised in 1996) (see Farrell, 2025). Most modern engine immobilizers use a challenge-response protocol that compares a code generated by a transponder embedded in the key to the code expected by the ignition system (Davis & DeLong, 1996). In early systems, each key associated with a vehicle issued a unique encrypted RF signal that the ignition system decoded and compared with authorized keys. More recent immobilizers generate a new encrypted "rolling code" each time the key is used (Brown, 2017; Davis & DeLong, 1996), much like website multi-factor authentication systems. Without a correctly paired key, the engine will not start. Of course, no practical security system can guarantee protection against theft (Wouters et al., 2020).

Unlike in the UK and Australia (Brown, 2004; Farrell, 2025), the MVTLA and ACTA did not require car manufacturers to include immobilizers as standard equipment in U.S.-sold cars. Instead, manufacturers were required to stamp or mark critical car parts to make them less desirable to so-called "chop shops" (see Harris & Clarke, 1991). Manufacturers could receive an exemption from the parts-marking requirements for specific car models if they demonstrated that thefts of the model were likely to fall below the median theft rate for passenger vehicles (3.2712 thefts per 1000 vehicles based on 1985 data under MVTLA, 3.5826 thefts per 1000 vehicles based on 1990–1991 data under ACTA). New models of high-theft lines could also be exempted if they included proven anti-theft technologies, such as an immobilizer, as standard equipment (Department of Transportation, 1999). Thus, the incentives in the MVTLA and ACTA were structured to encourage the adoption of immobilizers or other effective theft-prevention technologies in place of costly parts marking. As discussed in further detail below, Toyota introduced immobilizers on many vehicle models beginning in 1992, and Honda did so in 2001. Despite these incentives, however, not all vehicles with immobilizers were immediately granted exemption from parts-marking requirements.

Hyundai and Kia entered the U.S. car market in 1986 and 1997, respectively (Jacobs, 2023), and engine immobilizers were introduced on several models across the fleet in the mid-2000's. For example, the repair manual for the 2004 model-year Hyundai Sonata identifies a chip-based immobilizer as standard equipment on the entry-level model. Beginning in 2011, however, 11 Hyundai and nine Kia models were sold in the U.S. without engine immobilizers or with immobilizer functionality disabled (Kia Hyundai Vehicle Theft Litigation, 2023a). Without a functioning immobilizer, these cars proved easy to steal in minutes. Theft of one of these vulnerable cars typically involves gaining entry without triggering the alarm, opening the steering column casing, disassembling or breaking the ignition cylinder to expose the ignition switch, and mechanically turning the ignition switch to start the car (Kia Hyundai Vehicle Theft Litigation, 2023a; Kriven & Ziersch, 2007). In the vulnerable Hyundai and Kia models, the exposed ignition switch is a small metal post that serendipitously matches the female end of a USB-B cable, a ubiquitous item that makes for an ideal opportunistic tool. Hyundai and Kia updated the vulnerable car models by the 2022 model year at the latest to eliminate the vulnerability. In February 2023, some owners of vulnerable cars became eligible to receive free software updates or physical security devices (e.g., steering wheel locks) to address the problem, as part of a class action lawsuit filed in 2022 (Highway Loss Data Institute, 2024; Kia Hyundai Vehicle Theft Litigation, 2023b). Several details of the class action lawsuit remain under appeal, and the uptake of agreed-upon security fixes remains uncertain. An additional multi-state settlement was announced in December 2025, requiring Hyundai and Kia to replace ignition cylinders in vulnerable vehicles (Compton, 2025). The expected implementation time for the multi-state settlement extends into 2027.

2.2. Discovery of the 'Kia Boys' vulnerability

While several Hyundais and Kias manufactured and sold after 2011 were uniquely at high risk of being stolen, the vulnerability now labeled the 'Kia Boys' appears not to have been recognized by car thieves for at least a decade. Local media reporting in Milwaukee, WI, suggests that the vulnerability was first discovered sometime in mid-2020 (ABC News, 2021; Dortch, 2020). However, the earliest media reports do not attribute the surge in thefts to viral online content. The oldest video still posted on YouTube referencing the 'Kia Boys' dates to June 5, 2021 (YBKQUIN, 2021). The meme's online spread likely began much later, in June 2022, through national news coverage by mainstream media (Fig. 1A,B, and Fig. 3A).

Thefts of vulnerable Kia and Hyundai models surged after June 2022 in many cities, including Atlanta, GA, and Seattle, WA (Fig. 2A) (USAFacts, 2023). This pattern was also observed in insurance-claims data for several states (Highway Loss Data Institute, 2024). In these places, car thieves appear to have been unaware of the vulnerability until it went viral in 2022. In other cities, including Milwaukee, WI, and Denver, CO, the vulnerability appears to have been discovered independently during the summer of 2020, without the influence of a viral social media trend (Fig. 2B) (Highway Loss Data Institute, 2024; USAFacts, 2023). As discussed in detail below, Los Angeles, CA, appears to fall into this "early discovery" group (compare Fig. 2B, middle row, with Fig. 3A). In a handful of cities, there was no obvious change in thefts through the end of 2023 (Fig. 2C).

In our study, we examine the growth in thefts of Hyundai Sonatas in Los Angeles, CA, in relation to the rise of the 'Kia Boys' social media phenomenon, and then use a comparative mathematical model to forecast the long-term temporal and spatial pattern of thefts through 2050.

3. Methods

3.1. Data

Data on stolen cars in the City of Los Angeles were provided by the Los Angeles Police Department (LAPD). Between 2000 and 2023, a 24-year period, 565,333 vehicles of all types were reported stolen (Table 2). The vast majority of these thefts involve passenger cars (e.g., Honda Civic, Toyota Camry), crossovers (e.g., Ford Escape, Mazda CX7), SUVs (e.g., Cadillac Escalade, Ford Bronco), and mass-market light pickup trucks (e.g., Ford F150, Dodge Ram). For example, the top ten car makes by theft volume—Chevrolet, Honda, KIA, Toyota, Ford, Hyundai, GMC, Nissan, BMW, and Mercedes—alone account for 78.8% (n = 19,952) of the 25,307 thefts reported in 2022. These annual totals likely underestimate the total number of thefts by 10%–20% due to crime underreporting (Xie et al., 2024). Nevertheless, the totals illustrate that car theft in Los Angeles declined substantially between 2000 and 2013 before surging again during two periods in 2014–2017 and 2019–2023.

We focus on vehicle model-year for specific car makes in our analyses (e.g., 2017 Hyundai Sonata, 1999 Honda

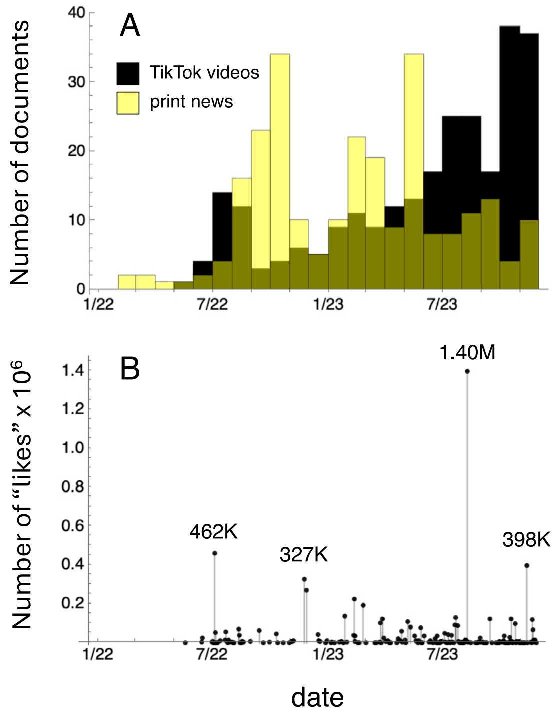

Fig. 1. 'Kia Boys' in U.S. print media and on TikTok. (A) Number of TikTok videos and print news stories mentioning the 'Kia Boys.' (B) Number of "likes" on the TikTok videos shown in A.

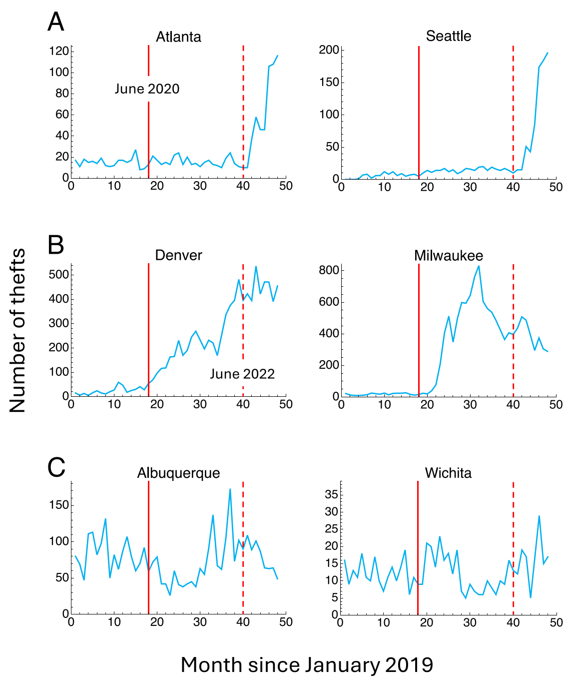

Fig. 2. Monthly number of thefts of combined Hyundai and Kia models in six U.S. cities. (A) Top Row. Cities with late onset of thefts. (B) Middle Row. Cities with early onset of thefts. (C) Bottom Row. Cities with no apparent change. Solid red lines mark June 2020. Dashed red lines mark June 2022. Aggregate theft data from 23 U.S. cities are available from USA Facts. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

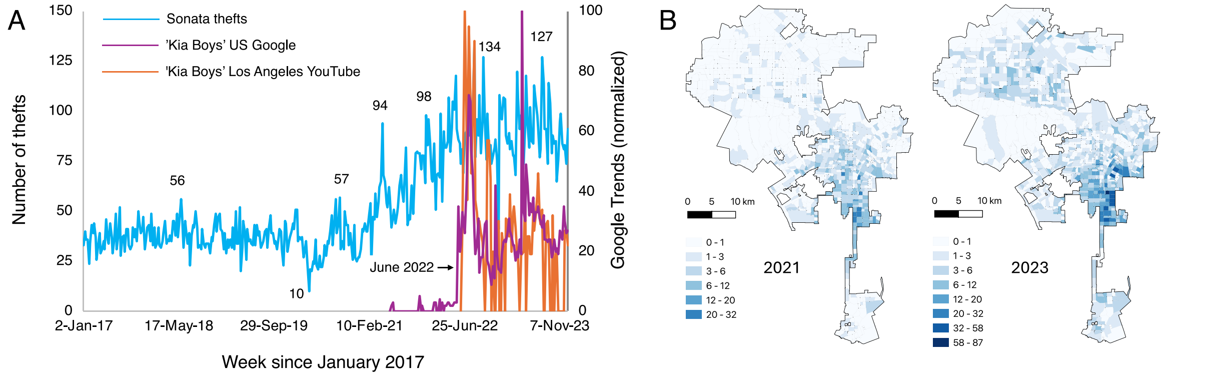

Fig. 3. Trends in Hyundai Sonata thefts in Los Angeles and the viral spread of 'Kia Boys' content online. (A) Weekly number of Hyundai Sonata thefts in Los Angeles and the normalized volume of searches for 'Kia Boys' in national Google Trends web and Los Angeles YouTube searches, 2017–2023. (B) Spatial distribution of Hyundai Sonata thefts across Los Angeles in 2021 and 2023.

Civic). Vehicle model-year is not only the most consistent level of data recorded by police for reported thefts (i.e., trim level is haphazardly recorded), but it is also the taxonomic scale at which offenders forage for targets and where changes in car design are most likely to affect ease of theft and desirability (Brantingham, 2013; Clarke & Harris, 1992; Light et al., 1993). We selected from reported thefts the make, model, and model-year of all vehicles identified as Hyundai Sonatas, Honda Civics, and Toyota Camrys. As shown below, Honda Civics and Toyota Camrys provide historical analogs for uniquely vulnerable cars that can be tracked over decades in theft data. Specifically, over the 24-year period of observation, 39,508 Toyota Camrys and 46,015 Honda Civics were reported stolen in the city of Los Angeles (Table 2). Over the same period, 5300 Hyundai Sonatas were stolen. The rank-order position for each focal make-model in each year of observation was determined relative to thefts of all unique make-models stolen during that year (Table 2). Thus, Honda Civics were among the top-five most stolen make-models in all 24 years and were the most popular target (i.e., Rank 1) of Los Angeles car thieves in five consecutive years (2016–2020). Toyota Camrys were among the top-five most stolen make-models in 20 of the 24 years and were the most popular target in seven consecutive years (2001–2007). Hyundai Sonatas were among the top-five most stolen make-models during three years and were the most popular target in 2022 and 2023, the last two years of observation.

3.2. Mathematical model

Our mechanistic, long-term forecasting approach is similar to compartmental model forecasts in epidemiology (Brauer, 2008). Here, the macroscopic, qualitative long-term behavior of the system is the primary focus. The forecasting model accounts for the entry of new model-year cars each year of observation, the loss of old model-year cars through so-called 'scrapping,' and the timing of the introduction (or discontinuation) of specific anti-theft technologies, such as immobilizers. When fit to observational data, the model provides a general mechanistic framework that can serve as a baseline for forecasting vehicle theft trends more broadly.

We model theft patterns separately for each unique car make-model type and focus on trends in thefts by car model-year m (e.g., the 2019 Hyundai Sonata is distinct from the 2020 Sonata). We first assume that the rate of car theft in year t is proportional to the abundance of model-year m vehicles in the environment (Appendix A):

$$\lambda_m(t) = h_m f_m(t) g_m(t) \tag{1}$$

where h_m is the number of model-year m cars sold in year $t = m$. We assume the number of cars sold increases as a power law over time (since 1975), $h_m = (t_m - 1975)^d$, where 1975 is an arbitrary starting year and d scales the rate of market expansion. In Appendix B, we present model-fitting results for several alternative specifications for h_m, including constant, exponential, and Gaussian functional forms, as well as a data-driven model based on empirical sales data for each year m.

The abundance of car model-years on the street decays due to the scrapping of older cars, which we model as a logistic function of the time since the model-year was introduced, $t - t_m$ (Bento et al., 2018; Greene & Chen, 1981):

$$g_m(t) = [1 + ae^{b(t-t_m)^c}]^{-1} \tag{2}$$

Eq. (2) can be viewed as a survival function with a logistic functional form. Parameters a, b and c determine the shape of the function and are fit from data. Generally, since $b > 0$, $g_m(t) \to 0$ as $t - t_m \to \infty$, meaning that cars of model-year m become less likely to survive, or, equivalently, more likely to be scrapped, as they age. The combined theft rate for all model-years of a car in year t is the sum of the rates for the individual model-years $\lambda(t) = \sum_{m \le t} \lambda_m(t)$.

Next, we model changes in theft vulnerability as a step function. We define s as the year when a security vulnerability is introduced or removed from a car model. Then, for $t \ge s$, the constant f_m in Eq. (1) increases or decreases by a fixed amount:

$$f_m(t) = (f_0 + f_1 \chi\{t \ge s\}) \tag{3}$$

where χ is an indicator function. If $f_m(t) > f_0$, a vulnerability was introduced in year $t = s$ that increased the theft rate relative to a baseline f_0; if $f_m(t) < f_0$, a defensive measure was introduced that decreased thefts. For Honda Civics and Toyota Camrys, s corresponds to the model-years $s = 2001$ and $s = 1992$, respectively, when ignition immobilizers were added as standard equipment. All model-years prior to s lacked this defense; all model-years starting with s had it.

Hyundai Sonatas are more complex because there was a date at which a particularly vulnerable ignition system was introduced ($s_1 = 2011$) and a date at which it was eliminated ($s_2 = 2020$) (see Table 1). In addition, the vulnerability apparently was not discovered by car thieves in Los Angeles until mid-2020 (see below). To model the dynamics of Sonata theft, we therefore modify Eq. (3) as follows:

$$f_m(t) = f_0 + f_1\chi\{t_m \geq s_1\}\chi\{t_m \leq s_2\}\chi\{t \geq u\}\sigma(r_0(t-u-x_0)). \tag{4}$$

Here, the increase $f_0 + f_1$ applies to vehicles manufactured between $s_1 = 2011$ and $s_2 = 2019$. However, the vulnerability takes effect only in year $u = 2020$. The term $\sigma(r_0(t-u-x_0))$ models logistic growth in car thieves' knowledge of the vulnerability, which we argue began with exploration at the start of the COVID-19 pandemic but may have been primarily influenced by viral videos elsewhere.

We also forecast the intensity of Hyundai Sonata thefts across spatial regions of Los Angeles. The term $f_m^b(t)$ partitions the intensity for region b, year t, and car model-year m by assuming a separable model of the form:

$$f_m^b(t) = f_m(t) \cdot p_{t,m}^b. \tag{5}$$

The theft fraction parameter $p_{t,m}^b$ is fit from historical data on other top-ranked stolen cars. For example, we assume that the empirical fraction p of Honda Civics of model-year m stolen in LAPD's South Bureau is a function only of the car's age, $t - t_m$ (i.e., the time since the model-year was introduced):

$$p_{t,m}^s = q(t - t_m) \tag{6}$$

and that the fraction of thefts in LAPD's West Bureau is a time-shifted version of q:

$$p_{t,m}^w = q(t - t_m + \tau). \tag{7}$$

We then use local polynomial regression to estimate q, with the offset set to $\tau = 15$.

We use STAN to fit Eqs. (1) and (4) (Carpenter et al., 2017). STAN is a probabilistic programming language that supports Bayesian inference for statistical model parameters. Because all parameters in the models are positive, we used weakly informative exponential priors to estimate them.

4. Results

4.1. The temporal trend in los angeles

A close examination of car theft data from Los Angeles suggests that what became known as the 'Kia Boys' vulnerability was identified before any recognizable social media trend emerged. We focus on Hyundai Sonatas as representative of the class of vulnerable vehicles (see Table 1 and Appendix E). Fig. 3A shows weekly counts of Hyundai Sonatas stolen in Los Angeles from Jan 1, 2017, to December 31, 2023, alongside Google Trends data on the term 'Kia Boys' in national Google searches and Los Angeles YouTube searches. Fig. 3B shows the spatial distribution of thefts in 2021 and 2023, before and after the 'Kia Boys' search spike. Through 2017–2019, Hyundai Sonata thefts were stable, averaging 37.6 thefts per week. A short period of suppressed thefts accompanied the start of COVID-19 lockdowns in March 2020, with 10 thefts per week, followed by a return to pre-lockdown theft volumes in July 2020, averaging 38.1 thefts per week. Theft counts surged in February 2021, rising to 94 during the week of April 19, 2021. Theft counts in 2021 were broadly distributed across the city. Theft counts peaked during the summer of 2022, with a high of 134 cars stolen during the week of August 15, 2022, and settled around a new equilibrium for the remainder of 2022 and through 2023. Theft counts in 2023 rose across most neighborhoods, with noticeable increased concentration in South and East Los Angeles. The present study thus offers confirmatory local-level analysis of observations made with insurance claim data (Highway Loss Data Institute, 2024).

A logistic growth model (Bertrand, 2019; Tsoularis & Wallace, 2002) of the form $N(t) = K_2(1+e^{-R0(t-c)})^{-1} + K_1$ fits the weekly data, showing a smooth transition from a pre-COVID-19 mean of $K_1 = 36.62$ thefts per week to a post-'Kia Boys' mean of $K_1 + K_2 = 91.17$ thefts per week, an average increase of $K_2 = 54.55$ thefts per week. Here, $R0 = 0.06689$ is the basic reproductive number and may reflect the intrinsic rate at which knowledge of the vulnerability spread among Los Angeles car thieves. The parameter $c = 243.5$ is the week number since the first week of 2017 (approximately August 26, 2021) at which the logistic growth curve begins to decelerate. The fastest phase of growth thus occurs more than a year

Table 1
Vulnerable Hyundai and Kia models and model years identified in the class action settlement (Kia Hyundai Vehicle Theft Litigation, 2023b). Model years listed in two-digit form (e.g., 11-22 is 2011–2022).

Hyundai		Kia	
Model	Years	Model	Years
Accent	11–22	Forte	11–21
Elantra	11–22	K5	21–22
Elantra GT	13–20	Optima	11–20
Elantra Coupe	13–14	Rio	11–21
Elantra Touring	11–12	Sedona	11–21
Genesis Coupe	11–14	Seltos	21–22
Kona	18–22	Soul	11–22
Palisade	20–21	Sorento	11–22
Santa Fe	11–22	Sportage	11–22
Santa Fe Sport	13–18		
Santa Fe XL	19		
Sonata	11–19		
Tucson	11–22		
Veloster	12-17, 19–21		
Venue	20–21		
Veracruz	11–12		

Table 2
Number and rank-order position of Hyundai Sonatas, Honda Civics, and Toyota Camrys stolen in Los Angeles by observation year.

Year	Hyundai Sonata	Honda Civic	Toyota Camry	All vehicle thefts
2000	22 (143)	1343 (5)	2399 (2)	28,935
2001	30 (145)	1969 (3)	3109 (1)	31,825
2002	16 (234)	2271 (4)	3830 (1)	34,522
2003	30 (148)	2161 (4)	4151 (1)	33,543
2004	28 (151)	2004 (3)	3633 (1)	30,104
2005	22 (175)	1969 (3)	3347 (1)	28,737
2006	18 (178)	2210 (3)	2928 (1)	26,532
2007	21 (168)	1970 (3)	2493 (1)	25,189
2008	30 (121)	2367 (2)	2156 (3)	24,372
2009	18 (154)	2289 (2)	1363 (3)	19,547
2010	20 (128)	2000 (2)	1309 (3)	18,213
2011	19 (131)	1845 (2)	1008 (3)	16,790
2012	24 (98)	1967 (2)	961 (3)	16,801
2013	36 (71)	1974 (2)	704 (3)	15,925
2014	55 (46)	1977 (2)	807 (3)	15,929
2015	63 (48)	2573 (2)	786 (3)	18,833
2016	113 (28)	2556 (1)	742 (3)	21,130
2017	111 (35)	2362 (1)	665 (3)	21,693
2018	132 (22)	1776 (1)	553 (4)	19,475
2019	115 (29)	1342 (1)	500 (4)	17,434
2020	286 (14)	1692 (1)	527 (6)	22,592
2021	943 (4)	1377 (2)	573 (6)	25,411
2022	1506 (1)	1089 (4)	485 (8)	25,307
2023	1642 (1)	932 (4)	479 (11)	26,494
Total	5300	46,015	39,508	565,333

before the first major spike in online interest in the 'Kia Boys' term nationally during the week of May 30, 2022, and in Los Angeles during the week of Jun 6, 2022 (Fig. 3A). While content related to the 'Kia Boys' vulnerability spread rapidly online after June 2022 and affected theft patterns in a number of cities, it appears to have played little role in the emergence of the theft problem in Los Angeles.

To support this last observation, we fit a vector autoregressive model (VAR) (Stock & Watson, 2001) to the data, focusing on the period after online searches for 'Kia Boys' first emerged in June 2021 (Fig. 3A). All three time series are stationary over this period (Dickey–Fuller and Phillips–Perron tests significant at $p < 0.05$). Lag-order selection statistics indicate that a three-lag model is appropriate. Pairwise comparisons indicate that lagged Hyundai Sonata thefts in Los Angeles predict (Granger-cause) U.S. Google searches for 'Kia Boys' ($\chi^2 = 10.748$, df $=$ 3, $p = 0.013$), but 'Kia Boys' searches do not predict Hyundai Sonata thefts ($\chi^2 = 2.747$, df $=$ 3, $p = 0.432$). There is no evidence of Granger causality in either direction between Hyundai Sonata thefts and Los Angeles YouTube searches for 'Kia Boys' (thefts $\rightarrow$ 'Kia Boys': $\chi^2 = 5.974$, df $=3$, $p = 0.113$; 'Kia Boys' $\rightarrow$ thefts: $\chi^2 = 4.613$, df $= 3$, $p = 0.202$).

Pinpointing the initial discovery of the mechanical vulnerability by Los Angeles car thieves to the late summer of 2020, before the rise of the social media trend, is consistent with self-reported behavior in Milwaukee around the same time. In a widely viewed YouTube profile of the 'Kia Boys' posted on May 31, 2022 (Tommy, 2022), a Milwaukee youth states that he started stealing Hyundais and Kias "two summers ago", which would date the start of the 'Kia Boys' phenomenon to the summer of 2020. We do not claim that the growth in Hyundai Sonata thefts in Los Angeles caused the viral 'Kia Boys' meme online, nor do thefts in Los Angeles serve as a proxy for when this meme first appeared. Once established, however, the spread of the 'Kia Boys' meme could have reinforced Hyundai and Kia thefts in Los Angeles. The evidence for such an effect is mixed, however. On the one hand, the number of TikTok videos posted with the tag 'Kia Boys' increased over 2022 and 2023, as did the number of car thefts nationally (Fig. 1A) (Highway Loss Data Institute, 2024; Tapp & Coen, 2024). On the other hand, relative stability in the number of Hyundai Sonata thefts in Los Angeles through 2022–2023 suggests the saturation of any role played by social media.

4.2. Historical analogs

The long-term consequences of knowledge of 'Kia Boys' vulnerability may be substantial, regardless of how individual car thieves acquired it. Fig. 4A shows the immediate impact of the steps taken by Hyundai America to eliminate the vulnerability in new Hyundai Sonata model-years (Supplemental Movie S1). The matrix plot shows the frequency of thefts by car model-year and the year the car was stolen (see Table 3 in Highway Loss Data Institute, 2024). The sharp boundary on either side of the vulnerable model-years (vertical arrows) is visually apparent, as is the sharp rise in theft numbers beginning in 2020 (horizontal arrow).

The model-year theft pattern shown in Fig. 4A is insufficient to forecast the long-term impact of the 'Kia Boys' vulnerability. Assuming Los Angeles car thieves are now fully aware of the vulnerability, we turn to historical analogs to forecast long-term trends. Figs. 4B and C show temporal trends in thefts of Honda Civics and Toyota Camrys, respectively. These well-known mid-sized

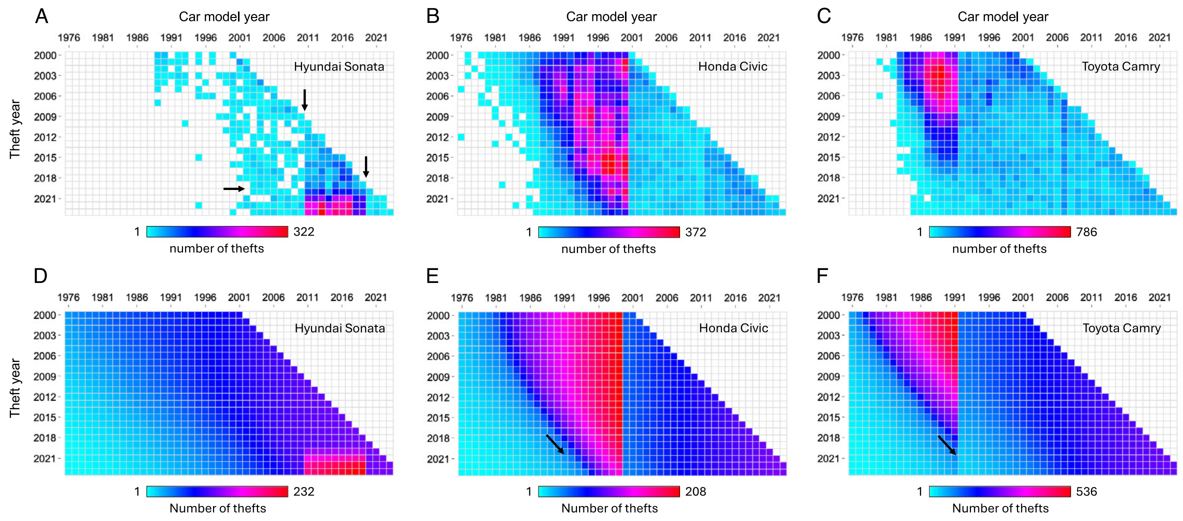

Fig. 4. Empirical and model-based matrix-frequency plots for cars stolen by model year and year of theft. (A–C) Thefts recorded by the LAPD between 2000 and 2023. (D–F) Model-based estimates of thefts. (A and D) Hyundai Sonata. (B and E) Honda Civic. (C and F) Toyota Camry. Vertical arrows in A mark the beginning and end of the window of vulnerable Hyundai Sonata model years, 2011–2020. Diagonal arrows in E and F indicate the direction of compression of the distribution due to vehicle scrapping.

sedans consistently ranked among the most frequently stolen vehicles in Los Angeles over the past 23 years, until Hyundai Sonatas surged to the top-ranked position (see Table 2). Both vehicles were known to be easy to steal with as little as a flat-head screwdriver (Light et al., 1993). This vulnerability changed only after the manufacturers adopted chip-based ignition systems in 2001 and 1992, respectively. Pre-immobilizer Honda Civics provide a comparative benchmark for what vulnerable Hyundai Sonata thefts might look like 23 years after the 'Kia Boys' vulnerability was eliminated by the manufacturer, while pre-immobilizer Toyota Camrys provide a comparative benchmark after 32 years.

The security updates to Honda Civics and Toyota Camrys dramatically reduced the risk of theft for later model-years of each car type (Brown, 2004; Farrell, 2025). Vulnerable model-years without the update remained preferred targets for car thieves long after those cars were first sold, a pattern previously recognized by Brown and Thomas (2003) following the introduction of immobilizers in the U.K. For Honda Civics, this is seen in the sharp vertical discontinuity in the numbers of thefts of 2000 model-year Honda Civics, the last vulnerable year, and the 2001 model-year with new security features (Fig. 4B) (Supplemental Movie S2). The vulnerable 2000 model-year Honda Civic averaged 187.9 (sd 67.6) more thefts per year than the adjacent 2001 model-year Civics with immobilizers (max +325 in 2016; min +104 in 2023) (Fig. 4B). A similar discontinuity is observed for Toyota Camrys (Fig. 4C, Supplemental Movie S3). Lacking immobilizers, 1991 model-year Camrys were stolen more than 1992 model-year Camrys with immobilizers every year between 2000 and 2018 (mean +202.6; sd 136.5; max +387 in 2005; min +19 in 2018). In 2019, five more 1992 Camrys were stolen than 1991 Camrys for the first time in 20 years of observation. However, by this point—27 years after the introduction of chip-based immobilizers—very few cars of either model-year were being stolen at all; in 2019 there were 11 of the 1991 model-year Camrys reported stolen in Los Angeles and 16 of the 1992 model-year, against a total of 17,434 vehicles of all types stolen that year (see Table 2). Using traffic accidents as a proxy for environmental abundance, it is clear that very few of either the 1991 or 1992 model-year cars remain on the streets in 2023 (Bento et al., 2018) (Supplemental Movies S2 and S3).

Figs. 4D-F show the results of fitting the preferred mechanistic model introduced above in Eqs. (1) and (4) (Appendix B). For the simpler case involving Honda Civics and Toyota Camrys, the model captures the sharp discontinuity observed with the introduction of immobilizers (Figs. 4E and F). It also captures the pressure of both market expansion and scrapping of older vehicles on theft patterns in any single year and over time. In the first row of Fig. 4E, for example, there is a gradual upward acceleration from very few thefts of older model-years (cyan) toward high numbers of thefts of younger model-years up to the discontinuity (red). The model predicts that older model-year cars are rarely stolen because fewer of those cars were sold new and because many of those sold initially were scrapped by the time of observation. Newer model-year cars are stolen more frequently under the same mechanisms. The aggregate effect over time is the gradual concentration of thefts among a dwindling population of vulnerable vehicles (arrows in Figs. 4E and F), bounded on the right by the introduction of immobilizers and squeezed from the left by the pressure of scrapping. Finally, the model captures the point at which a theft hotspot collapses, identified where thefts of the last vulnerable model-year are no longer more numerous than thefts of the next model-year in line. For Toyota Camrys, this is visible both in the empirical data and in the model fit around 2018–2019 (Figs. 4C and F). Supplemental Movies provide a dramatic illustration of

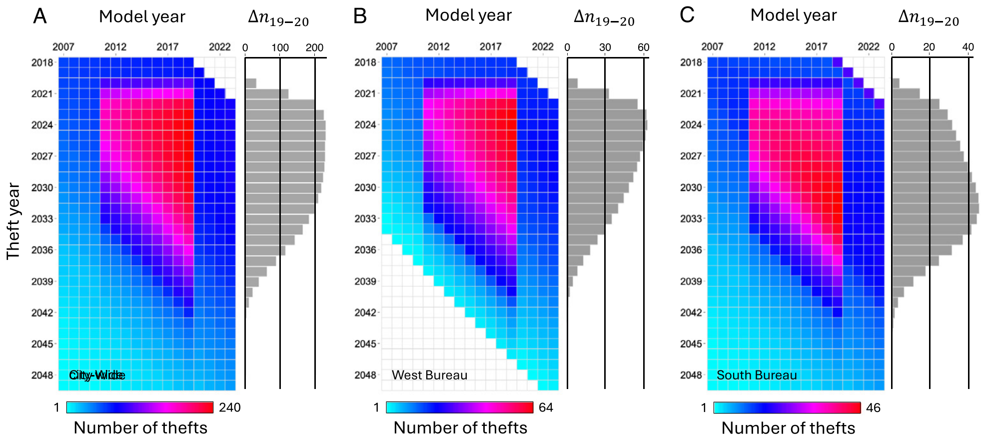

Fig. 5. Projected Hyundai Sonata thefts by model year from 2018 to 2049, and the difference in thefts Δn between the last vulnerable model year, 2019, and model year 2020, when chip-based ignition immobilizers were reintroduced. (A) Citywide forecast for all of Los Angeles. (B) Forecast for LAPD's West Bureau. (C) Forecast for LAPD's South Bureau.

the increasing compression of thefts around the youngest remaining vulnerable model-years (Movie S2) and the eventual collapse of thefts as those cars finally become unavailable in the environment (Movie S3).

The emerging dynamics for Hyundai Sonatas are conceptually similar to those for the Civic and Camry cases. The key difference is that the vulnerable cars are bounded both above and below by immobilizer technologies that were removed for a certain period of time. Aside from this difference, we expect the dynamics of market expansion and scrapping to be the same going forward as observed for Honda Civics and Toyota Camrys. In the model, we therefore observe a sharp concentration of thefts from 2011 to 2019, with a slight acceleration over this period due to both market growth and the scrapping of older cars (Fig. 4) (Supplemental Movie S1).

In Appendix D, we compare our baseline fitted models for Hyundai Sonata, Honda Civic, and Toyota Camry forecasts, determined by Eq. (4), with a naive k-step-ahead forecast using the mean absolute scaled error (MASE). For Hyundai Sonatas, the MASE score shows that the mechanistic approach performs similarly to the naive approach over a short time horizon (1 year), which is understandable since the mechanistic model is not designed to capture short-term fluctuations in the intensity of thefts. The Sonata model performs substantially better over longer time horizons (5–10 years). The naive approach also performs well in short-term forecasts of Civic and Camry thefts, with the mechanistic model again performing better over long time horizons (5–10 years).

4.3. Forecasting future impact

We use a combination of empirical comparisons and model projections to forecast the long-term impact of the 'Kia Boys' vulnerability in Los Angeles. The empirical observations are straightforward and can be gleaned from Fig. 4. Specifically, the concentration of thefts on vulnerable pre-2001 model-year Honda Civics had not dissipated by 2023, 23 years after chip-based immobilizers were introduced. In 2023, model-year 2000 Honda Civics were still being stolen at significantly higher rates than model-year 2001 Civics. For Toyota Camrys, by 2023 sufficient time had passed to observe the full impact of chip-based immobilizers. The concentration of thefts on vulnerable pre-1992 Camrys was visible through at least 2018. In other words, model-year 1991 Toyota Camrys were still being stolen at higher rates than model-year 1992 Camrys in 2018, a full 27 years after the introduction of chip-based immobilizers.

Fig. 5A presents model-based forecasts of citywide Hyundai Sonata thefts by model year from 2018 through 2050. The forecast suggests that thefts peaked in 2024, with a projected 1783 total thefts of the vulnerable Sonata model years (2011–2019) that year. We expect 235 more thefts of model-year 2019 cars than of model-year 2020 cars in both 2024 and 2025. In 2032, thefts of the vulnerable cars citywide will fall below 1000 units per year for the first time ($n = 965$, 203 more 2019 model-year thefts than 2020 model-year) and below 100 units only in 2039 ($n = 82$, 41 more 2019 model-year Sonata thefts than 2020 model-year). Projected thefts of the vulnerable model years will finally fall below ten units citywide in 2042 ($n = 7$, five more thefts of 2019 model-year cars than 2020 model-year cars), 23 years after the vulnerability was first learned by Los Angeles car thieves in 2020. Overall, the model projects 15,970 thefts of vulnerable model-year Hyundai Sonatas between 2024 and 2042.

In Appendix E, we extend the model to include the impact of manufacturer recalls to fix the security vulnerability (Compton, 2025; Highway Loss Data Institute, 2024; Kia Hyundai Vehicle Theft Litigation, 2023a). Evidence suggests that recall completion rates decline as a function of vehicle age relative to the recall date (NHTSA, 2021). We therefore expect that recalls issued by Hyundai and Kia in response to the 2022 class-action lawsuit to address the security vulnerability will have much higher completion rates among 2019 model-year Hyundai Sonatas (four

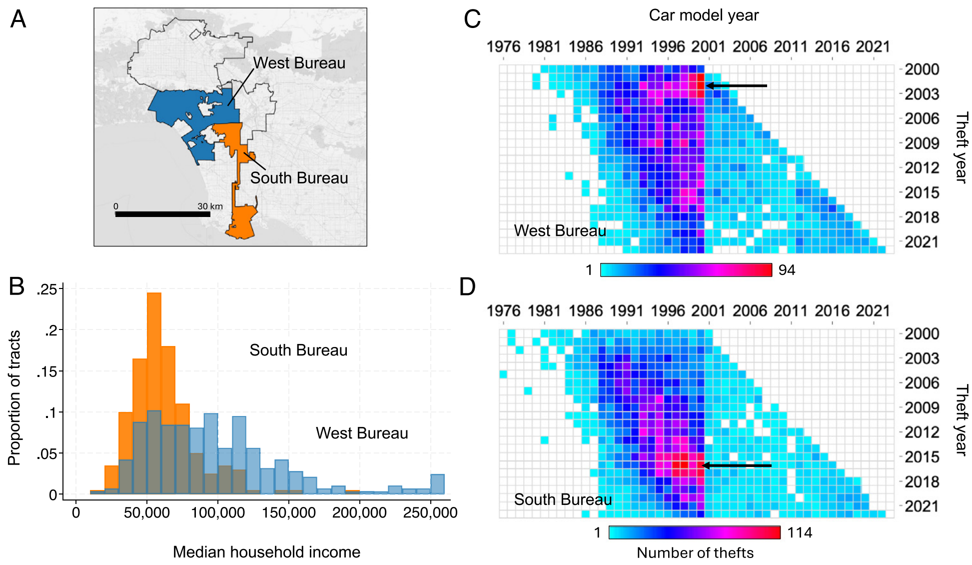

Fig. 6. Median income distributions and Honda Civic theft patterns in LAPD West and South Bureaus. (A) Location of LAPD's West and South Bureaus. (B) Median household income distribution in the West and South Bureaus by Census tract in 2023. (C) Number of Honda Civic thefts by model year in the West Bureau from 2000–2023. (D) Number of Honda Civic thefts by model year in the South Bureau from 2000–2023.

years old in 2024) than among 2011 model-year Sonatas (12 years old in 2024). For a recall that takes full effect in 2024, we expect thefts of vulnerable model-year Sonatas to have peaked in 2023. In 2024, the model suggests that theft volumes of Sonatas might be 40.7% lower than if no recall were issued (Appendix E, Fig. 10B). However, the projected impact of recalls is attenuated over time. With a 2024 recall, thefts of vulnerable model-year Sonatas are expected to fall below 1000 units for the first time in 2026 ($n = 997$, 91 more 2019 model-year thefts than 2020 model-year), six years earlier than without a recall. Thefts of vulnerable Sonatas are expected to fall below 100 units in 2038 ($n = 66$, 24 more 2019 model-year thefts than 2020 model-year thefts), and below 10 units in 2041 ($n = 8$, four more 2019 model-year thefts than 2020 model-year), in both cases just one year earlier than without a recall. The overall number of thefts with a 2024 recall is projected to be about 44% lower ($n = 8955$) between 2024 and 2042. Appendix E also presents alternative scenarios in which the recalls are issued in 2025 or 2026, more consistent with the multi-state settlement agreed upon in 2025. Delaying recalls increases the expected total number of thefts over time while also prolonging the period of excess thefts, keeping conditions closer to those expected without a recall.

4.4. Impact on communities

Our forecasting model suggests that the 'Kia Boys' vulnerability will continue to affect Los Angeles car thefts through at least 2042. However, examination of spatial trends in Honda Civic thefts from 2000 to 2023 indicates that Los Angeles communities will be affected differently over that period. Fig. 6 disaggregates the matrix plot for Honda Civics shown in Fig. 4B by whether thefts occurred in the LAPD's West or South Bureau. Theft of vulnerable Honda Civics—particularly the 2000 and 1999 model-year cars—was concentrated in the West Bureau during 2001–2003 (Supplemental Movie S4). The hotspot then moved to the South Bureau during 2015–2018. The peak in Honda Civic thefts in the West Bureau targeted cars that were just one or two years old. By contrast, the peak in the South Bureau targeted cars that were already 15 years old. This evidence shows that car theft hotspots follow the life cycle of cars across both time and space. Specifically, new cars tend to be sold and driven in higher-income areas of a city. As cars age, they are resold multiple times and, through that market process, migrate to lower-income areas of a city. In 2022, the West Bureau had a median household income of $88,471. The median household income in the South Bureau was a third lower, at $57,276. Thus, the impact of thefts of vulnerable model-year Honda Civics migrated over time from higher- to lower-income areas of the city and continues to linger in those low-income areas of Los Angeles. Hodgkinson et al. (2016) observed a similar geographic shift in car theft hotspots from higher- to lower-income areas in Vancouver, British Columbia, between 2003 and 2013. Supplemental Movie S4 provides a vivid illustration of the shift in thefts from the West to the South Bureau beginning in 2013.

Figs. 5B and C disaggregate the citywide forecast of Hyundai Sonata thefts into expected patterns for LAPD's West and South Bureaus, respectively. In West Bureau, the model projects that thefts of all vulnerable model-year Sonatas peaked in 2023 at 445 total thefts. The model projects a peak difference of 63 more 2019 model-year cars stolen than 2020 model-year cars in 2024 (Fig. 5B). Thefts will fall below 100 units in West Bureau for the first time in 2034 ($n = 99.5$, 30 more 2019 model-year

Sonata thefts than 2020 model-year) and below 10 units in 2039 ($n = 9$, five more 2019 model-year Sonata thefts than 2020 model-year). The hotspot is expected to fully dissipate in West Bureau by 2042. In total, the model projects 3213 thefts of vulnerable model-year Hyundai Sonatas in West Bureau between 2024 and 2042.

In South Bureau, by contrast, thefts of vulnerable Sonatas are expected to peak in 2027 at 330 vehicles (Fig. 5C). The peak difference in thefts between model-year 2019 and 2020 cars is not expected to occur until 5 to 6 years after the peak in total thefts. The model projects 46 additional thefts of the last vulnerable model-year in 2032. Total thefts are expected to fall below 100 units for the first time in 2036 ($n = 93$, 31 more 2019 model-year Sonata thefts than 2020 model-year) and below 10 units in 2041 ($n = 5$, three more 2019 model-year Sonata thefts than 2020 model-year). The hotspot in South Bureau is expected to dissipate by 2043. In total, the model projects 3459 thefts of vulnerable model-year Hyundai Sonatas in South Bureau between 2024 and 2042. Overall, approximately 246 more vulnerable model-year Sonatas are expected to be stolen in LAPD's South Bureau than in West Bureau over the long run.

5. Discussion

Our findings suggest that the narrative surrounding the emergence of the 'Kia Boys' vulnerability and its impact on thefts of many Hyundai and Kia car models is more complex than widely portrayed. The story popularized by mainstream and social media during the summer of 2022 framed the problem as a viral online threat spilling over into offline settings. The implication is that, absent the online environment, the threat would not exist, or at least would not exist at the scale observed. This is an important counterfactual question central to understanding a wide range of offline harms (Hartanto et al., 2021; Williams et al., 2023).

While it appears that the 'Kia Boys' vulnerability was not widely known among car thieves in some cities prior to widespread media reporting in 2022, in other cities the vulnerability appears to have been discovered years before the viral spread of the 'Kia Boys' meme, without an obvious contribution from social media. In Los Angeles, the main focus of the present work, the discovery likely occurred in mid-2020 through trial-and-error exploration by car thieves and then spread by word-of-mouth over the course of the next two years. We suspect, but cannot prove, that the social disruption caused by COVID-19 lockdowns facilitated the discovery of the vulnerability. Thus, the aggregate pattern across the U.S. mixes situations where social media may have played a decisive role with others where it likely did not. It is possible that the vulnerability was discovered even earlier in some places, given that immobilizers were absent beginning with the 2011 model year for some Hyundai and Kia models. Close inspection of the car theft data for other cities not discussed here may reveal these very early discoveries. Whatever role social media played in spreading knowledge of the vulnerability more recently, that role has likely ended. The 'Kia Boys' vulnerability is now 'baked in' to offline theft dynamics.

Our models forecasting the long-term impact of the 'Kia Boys' vulnerability suggest that we will still be dealing with the consequences for years to come. In the baseline case, thefts of vulnerable Hyundai Sonatas are expected to have peaked in 2024 but will remain elevated relative to non-vulnerable model-years through 2042. After 2042, the volume of thefts of the vulnerable model-years will be similar to that of non-vulnerable model-years. Similar forecasts apply to vulnerable Kia Optimas, suggesting that the models are useful in describing risks across the full class of vulnerable vehicles (see Appendix C). Importantly, recalls issued by the manufacturers to address the 'Kia Boys' vulnerability may substantially reduce the total number of thefts over the long term. However, these recalls are not expected to substantially shorten the tail of elevated thefts. For example, uptake of security fixes at the rate seen historically for other recalls is expected to shorten the period of elevated thefts for Hyundai Sonatas by just one year, with thefts falling below 10 units in 2041 rather than 2042.

Our analysis also suggests that the impact of the 'Kia Boys' vulnerability will vary across communities in Los Angeles. Higher-income areas are expected to move past the spike in thefts as vulnerable model years are replaced by new cars that lack the vulnerability. By contrast, lower-income areas may continue to see higher thefts for a longer period, as used cars with the vulnerability are sold into these communities.

The present study has several policy implications. First, the results add to the overwhelming evidence that chip-based engine immobilizers are an extremely effective car anti-theft technology (Brown, 2015; Clarke & Harris, 1992; Farrell, 2025). While there is reason to worry that today's thieves will gain ready access to sophisticated tools to defeat the high-tech security of modern cars (Jacobson, 2023; Vardy, 2025), the 'Kia Boys' example suggests that most car theft remains an opportunistic and low-skilled endeavor. Engine immobilizers present enough of a challenge for most thieves that they successfully deter (or at least thwart) most thefts. Yet U.S. law still does not require immobilizers as standard equipment on new cars. It is possible that large tort settlements, such as those arising over the 'Kia Boys' vulnerability, may create incentives for other manufacturers to make immobilizers standard equipment voluntarily. However, it is disputed whether class action lawsuits stimulate voluntary corrective action by an industry at large (see Fitzpatrick, 2017). It is more likely that such suits generate public awareness that can indirectly spur new government regulation. The present example suggests that updating the U.S. Motor Vehicle Theft Law Enforcement Act and the Anti-Car Theft Act to require immobilizers as standard equipment would be a reasonable precaution against future emergent theft spikes like the 'Kia Boys' case.

Second, even with engine immobilizers now standard on all new cars, thefts of vulnerable older cars may remain a challenge for years. The example of pre-1992 Toyota

Camrys suggests that vulnerable cars can remain preferred targets for nearly three decades after they first hit the market. Related model forecasts for Hyundai Sonatas suggest elevated thefts through 2042. Security recalls may shorten the period of risk but not eliminate it. Following examples aimed at eliminating high-emission older vehicles to improve quality (Rodrigues, 2025), city- or state-level policies could offer incentives for scrapping older vulnerable vehicles. However, since the cost of theft is borne primarily by individuals and their insurers, it seems more plausible that the scrapping rate might rise naturally as the cost of insuring vulnerable cars increases (Bennett & Wong, 2023).

Finally, crime prevention efforts need to account for potential geographic shifts in demand over time. The research presented here suggests that car theft hotspots migrate from higher- to lower-income areas of a city (see Hodgkinson et al., 2016) as a byproduct of vehicles following a natural life cycle from new purchase to used car and eventually to scrap. In Los Angeles, the balance of Hyundai Sonata thefts is expected to shift from West to South Bureau in 2028 and reach a peak difference in South Bureau around 2032. Policy makers thus have time to prepare for crime prevention and enforcement demands as they shift to South Bureau. The response could be as straightforward as engaging local communities to make car owners aware of the risks so they can take appropriate action (Wortley & Denning, 1998). This might be particularly important as media coverage of the 'Kia Boys' vulnerability fades.

There are several limitations to this study that are worth noting. We have tried to account for the possibility that car owners will take advantage of security fixes offered by Hyundai and Kia. The class action lawsuit against Hyundai and Kia, settled in 2022, mandates free software updates that rectify the vulnerability whenever authorized dealers come into contact with an eligible car (Kia Hyundai Vehicle Theft Litigation, 2023a). The multi-settlement announced in December 2025 mandates the replacement of ignition cylinders in affected vehicles. We extended the baseline model to include recall completion rates based on data model-year age for a wide range of manufacturer recalls (Malec et al., 2021; NHTSA, 2021). This model shows that, if recalls are eventually completed at the historical rate, the total number of thefts could be cut nearly in half, but the time horizon for elevated thefts of vulnerable cars remains roughly the same as without a recall. However, the completion rate for the 'Kia Boys' vulnerability may be higher than for other types of manufacturer recalls. Model forecasts will need to be adjusted as more information becomes available.

We have not controlled for macroscopic trends in car theft rates unrelated to specific vulnerabilities in our forecasts. Long-term theft rates are affected by several factors, including changes in offender populations and the role that cars play in routine, day-to-day activities (Copes, 1999; Mohler et al., 2020; Rosenfeld, 2024). The forecasts presented here are therefore subject to change given shifts in these macroscopic conditions. However, because our forecasts concern thefts only of the vulnerable Hyundai Sonata model-years produced between 2011 and 2019, the environmental abundance and vulnerabilities of more recent model-years (including those yet to be produced) are irrelevant. Nevertheless, future mechanistic models might seek to include demographic and routine activity features to better anticipate general changes in crime environments (Rosenfeld, 2024).

CRediT authorship contribution statement

P. Jeffrey Brantingham: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Craig D. Uchida:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Fred Morstatter:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **George Mohler:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization.

Data and code availability

Aggregated data by car model-year and theft year, along with Mathematica, R and STAN code, are deposited on GitHub (https://github.com/ucmasc/KiaBoys_LosAngeles/blob/main/README.md). Minor differences in numerical results may arise across different operating systems due to parallelisation and numerical precision. All other data and additional analyses are included in the manuscript and/or the SI Appendix.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: P. Jeffrey Brantingham reports financial support was provided by Air Force Office of Scientific Research. Craig D. Uchida reports financial support was provided by California Board of State and Community Corrections. Fred Morstatter reports financial support was provided by Air Force Office of Scientific Research. George Mohler reports financial support was provided by Air Force Office of Scientific Research. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Traffic collisions as a proxy for abundance

The environmental abundance of specific car make-model-years plays an important role in long-term theft dynamics. Here we suggest that traffic accidents provide a suitable proxy for the relative availability of different car make-model-years in the environment. Specifically, the number of traffic accidents reported to the police by car make-model-year is a function of the number of such cars present in the environment, their road activity, and the reporting behavior of parties involved in the accident. We assume that factors such as driver skill are randomly distributed within make-model-years. The number of cars in operation is determined by the number joining the fleet through sales of new cars and the number leaving through scrapping, with the impact of scrapping compounding as cars age (Bento et al., 2018). The road activity of a car is also a function of car age, with newer cars systematically accumulating more miles than older cars (Cooper et al., 2010; Dutt et al., 1977). Finally, we expect that the willingness to report a traffic accident to the police skews toward newer model-years, consistent with the observation that the costs of calling the police are weighed against the cost of the crime or accident (Bowles et al., 2009; Brantingham et al., 2025). We expect vehicles to be stolen in proportion to their availability, conditional on any unique vulnerabilities that might make some make-model-years more at risk than others.

Supplemental Movies S1, S2, and S3 show the number of reported thefts and accidents (y-axis) by make-model-year (x-axis) for Hyundai Sonatas, Honda Civics, and Toyota Camrys, respectively. Thefts of and accidents involving Hyundai Sonatas in Los Angeles were extremely rare until the 2011 model year, when accidents began to rise (Movie S1). This rise may reflect an increase in the number of Hyundai Sonatas sold new, as indicated by national sales figures (see Fig. 7). Thefts of Hyundai Sonatas remain subdued until 2020, when the shape of the distribution first resembles the distribution of accidents. Thefts dramatically exceed accidents in each year from 2021 to 2023, suggesting a substantial shift in thieves' targeting of a largely stable abundance of vehicles in the environment. The concentration of thefts in 2020–2023 is clearly restricted to the vulnerable 2011–2019 model years.

Honda Civics provide a clear demonstration of the impact of both the introduction of immobilizers and the scrapping of older cars (Supplemental Movie S2). At the outset of the observational time window in 2000, the accident and theft distributions are similarly shaped, with a sharp leading edge at the concurrent model-year, which includes a handful of 2001 cars introduced at the end of 2000. The theft and accident distributions both have tails that decay toward older model-year cars. We conclude that the distribution of thefts largely follows the same abundance constraints as accidents. Beginning with the 2001 observation year, we see a divergence between the accident and theft distributions. The leading edge of the accident distribution continues to move forward in time, retaining a characteristic skewed shape, while the theft distribution develops a sharp boundary that is stationary at model-year 2000. By 2016, 53.7% of the mass of the accident distribution was concentrated among post-2000 model-years, while 98.2% of the theft distribution was concentrated among pre-2001 model-years lacking an immobilizer. A small leading edge of thefts among post-2000 model-year Civics moves forward in time, reflecting the limited number of thefts of post-2000 Civics, which are much harder to steal. The theft distribution begins to dissipate after 2017 as model-year 2000 and earlier Honda

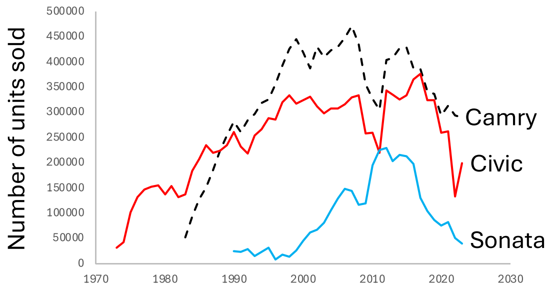

Fig. 7. Number of car units sold in the United States per year since entry into the market for Hyundai Sonatas, Honda Civics and Toyota Camrys. Data compiled from marketing materials published by each manufacturer.

Civics become harder to find, a situation documented by the substantial reduction in accidents involving these early model-year cars (Movie S2).

The animation for Toyota Camrys provides a guide to what may lie in store for Honda Civics and Hyundai Sonatas (Movie S3). Toyota introduced engine immobilizers for the Camry in 1992, so this theft-prevention device had already been in place for nine years by the first year of observational data in 2000. By 2000, the accident distribution had already diverged substantially from the theft distribution, and thefts were strongly concentrated among the youngest of the vulnerable model-years (i.e., model-years 1988–1991). The concentration among vulnerable model-years peaked in 2003—11 years after the introduction of immobilizers. Thefts then began to collapse, so the special status of the pre-1992 Toyota Camry among Los Angeles car thieves is largely gone by 2018. The distribution of accidents suggests that the lack of availability of cars was a primary driver of the reduction in thefts of vulnerable Camrys.

Appendix B. Alternative model forms

We compare alternative specifications for the sales trend function h_m included as a term in Eq. (1). We compare power $h_m = (t_m - 1975)^d$, exponential $h_m = \exp(d(t_m - 1975))$, constant $h_m = 1$, and Gaussian $h_m = \exp(-(s_m - \mu)^2/(2\sigma^2))$ functions, where t_m is the year for each model-year and h_m is the expected number of cars of that model-year sold. The Gaussian function uses observed sales data s_m in place of model-year t_m (Fig. 7).

Table 3 presents the relative performance of alternative specifications of h_m when fitting Equations (1) and (4) to Hyundai Sonata theft data. The Gaussian function yields the best relative fit among the abstract functional forms considered for the Sonata theft data. The power model ranks second. Nevertheless, we favor the power model for three reasons. First, the model comparison statistics suggest that the power model is a good generic choice when car sales data are unavailable. In practice, car sales data are difficult to obtain at the local level. Second, Fig. 4 shows that the stylized power model fits the historical data well. In fitting the main model, we suspect that the effects of scrapping, captured by the function g_m, largely

Table 3
Model comparison for different specifications of h_m fit to Sonata data.

Model	Log likelihood	# Parameters	AIC
power	22 076.74	8	−44137.48
exp	22 030.40	8	−44044.80
constant	21 954.69	7	−43895.38
sales	22 215.63	9	−44 413.25

override subtle differences across alternative forms of h_m. Finally, since future sales are unknown, the stylized power model is a reasonable representation of how companies expect market share to grow over time, facilitating projection of the model through 2050.

Appendix C. Replicating results with the Kia Optima

In the main text, we focus on Hyundai Sonatas because they were the most frequently targeted vehicle among the vulnerable Hyundai and Kia models listed in Table 1. Here, we show that our results generalize to other make-models in the class.

Like the Hyundai Sonata, the Kia Optima surged in popularity among Los Angeles car thieves beginning in 2020. The Kia Optima jumped to the 13th most frequently stolen car that year and then rose to the number five and number three positions in 2021 and 2022, respectively. It occupied the number two position in 2023, immediately behind Hyundai Sonatas. It was not in the top 100 most stolen cars (rank 101) as recently as 2013. Fig. 8A shows that the increase in thefts followed a trajectory similar to that of Hyundai Sonatas, rising from a stable mean number of thefts per week (2.1) prior to June 2020 to a new weekly mean (26.4) after June 2022. The rise in thefts predates the emergence of the ‘Kia Boys’ meme. Fig. 8B shows that the theft hotspot is concentrated among the vulnerable model-years 2011–2020, falling sharply with the 2021 model-year, when fixes were introduced by Kia.

Fig. 9 shows the expected number of Kia Optima thefts through 2049 under the baseline model introduced in the main text. Theft of the vulnerable model-year cars is expected to have peaked in 2023 ($n = 1495$). Theft is expected to fall below 1000 units for the first time in 2029 ($n = 894$, 181 more 2020 model-year than 2021 model-year cars), below 100 units for the first time in 2036 ($n = 75$, 39 more 2020 model-year than 2021 model-year cars), and below 10 units in 2039 ($n = 4$, three more 2020 model-year than 2021 model-year cars). The Kia Optima hotspot is expected to dissipate in 2041, one year earlier than the Hyundai Sonata hotspot under the baseline model.

Appendix D. Mean absolute scaled error

Here, we compare mechanistic forecasts based on Eq. (4) in the main text with naive k-step-ahead forecasts using the Mean Absolute Scaled Error (MASE) (Hyndman & Koehler, 2006). Let $e_t^m = y_t^m - \hat{y}_t^m$ denote the model forecast error in year t for model-year m; let y_t^m denote the observed number of thefts in year t for model-year m; and

$$q_t = \frac{e_t^m}{\frac{1}{n-k}\sum_{i=k+1}^{n} |y_i^m - y_{i-k}^m|},$$

then the MASE is computed as mean($|q_t|$).

Table 4
MASE values for Sonata, Civic, Camry, and Optima forecasts and different year lags for the naive k-step ahead method.

Lag k	Sonata	Civic	Camry	Optima
1	1.03	2.22	1.97	1.67
2	0.64	1.59	1.18	1.21
3	0.51	1.26	0.83	0.96
4	0.48	1.09	0.63	0.93
5	0.47	0.94	0.49	0.91
6	0.46	0.84	0.39	0.89
7	0.45	0.79	0.32	0.86
8	0.44	0.73	0.27	0.84
9	0.43	0.72	0.24	0.83
10	0.42	0.67	0.21	0.82

Table 4 displays the MASE values for Sonata, Civic, Camry, and Optima forecasts (see Fig. 4). For Sonata, the model performs similarly to the naive method for short-term (1-year-ahead) forecasts. This is expected because our mechanistic approach is not designed to capture short-term trends in the data. Our mechanistic Sonata model performs significantly better than the naive approach for longer-term forecasts. For Civic, Camry, and Optima forecasts, the 1-step and 2-step-ahead forecasts are better able to capture short-term spikes in thefts. However, the mechanistic model outperforms the naive k-step-ahead forecast for longer-term (5-10-year) horizons.

Appendix E. Forecasting the impact of a recall

We consider an alternative model for Sonata thefts that accounts for a recall to fix the vulnerability. For this purpose, we use the recall completion rate model detailed in Fig. 10 of the National Highway Traffic Safety Administration (NHTSA) 2021 report to Congress on vehicle safety recall completion rates (NHTSA, 2021). The completion rate is modeled as a logistic function of the vehicle's age at the time of the recall (i.e., older cars are less likely to be brought to a dealer for the work to be done). The completion rate $w_r^m(t)$ in year t for model-year m and recall year t_r for Hyundais is given in Eq. (8), with parameters $C_1 = 100.511$, $r_1 = -0.223$, $x_1 = 7.968$, and $C_0 = -0.266$. We plot the completion rate in Fig. 10A.

$$w_r^m(t) = C_0 + (C_1 - C_0)\sigma(r_1(t_r - t_m - x_1)) \tag{8}$$

$$f_m(t) = f_0 + \tag{9}$$

$$f_1\chi\{t_m \geq s_1\}\chi\{t_m \leq s_2\}\chi\{t \geq u\} \tag{10}$$

$$\cdot\sigma(r_0(t - u - x_0)) \cdot w_r^m(t) \tag{11}$$

We assume that the vulnerability is either fixed in the same year as the recall announcement or not fixed at all. The intensity of Sonata thefts for model year t_m in theft year t for a recall in year t_r is then reduced by $w_r^m(t)$ (Eq. (11)).

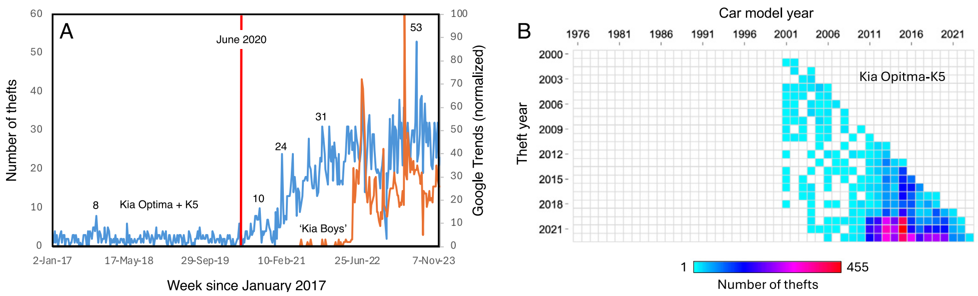

Fig. 8. Trends in thefts of Kia Optima. (A) Thefts of Kia Optima per week during 2017–2023, plotted alongside Google Trends data for the search term 'Kia Boys'. Compare with Fig. 1A in the main text. (B) Thefts of Kia Optima by model year recorded by the LAPD. Note: The Kia Optima was rebranded as the Kia K5 in 2021. Theft counts in A and B combine the Optima and K5 for 2021–2023.

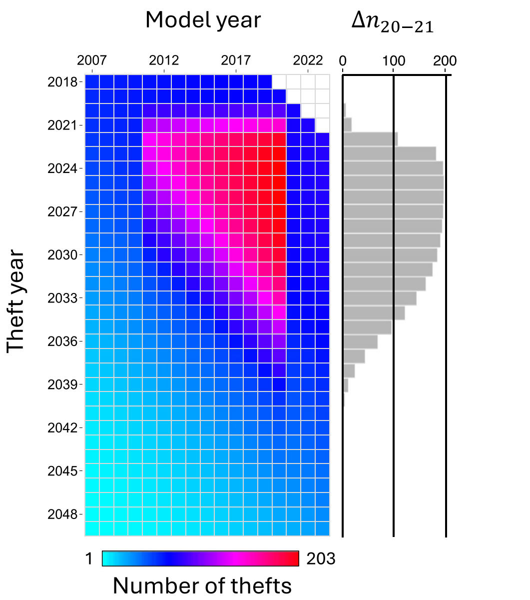

Fig. 9. Matrix plot of the number of Kia Optima thefts by model year and year of theft. Theft counts combine the Optima and K5 for 2021–2023.

In Fig. 10B, we plot the total forecasted Sonata thefts per year and compare scenarios in which the recall is issued in 2024, 2025, or 2026. For the 2024 recall, we project that Sonata thefts would be cut in half overall but would remain statistically elevated through 2041, only one year shorter than without a recall. Further outcomes of the recall model are described in the main text.

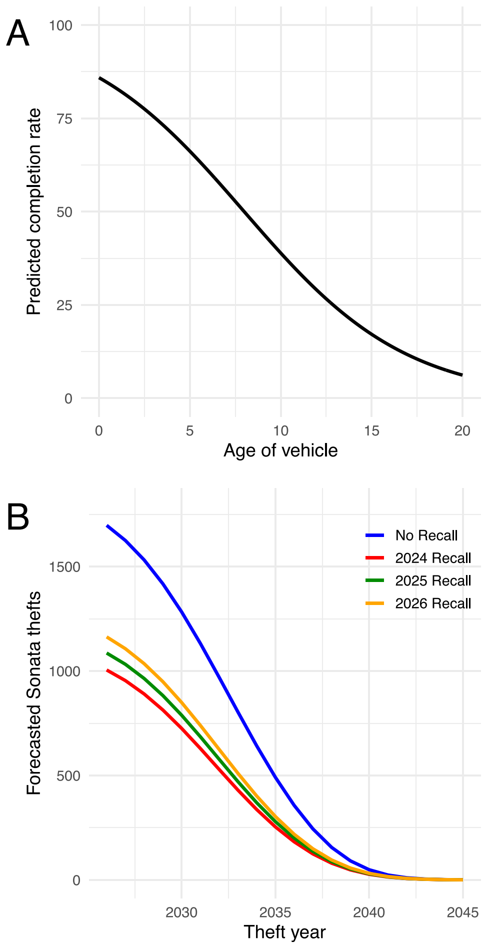

Fig. 10. Recall completion rates and their impact on thefts. (A) The recall completion rate for all Hyundai make-models as a function of vehicle age at the time of the recall. (B) Total forecasted Hyundai Sonata thefts per year for security recalls issued in different years.

Appendix F. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.ijforecast.2026.07.006.

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