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Motor Vehicle Recovery: A Multilevel Event History Analysis of NIBRS Data

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Abstract

Despite its importance for victims, and society as a whole, motor vehicle theft (MVT) recovery is rarely studied. The current research note draws on rational choice and opportunity-based perspectives, and police agency technology use, to develop and test a multilevel event history (survival) analysis model for MVT recovery. Contrary to the hypothesis that more expensive vehicles have a lower chance of recovery due to their attractiveness for permanent retention, the analysis found that recovery was least likely for incidents in which the stolen car had little value (less than $1,000), with no significant differences among the categories of $1,000 or greater. Measures of local opportunity for permanent retention MVT did not have statistically significant effects on recovery, but closer proximity to a major port or US-Mexico border crossing was associated with lower odds of recovery. Furthermore, police agency use of a stolen vehicle tracking system increased odds of recovery.

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Introduction

Failure to recover stolen motor vehicles has serious negative consequences. In 2008, motor vehicle theft (MVT) in the United States involved a total direct value of more than $6.4 billion, for an average of $6,751 per vehicle. This average is much higher than for other serious property crimes like burglary (Federal Bureau of Investigation 2009). Financial compensation from insurance is usually not enough to fully replace a lost vehicle (Walsh 2009), and victims may be subjected to other costs as well (Barnett 2005). Recovery of stolen vehicles is the main way to "lessen the economic impact of auto theft," even if recovered vehicles may be damaged (Cherbonneau and Wright 2009:194). In addition to its impact on victims, lack of recovery has a variety of negative influences on society. To make up for costly payouts on non-recovered vehicles, insurance companies raise premiums and deductibles for all motorists (Walsh 2009). Because stolen vehicles are often used in illegal activity, slow recovery also contributes to other crimes in a community (Clarke and Harris 1992a; McCaghy, Giordano, and Henson 1977). Also, non-recovery of expensive property like motor vehicles is likely to decrease public trust in the efficacy of law enforcement agencies.[1]

Although MVT has a higher recovery rate than other property offenses (Cherbonneau and Wright 2009), estimates from 2008 UCR data indicated a motor vehicle recovery rate of only 61 percent (581,806 recoveries for 955,756 stolen vehicles).[2] Given the negative consequences of non-recovery and long intervals to recovery, it is crucial that systematic research on MVT recovery provide better understanding of the factors that influence timely recovery.

MVT *occurrence* is an active research area (e.g., Clarke and Harris 1992a; Copes and Cherbonneau 2006; Rice and Smith 2002; Walsh and Taylor 2007a, 2007b; see Cherbonneau and Wright 2009 for a complete review). However, multivariate studies focusing on MVT *recovery* across many jurisdictions are rare; existing work is mainly descriptive (e.g., Barnett 2005; Clarke and Brown 2003; Clarke and Harris 1992a, 1992b; Miller 1987) or restricted to a limited set of independent variables (Field, Clarke, and Harris 1991; Nunn 1993, 1994). Also, Tremblay, Yvan, and Cusson (1994) examined time trends in recovery and non-recovery rates per 10,000 registered vehicles in Quebec. The current research note draws on rational choice and opportunity-based perspectives, and police agency technology use, to develop and test a model for MVT recovery in a multilevel event history (survival) analysis of linked data from 2003 National Incident-Based Reporting System (NIBRS), the 2003 Law Enforcement Management and Administrative Statistics (LEMAS), and the 2000 Census.

Offender's Goal, Opportunity Structure, and MVT Recovery

Rational choice perspectives focus on how offenders make crime choices based on particular motives or goals within a specific setting (Felson and Clarke 1998). From the rational choice perspective, MVT incidents can be classified based on the offender's goal. Some thefts are for temporary use (joy-riding or short-term transportation). Others are committed for permanent retention purposes, including resale, export, or dismantling for spare parts (Clarke and Harris 1992a; Felson and Clarke 1998).[3] It follows that recovery of a stolen vehicle depends heavily on the car thief's goal, as recovery will be difficult when a car was stolen for permanent retention. Some stolen cars are given a new and seemingly legitimate identity through counterfeiting techniques including "body switching" transfer (using a wrecked vehicle's VIN for a similar stolen vehicle) before sale in the black market (Tremblay, Talon, and Hurley 2001). Others might be dismantled in "chop shops" and sold for major parts (Tremblay et al. 1994). On the other hand, vehicles stolen for temporary use are more likely to be abandoned quickly and recovered (perhaps with damage).

Offenders' goals are shaped by macro-level opportunity structure (Felson and Clarke 1998). A thriving local fencing market promotes MVT for resale and dismantlement. According to Tremblay et al. (1994, 2001), poor economic conditions that make consumers, especially the economically disadvantaged, more willing to buy stolen vehicles and parts may encourage local fencing markets. By increasing MVT for permanent retention purposes, a strong fencing market reduces recovery. In addition to local opportunities, the foreign black market provides opportunity for permanent retention MVT (Tremblay et al. 2001). Cars stolen in the United States constitute a substantial proportion of those sold or traded in global black markets (Miller 1987). Stolen cars can be driven across international borders, transported in ferries, or shipped out of ports in sealed containers (Clarke and Brown 2003; Miller 1987; Resendiz 1998). Cars stolen for illegal export have lower chances of recovery; one obvious reason is the difficulty that local police have in investigating an MVT case once the stolen car leaves the country.

Also, police in countries receiving illegal exports usually face high rates of more serious crimes and cannot allocate resources to MVT recovery (Clarke and Brown 2003). Miller (1987) went further, suspecting that some Mexican law enforcement officers and government officials are permissively and actively involved in the illegal import of stolen American vehicles. Miller found that Texas border cities had lower recovery rates than did cities in the state's interior, and Field et al. (1991) found that the recovery rate for models sold in Mexico is lower in border states than in the rest of United States.

Police Agency Technology and MVT Recovery

Police agency initiatives also should influence MVT recovery outcomes. MVT's frequency and low priority (compared to serious violent crimes) may lead police to allocate limited personnel time to its investigation (Ratcliffe 2009). This makes technological assistance especially important; relevant initiatives include stolen vehicle tracking systems, in-field computers with accessibility to vehicle records, and computerized crime mapping. LOJACK is the stolen vehicle tracking system most widely operated by American police departments (Terp 2009). When a LOJACK-equipped vehicle is reported stolen to police, the vehicle's wireless receiver is activated and sends a radio frequency signal that allows tracking and recovery by LOJACK-trained officers (Ayres and Levitt 1998; Clarke and Harris 1992a; Terp 2009). LOJACK claims a 90 percent recovery rate, with recovery typically within a few hours (www.lojack.com). LOJACK also could lead to chop shop operations and discovery of multiple stolen vehicles (Ayres and Levitt 1998).

Laptop computers or patrol car-installed computers with digital communication capability aid in MVT recovery. Such computers allow in-field officers to access central databases like the NCIC that indicate whether a car has been reported stolen. Compared to traditional voice dispatch systems, in-field computers allow such checks to be made on many more vehicles, increasing the probability of detection and recovery of stolen vehicles (Nunn 1993, 1994). Geographic information systems (GIS) for computerized crime mapping are useful for high volume offenses; for MVT recovery, GIS helps identify locations of popular cooling-off zones and dumping sites, including detailed reports disaggregated by type and value of stolen vehicle, modus operandi, and site of the theft (Ratcliffe 2009).

Because adoption of new technology can be costly, evaluation of its effectiveness is prudent. Nunn's (1993) interrupted time-series analysis of data over 10 years in Fort Worth, Texas examined the effect on MVT recovery of equipping patrol cars with computers with Mobile Digital Terminal (MDT) technology. While that research did not find clear evidence for improved recovery rates, in Nunn's (1994) later analysis of three Texas cities (Fort Worth, Dallas, and Austin), MDT technology was associated with higher recovery rates. One goal of the current research note is to evaluate the impact of such technology on stolen vehicle recovery in a multivariate context, using data from more jurisdictions and also considering other technologies such as stolen vehicle tracking systems and computerized crime mapping.

Stolen vehicles can be quickly driven far, so recovery of stolen cars may involve multiple jurisdictions (Krimmel and Mele 1998; Maxfield 2004). With half of the cars stolen in the United States never recovered, the exact proportion of stolen cars leaving their original jurisdiction is not known, but surely it is not trivial. For example, 1,382 of the 5,538 vehicles stolen from Newark, New Jersey in 2002 were found elsewhere, indicating that at least 25 percent of the vehicles stolen in Newark eventually traveled out of that jurisdiction (Maxfield 2004). For Arizona police agencies, this figure was 20 to 50 percent (Arizona Criminal Justice Commission 2004).[4] This aspect of MVT makes interagency cooperative efforts especially relevant to recovery. Krimmel and Mele (1998) described New Jersey agencies' use of a multijurisdictional approach that focused on vehicle dumping sites spread across the region. Plouffe and Sampson's (2004) work on Southern California concluded that regional responses involving several police agencies better address MVT than efforts focused on a single jurisdiction. Current Study

The current research note draws on previous literature to consider possible influences of measures reflecting offender's goal, opportunity structure, and police agency technology. Offender's goal involves incident-level influences on recovery, whereas opportunity structure and police agency technology are contextual-level influences. Hence, this research uses a multilevel approach to simultaneously investigate incident- and contextual-level influences on MVT recovery. Analysis was restricted to city jurisdictions, to ensure comparability of measured contextual characteristics. Along with this multilevel approach, the analysis also considers the relevance of time-to-recovery and -censoring via event history (survival) methods.

Data and Method

Data

NIBRS incident data record whether a stolen vehicle was recovered (during the reporting period of January 1, 2003 to December 31, 2004 for 2003 NIBRS incidents) and, if it was, the time between incident and recovery, providing time-to-recovery data needed for event history analysis. Following Barnett (2005), analysis was restricted to incidents involving a single stolen vehicle; almost all (98 percent) MVT incidents recorded in 2003 NIBRS involved only one vehicle. NIBRS data also provide a proxy for offender's goal and other incident-level variables that might influence recovery outcomes.[5]

Opportunity structure for permanent retention MVT was indicated by local fencing market activity and proximity to foreign outlets. City-level data from aggregated 2003 NIBRS provided a measure for local illegal market activity. A city-level measure of economic conditions that may encourage local fencing markets (Tremblay et al. 1994) was obtained from the 2000 Census. Proximity of the jurisdiction to potential foreign outlets was based on distances to the 61 American ports with foreign cargo value of $1 billion or more (www.aapa-ports.org), and 24 cities with U.S.-Mexico border crossings (apps.cbp.gov/bwt). 2003 LEMAS, representing a census of large law enforcement agencies and a nationally representative sample of smaller agencies, provided city-level data on use of police technology. Details of all measures are discussed below.

The multilevel data set linked MVT incidents in NIBRS to city-level data on opportunity structure and police agency technology. Linking NIBRS incidents to city-level data sets such as LEMAS is common in research investigating multilevel research questions (e.g., Roberts 2008; Stolzenberg, D'Alessio, and Eitle 2004). However, researchers should be aware of potential problems in using NIBRS and linking it to other data. Agency participation in NIBRS is voluntary; fewer than half of the states participated in 2003 NIBRS, and not all agencies in participating states reported data, so that NIBRS incidents are not nationally representative.[6] Linking NIBRS to LEMAS further skews the sample because NIBRS and LEMAS cannot be completely matched, as the smaller agencies common in NIBRS are underrepresented in LEMAS (Addington 2006). Thus, the results of this analysis should be interpreted with caution and, strictly speaking, generalized only to small to mid-size American cities with population between 1,856 and 728,432. Still, NIBRS is unique in providing incident-level MVT data, including time-to-recovery, across many jurisdictions, and so on balance is more than worthwhile for MVT recovery research. To ensure credible estimates of city-level effects, agencies with fewer than five MVT incidents during 2003 were excluded. The final linked data included 56,924 completed MVT incidents in 231 cities from 22 states.[7] Note that the recovery rate in these incidents (63 percent) was slightly higher than in all NIBRS incidents (55 percent).

Table 1. Frequency Distribution of Time-to-Recovery for Recovered Stolen Vehicles, 2003 NIBRS

	Stolen Vehicles	
Time to recovery	Frequency	Percentage
0 to 1 day	16,550	46.04
2 to 3 days	5,832	16.23
4 to 7 days	4,771	13.27
8 to 14 days	3,146	8.75
15 to 30 days	2,659	7.40
31 to 180 days	2,460	6.84
181 to 365 days	386	1.07
366 to 547 days	127	.35
548 to 730 days	13	.04
Total recoveries	35,944	

Hierarchical event history analysis

The current study used a hierarchical discrete-time event history analysis of stolen vehicle recovery that permitted estimation of incident- and contextual-level effects in the same analysis.[8] Table 1 shows the substantial variation in time-to-recovery for recovered vehicles in 2003 NIBRS. As reported by Barnett (2005), the first few days after theft are very important for recovering stolen vehicles, and the chance of recovery declines as time passes. The event history approach incorporates this variation in time to recovery. Because stolen vehicles that were not recovered by the end of the study period could still have been recovered later, such incidents are "censored." Event history analysis uses the known length of time until censoring in such incidents along with the time to recovery for recovered vehicles to estimate effects of independent variables. Using information on both time to recovery (for recovered vehicles) and time to censoring (for non-recovered vehicles), event history models should better estimate the effects of independent variables on recovery than would models that simply examined the dichotomous outcome of recovery or not within, say, 6 months (Allison 1995).

A discrete-time event history approach has been used in crime clearance research to model time-to-clearance (Lee 2005; Roberts 2008) and is likewise appropriate for MVT recovery research. Estimates for discrete-time event history models can be obtained through logistic regression on a specially constructed data set. This holds for both single-level (Allison 1982) and multilevel (Barber et al. 2000) models. The current analysis used six periods of "time after the incident:" 0-1 day, 2-3 days, 4-7 days, 8-14 days, 15-30 days, and 31-180 days. The maximum time (before censoring) between incident and recovery date was set at 180 days in this study; very few vehicles have longer time to recovery (Table 1), and such vehicles are often found damaged or burned.

A new data set was constructed in which each incident contributed a record for each time period up to (and including) the period in which recovery or censoring took place. For recovered vehicles, the binary dependent variable was given value 1 for the period in which the stolen vehicle was recovered and value 0 for any earlier periods. For example, an incident in which the vehicle took 6 days to recover would contribute three records to the data set, with the dependent variable equal to 0 for period 1 (0-1 day) and period 2 (2-3 days), and 1 for period 3 (4-7 days). A censored incident—one that did not result in recovery by 180 days—would have 0 for the dependent variable in all its records. Although multiple records often would be created from a single incident, estimates based on this new data set are valid for the discrete-time event history model (Allison 1982, 1995). Because a single incident can contribute multiple records, the new data set had many more records (212,202) than the original number of incidents. To examine the impact of passage of time on the likelihood of recovery, five dummy variables represented the six time periods.

Analysis of the new data set involved a basic random intercepts logit model, with incident-, time period-, and contextual-effects affecting odds of recovery in a given time period. The city-level random term (shared by all records from a given city) was assumed to be drawn from a normal distribution with mean 0 and an unknown variance. This variance and other model parameters were estimated in hierarchical linear modeling (HLM; Raudenbush, Bryk, and Congdon 2005).

Dependent Variable

The analysis modeled logged odds of recovery in a given time period. Less formally, time-to-recovery or -censoring can be viewed as the dependent variable (before construction of the special event history data set above). Time-to-recovery was the number of days between incident and recovery for recovered vehicles, and time-to-censoring was 180 days for non-recovered cases.

Incident-Level Independent Variables

Proxy for offender's goal. The offender's goal (temporary use vs. permanent retention) likely influences the recovery outcome but is difficult to measure, especially when using official statistics like NIBRS. One possible proxy that is available in NIBRS is the stolen vehicle's monetary value. Inexpensive cars tend to be older and equipped with less sophisticated antitheft devices, and so may be targets for temporary use theft (with more chance of recovery). Professional thieves interested in greater profit per vehicle may disproportionately target pricier vehicles for illegal resale and dismantlement, leading to a lower chance of recovery for such vehicles. Illegal export often involves expensive cars, whose high price helps compensate for costs and risks associated with a complicated transaction and transportation process involving many parties (Tremblay et al. 2001). The Highway Loss Data Institute's (2008) analysis of county-level insurance data found that average loss per claim is much higher in counties near the U.S.-Mexico border or with major ports (e.g., Miami-Dade), implying that more expensive vehicles are targeted for illegal export.

On the other hand, very expensive cars are less marketable in the local fencing market. Affluent local consumers generally do not search the used car market for bargains, and attracting less affluent consumers with large discounts on luxury vehicles might raise suspicion (Tremblay et al. 2001). Instead, local fencing and auto parts markets demand middle-range vehicles favored by typical consumers in the used car market (Tremblay et al. 2001). Advanced counterfeiting techniques such as body switching make it possible to sell high volumes of stolen cars without detection and allow profit-seeking professional thieves to eschew very expensive vehicles (Tremblay et al. 2001). Despite laws meant to thwart counterfeiting (Cherbonneau and Wright 2009), criminals use specialized counterfeiting techniques on cars intended for resale and are not too concerned with identification of chopped parts (Tremblay et al. 2001). In any case, inexpensive cars are less attractive for both local and foreign black markets than very or moderately expensive cars and are less likely to be stolen for permanent retention purposes, which should make their recovery more likely. Clarke and Harris (1992a, 1992b) reported that few of the top 20 models for non-recovery were inexpensive. In the current research note, value was classified into five categories: less than $1,000, $1,000 to $4,999, $5,000 to $9,999, $10,000 to $19,999, and $20,000 and up.

Control variables. In addition to stolen car value, the current analysis included other incident-level variables including presence of a concomitant offense and availability of offender information. Gottfredson and Hindelang (1979) hold that police investigation (like the legal system's other responses to crime) is affected by the offense's legal seriousness. MVT incidents with other concomitant offenses may be perceived as more serious and receive greater police attention than those without concomitant offenses, and therefore be more likely to result in recovery.[9] When police records of an MVT incident show any offender information, there was likely an eyewitness who provided information for investigation. Also, victims in such incidents may tend to have been aware of the theft more quickly and reported it to the police sooner, thereby giving the stolen vehicle less of a head start. Incidents were categorized into those having any offender demographic information (gender, race, or age) available, and those having none. Appendix A gives descriptive statistics for incident-level variables.

Contextual (City-level) Independent Variables

Opportunity structure. Opportunity structure for permanent retention MVT was indicated by measures of the city's illegal auto or parts market activity and economic conditions. Local fencing market activity was measured by the total number of incidents involving buying and selling of stolen cars, parts, or accessories, or counterfeiting of cars and their parts (converted to a rate per 100,000 using total serving population). Local economic conditions were measured by the unemployment rate. Active illegal markets and poor economic conditions should reduce recovery likelihood by increasing the attractiveness of MVT for permanent retention. Proximity to foreign black markets was measured by the city's distance (in miles) to the nearest major international port or U.S.-Mexico border crossing. A positive relationship between distance to foreign outlets and chances of recovery is expected, because longer distances to foreign outlets should indicate less theft for illegal export, and therefore higher likelihood of recovery.

Police technology. Police technology use is expected to enhance stolen auto recovery and is measured here by variables indicating whether an agency used a computerized crime mapping system, a stolen vehicle tracking system, and had accessibility to motor vehicle records from in-field computers. Given MVT's multijurisdictional nature, interagency cooperation is also expected to influence recovery. LEMAS does not collect information specifically on interagency cooperation regarding auto theft, so the analysis used a proxy indicating whether an agency used computers for interagency information sharing. An agency's general willingness to communicate with other agencies may also indicate whether it cooperates with others in auto theft recovery.

Control variables. City-level control variables used 2003 LEMAS and NIBRS to measure physical constraints on police activity related to MVT recovery, including police searching difficulty, workload, and restriction on pursuits of suspicious vehicles. Searching difficulty was measured as the size of the jurisdiction in square miles (from the 2000 Census) divided by the number of full-time sworn officers, and workload was calculated as the number of completed MVT incidents divided by the number of full-time sworn officers. For restriction on pursuits, police agencies were categorized as "restrictive" if LEMAS reported that the agency either discouraged all pursuits or restricted them to particular situations (e.g., violent felonies), and "non-restrictive" if the agency had no restriction on pursuits. In "non-restrictive" jurisdictions, police officers might pursue stolen cars more aggressively, thus leading to more apprehension and recovery. Appendix B gives descriptive statistics for city-level variables.

Missing Data Imputation

Like other official data, NIBRS records are subject to missing information: 14.8 percent of the incidents here had no data on the stolen car's value. Discarding those incidents would waste potential information and, because in crime research data are highly unlikely to be missing completely at random, potentially bias results (Riedel and Regoeczi 2004). For the current analysis, 10 data sets with imputed values for missing data were created with the SAS multiple imputation routine PROC MI; after transformation into event history data, these 10 data sets were analyzed in HLM's missing data routine. Reported parameter estimates reflect the average across imputed data sets, and estimated standard errors include variability across the imputed data sets as well as the usual uncertainty in parameter estimates.[10]

Results

Variance inflation factor scores indicated no multicollinearity problem among the independent variables. Table 2 shows the multilevel event history analysis results.

Incident-Level Variables

A joint test of the set of monetary value parameters showed statistically significant ($p < .0001$) differences in recovery odds among the categories of stolen car value. However, analyses using different reference categories

Table 2. Coefficients and Odds Ratios for MVT Recovery in Multilevel Event History Analysis

	b	*SE*	Odds Ratio
Incident-level variables			
Value of stolen vehicle[a]			
$1,000 to $4,999	.124**	.029	1.132
$5,000 to $9,999	.121**	.037	1.129
$10,000 to $19,999	.122**	.038	1.130
$20,000 and more	.131*	.057	1.140
Concomitant offense			
Present	.280**	.077	1.323
Offender information			
Available	.356**	.036	1.428
Time effect[b]			
2 to 3 days	−.798**	.086	.450
4 to 7 days	−.794**	.091	.452
8 to 14 days	−1.043**	.108	.352
15 to 30 days	−1.057**	.155	.347
31 to 180 days	−.982**	.119	.375
Contextual variables			
Local illegal activity rate	.002	.005	1.002
Unemployment rate	.024	.019	1.024
Distance (miles) to foreign outlets	.001**	.000	1.001
Crime mapping	−.115	.100	.891
Stolen vehicle tracking system	.266*	.118	1.305
Motor vehicle record accessibility	.066	.102	1.068
Inter-agency information sharing	.037	.100	1.038
Searching difficulty	−.458*	.184	.633
Workload	.054	.037	1.055
Restriction on pursuit	−.196	.134	.822
Number of event history records	212202		
Number of cities	231		

Notes: [a] Referent is less than $1,000.
[b] Referent is 0 to 1 day.
* $p < .05$.
** $p < .01$.

indicated that there were no statistically significant differences in odds of recovery among higher value categories ($1,000 and up). The statistically significant differences were *only* between the lowest value category (less than $1,000) and the higher value categories ($1,000 to $4,999, $5,000 to $9,999, $10,000 to $19,999, and $20,000 and more). Odds of recovery in a given time period were about 13 to 14 percent greater for cars in higher value categories ($1,000 and up) than for cars in the lowest value category (less than $1,000), controlling for contextual and other incident characteristics. These unexpected results are discussed further below.

Consistent with the view that legal seriousness determines criminal justice response (Gottfredson and Hindelang 1979), estimated odds of recovery were greater for MVT incidents with concomitant offenses. Incidents with offender information available had much higher odds of recovery in a given period than those without, supporting the importance of information provided to the police. As expected, the time parameters showed a substantial decrease in the odds of recovery 2 days after the incident date. With minor exceptions, estimated time parameters decreased (indicating lower odds of recovery) for periods representing a longer time after the incident.

Contextual (City-Level) Variables

Measures of local opportunity (illegal market activity and unemployment) for permanent retention MVT did not significantly affect recovery. Results supported previous research (Clarke and Brown 2003; Miller 1987) by finding that greater distance to foreign outlets was associated with higher odds of recovery. As distance to the nearest major port or U.S.-Mexico border crossing increased by 50 miles, estimated odds of recovery in a given time period increased about 5 percent.[11] Stolen vehicle tracking system use was the only police technology variable that was statistically significant in the expected direction. MVT incidents in cities whose police utilized a stolen vehicle tracking system had an estimated 31 percent greater recovery odds in a given time period than did incidents in cities without such a system. Regarding constraints on police activity, estimated odds of recovery declined (as expected) significantly as searching difficulty increased. However, workload and restriction on pursuits did not have statistically significant effects.

Discussion and Conclusion

This research note used multilevel event-history analysis to explore a model of MVT recovery drawing on rational choice and opportunity-based perspectives and police technology use. The main unexpected finding was that recovery was significantly less likely for the least valuable (less than $1,000) stolen cars than for those with higher value, with no significant differences among the categories of value greater than $1,000. Higher value (moderate to very expensive) vehicles were expected to be more often stolen for permanent retention purposes locally and internationally, leading to less recovery, especially given Clarke and Harris' (1992a, 1992b) report that expensive models made up a large share of the cars most frequently stolen for permanent retention. One possible reason for the non-difference in recovery among vehicles valued $1,000 or greater is that use of LOJACK or similar systems has grown since Clarke and Harris' (1992a, 1992b) study, and more expensive cars are more likely to be equipped with such a system (Ayres and Levitt 1998). If so, luxury cars may still be more attractive targets for profit-driven thieves, but also more likely to be equipped with a recovery-aiding system, leaving their chance of recovery similar to that of less expensive cars. Also, the gap in attractiveness for permanent retention between very expensive and other cars may have shrunk. Advances in counterfeiting technique and the possibility of high-volume sales suggested by Tremblay et al. (2001) may have made fairly inexpensive, but still resalable, cars roughly as attractive for permanent retention as more expensive cars. Further, the lower odds for recovery for the least expensive cars (under $1,000) may be because such vehicles rarely use LOJACK or similar tracking systems, and victims may be less aggressive in demanding investigation for cars with almost no value.

Incident characteristics such as the vehicle's make, model, and age have not been explored here because NIBRS does not record such information. Make and model likely influence recovery, in part by attracting different types of thieves (Tremblay et al. 2001). For instance, joy riders may favor small and high-performance models, making quick dumping and recovery more likely (Clarke and Harris 1992b). Makes manufactured in Mexico are frequently targeted for illegal export, as they may be more difficult to detect (Field et al. 1991; Miller 1987; Resendiz 1998). Numerous studies have found that older cars are at greater risk of theft (e.g., Brown 1995, 2004; Brown and Saliba 1998; Houghton 1992; Kriven and Ziersch 2007). For recovery, the U.S. National Highway Traffic Safety Administration (1991, 1998) found no relationship between vehicle age and recovery, but Tremblay et al.'s (2001) more recent Canadian study found that relatively newer vehicles were stolen for resale in illegal auto and parts markets, suggesting an association between age and recovery (with newer cars less likely to be recovered). Similarly, Kriven and Ziersch's (2007) study in Australia found that the mean age of unrecovered stolen vehicles was slightly younger than that of recovered vehicles in both 2001 and 2004. It would be desirable for

NIBRS to collect more detailed vehicle data to allow better examination of such potential influences on recovery.

Measures of local opportunity for permanent retention did not have statistically significant impacts on MVT recovery, but the analysis supported earlier research (Field et al. 1991; Miller 1987) on the importance of illegal export by finding lower recovery odds for vehicles stolen closer to foreign outlets. In 1999, Customs suggested various regulation changes to prevent stolen vehicles from leaving the United States and improve recovery from other countries (General Accounting Office 1999). At international ports and crossings, traffickers' attempts to avoid detection include presenting counterfeited documents, switching vehicles after inspection by custom officials, and concealing them in shipping containers (General Accounting Office 1999). Customs management proposed accepting only original or certified documents for export vehicles, and some programs encouraging faster and more comprehensive checks of vehicle status, coordinated with the National Insurance Crime Bureau, were introduced in some seaports. Gamma ray scanners to check shipping were tested in Miami and spread to other Florida ports. New international treaties and stolen vehicle database sharing aimed to increase cooperation on recovery of stolen vehicles across national borders (Clarke and Brown 2003; General Accounting Office 1999). However, these efforts seemed to do little to deter illegal export, as insurance claim rates and overall losses near U.S.-Mexico borders and major ports have remained higher than in the rest of the United States (Highway Loss Data Institute 2008). Clarke and Brown (2003) argue that efforts to improve recovery from other countries will have relatively little impact and call for more research on the earlier stages of the international trafficking process, particularly at border crossings and ports.

Most police agency variables, except for stolen vehicle tracking system use, did not show statistical significance; this is consistent with Tremblay et al.'s (1994) claim that proactive police investigation accounts for few recoveries and may also reflect limited relevance of characteristics of the jurisdiction where the MVT took place. Stolen cars can, and often do (Maxfield 2004), quickly travel out of the originating jurisdiction. This is less applicable to stolen vehicle tracking system use (which significantly improved odds of recovery here) because jurisdictional lines do not necessarily limit this technology's utility. Police can usually continue to follow tracking system hits into cooperating neighboring jurisdictions. At minimum, police can help the neighboring agency continue the search by providing a description and direction of the stolen car (Anne Arundel County Police 2008).

Many police agencies do not have stolen vehicle tracking capability. Only 16 percent of agencies in the full 2003 LEMAS sample did, and

LOJACK is currently offered in only 28 states and the District of Columbia (www.lojack.com). However, the significance (and effectiveness) of stolen vehicle tracking systems suggests that not only should police agencies use these systems but also that citizens should be encouraged to install compatible receivers in their cars.[12] Many insurance companies offer discounts for LOJACK-installed cars, and LOJACK now can immediately notify the owner when a car is moved without permission (www.lojack.com). Greater adoption of such devices in areas nearest to foreign outlets may be especially important in recovering stolen vehicles before they can leave the United States. However, Clarke and Harris (1992a) raise the concern that police will be overwhelmed if too many cars come to be equipped with such tracking devices. Also, because installation of such devices is costly, recovery may become more strongly associated with the victim's socioeconomic class. Systematic evaluation of differing tracking systems such as General Motors' OnStar (using Global Positioning System technology) and Boomerang remains an important topic for future research. Incident-level information on presence of a tracking system, and what type, would be a valuable addition to NIBRS MVT data.

Despite MVT's multijurisdictional nature (Maxfield 2004), there was no significant influence of interagency cooperation on recovery. However, a proxy measure was used, and it would be preferable to obtain more direct measures, such as participation in a multi-agency auto theft task force. Also, other potentially important police technologies and policies such as license plate readers and aggressive traffic stops are not measured by LEMAS and should be examined in future research. Analysis over time might also be useful since Tremblay et al. (1994) found a delayed effect of accident rates on the number of recoveries per 10,000 registered vehicles. Time-series analysis can also explore the declining trend of MVT recovery mentioned in the introduction. For example, improved car security and other opportunity-reducing techniques may have contributed to the recent decrease in MVT occurrence rates. However, this could have also reduced recovery rates by making it more difficult for low-skilled joy riders to steal cars, thereby increasing the proportion of thefts that are committed by experienced professional thieves stealing for permanent retention.13

Even with further study needed, this research note's exploration of a more comprehensive model drawing on rational choice and opportunity-based perspectives and police technology use to explain MVT recovery makes an important contribution. Given the substantial negative consequences that failure to recover stolen vehicles can have, continued research into incident- and contextual-level factors influencing recovery is crucial.

Appendix A

Descriptive Statistics for Incident-Level Variables before Missing Value Imputation

	Motor Vehicle Thefts ($n = 56{,}924$)	
	Frequency	Percentage
Recovery		
Recovered	35,944	63.14
Not recovered	20,980	36.86
Value of stolen car		
Less than $1,000	5,184	9.11
$1,000 to $4,999	21,386	37.57
$5,000 to $9,999	10,802	18.98
$10,000 to $19,999	7,726	13.57
$20,000 and more	3,401	5.97
Missing	8,425	14.80
Concomitant felony		
Present	4,202	7.38
Absent	52,722	92.62
Offender information		
Available	13,970	24.54
Not available	42,954	75.46

Appendix B

Descriptive Statistics for Contextual Variables before Missing Value Imputation

	N	Mean	*SD*	Definition
Local illegal market activity rate	231	3.43	12.57	Total number of incidents involving buying and selling of stolen cars, parts, or accessories, or counterfeiting of cars and their parts, converted to rate per 100,000 using total serving population
Unemployment rate	231	5.65	2.32	Percentage unemployed in civilian labor force

(continued)

(continued)

	N	Mean	*SD*	Definition
Distance to foreign outlets	231	254.41	214.17	Miles to nearest major port or U.S.-Mexico border crossing
Crime mapping	231	.52	.50	Whether a police agency uses computerized crime mapping (1 = *yes*, 0 = *no*)
Stolen vehicle tracking system	231	.14	.35	Whether a police agency uses a stolen vehicle tracking system (1 = *yes*, 0 = *no*)
Motor vehicle record accessibility	231	.65	.48	Whether motor vehicle records are accessible from in-field computers (1 = *yes*, 0 = *no*)
Inter-agency information sharing	231	.50	.50	Whether a police agency used computers for interagency information sharing (1 = *yes*, 0 = *no*)
Searching difficulty	231	.29	.24	Size of jurisdiction in square miles divided by number of full-time sworn officers
Workload	231	1.65	1.26	Number of completed MVT incidents divided by number of full-time sworn officers
Restriction on pursuit	231	.83	.38	Whether agency has a restrictive policy on pursuits (1 = *restrictive*, 0 = *non-restrictive*)

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Notes

1. From some perspectives, non-recovery could also have beneficial effects, as it increases access to vehicles for people who cannot afford conventional car purchases. Similarly, while insurance fraud will increase the number of unrecovered vehicles, it also can be viewed as helping people escape from unmanageable financial problems.
2. The estimated theft and recovery totals were calculated using the UCR imputation methods described in Lynch and Jarvis (2008) and Maltz (2007).
3. Of course, a thief may steal a vehicle for multiple purposes (Clarke and Harris 1992b; Copes 2003). See McCaghy et al. (1977), Clarke and Harris (1992a), and Copes (2001) on typologies of MVT offenders.
4. When a stolen car is recovered in another jurisdiction, NIBRS data record it as a recovery for the original jurisdiction in which it was reported stolen.
5. For more description of NIBRS and its advantages and disadvantages, see Roberts (2009).
6. According to Chilton and Regoeczi (2007), southern agencies are overrepresented and western agencies are underrepresented in NIBRS. Also, many large police departments representing urban and high crime jurisdictions are absent from NIBRS (Maxfield 1999). Police agencies serving populations over 250,000 are especially underrepresented (Addington 2008).
7. The included states are Arkansas, Colorado, Connecticut, Delaware, Iowa, Idaho, Kansas, Louisiana, Massachusetts, Michigan, Nebraska, North Dakota, Ohio, Oregon, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Vermont, and West Virginia.
8. The analysis also addresses the likely nonindependence of incidents that occurred in the same city. For more on hierarchical modeling of criminal justice outcomes, see Stolzenberg et al. (2004).
9. While most concomitant offenses were burglary, vandalism, or larceny, some were serious violent offenses such as homicide, rape, and robbery.
10. Analyses without any missing value imputation gave the same signs and statistical significance of estimates. Details of results without missing value imputation are available on request.
11. This 5 percent increase in estimated recovery odds for a 50 mile increase in distance to foreign outlets is calculated from $e^{b \times 50} = e^{001 \times 50} = 1.051$.
12. LOJACK may have other beneficial effects. Ayres and Levitt (1998) found that an increase in the proportion of LOJACK equipped vehicles reduced auto theft *occurrence* rates, without displacement and dislocation effects.
13. Studies have found that, in response to increased car security, some car thieves have switched from traditional methods of breaking into cars to using keys

obtained through burglary, robbery, and fraudulent transactions (Copes and Cherbonneau 2006; Donkin and Wellsmith 2006; Levesley et al. 2004). Stealing keys involves a more complicated and time-consuming process than traditional methods. Hence, one might argue that car thefts using keys are more likely to be committed by professional thieves for permanent retention, resulting in a lower recovery rate for key MVT than for MVT overall (Levesley et al. 2004). However, Donkin and Wellsmith's (2006) study in Sandwell, England did not find clear evidence for this.

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