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Article

Analysis of the Flow of Offenders to the Metropolitan Region of Chile

Pablo Cadena-Urzúa [1], Javier Guardiola [2], Adina Iftimi [3] and Francisco Montes [3,*]

[1] Doctoral Programme in Law, Political Science and Criminology, Universitat de Valencia, 46022 Valencia, Spain; pacaur@alumni.uv.es
[2] Department of Criminal Law, Universitat de Valencia, 46022 Valencia, Spain; javier.guardiola@uv.es
[3] Department of Statistics and Operations Research, Universitat de Valencia, 46100 Burjassot, Spain; adina.iftimi@uv.es
* Correspondence: francisco.montes@uv.es

Abstract: This study, based on data from 2015 to 2019 on the movement of offenders to the Metropolitan Region of Chile, uses Poisson and Negative Binomial models to analyze the flow of offenders from other Chilean regions. It confirms that factors such as gender, educational level, location of crime, and type of crime significantly motivate displacement. The profile of the typical offender is an educated man who commits crimes against property on public roads, coming mainly from neighboring and populated regions. These findings have implications for crime prevention, suggesting that strategies to prevent crime should take this into account. Future research at the commune level is proposed for a more detailed understanding of offender displacement patterns and to inform local crime-prevention strategies.

Keywords: criminal mobility; journey to crime; Poisson regression; Negative Binomial regression

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1. Introduction

Criminal analysis is an essential tool in modern criminology, as it allows for the identification of patterns of criminal behavior and can thus help prevent future crimes. This analysis is based on collecting and studying data related to specific crimes to identify key trends and issues. This process can reveal valuable information about the characteristics of people who engage in crime, including their methods of operation (modus operandi), origins, chosen locations for crimes, and peak times of activity.

Examining the patterns or habits (habitus) that people who engage in crime follow is of great use in helping to prevent crime. The authors of Bourdieu (1979, 2006) identify habitus as a set of mental or cognitive structures by which people live, work, and interact in society; habitus is neither conscious nor subject to volition, yet it is constantly present in everyday practices and interpretations. By carefully analyzing trends in criminal behavior, researchers can identify common contributing factors and develop effective strategies to reduce crime. For example, crime pattern analysis can help police to identify specific geographic areas where certain types of crimes or *hot spots* are concentrated (Sherman and Weisburd 1995), or establish detailed profiles of the people who might be responsible for those illegal acts. Thus, the phenomenon of criminal mobility, or the movement of people engaging in crime to the place where their crimes are committed—generally known as the journey to crime—has been studied for years (Andresen and Shen 2019b; Rengert 2004) to understand the relationship between these factors and the criminal decision. To date, the existing literature has established a relationship between travel distance and offending acts (Drawve et al. 2015; Levine and Lee 2009; Pizarro et al. 2007). However, this relationship is complex and multifaceted and involves a number of risk and opportunity factors; it remains open to debate.

It has often been verified that the distance which a person engaging in crime travels tends to be small (Andresen 2020; Andresen and Shen 2019a; Andresen et al. 2014; Canter and Larkin 1993; Gabor and Gottheil 1984; Nichols 1980; Phillips 1980; Rengert et al. 1999; Snook 2004); it is lower for violent crimes than for other types of crimes (Ackerman and Rossmo 2015; Wiles and Costello 2000), as White (1932) pointed out in their pioneering study. Thus, there are several publications that attempt to explain the path or route that an person follows from their place of residence to where they commit a crime (Beauregard and Busina 2013).

As for the flow of criminal displacement, this has been studied much less; previous work has shown that there is a positive correlation between this flow and the crime rate at the destination (Boba 2001; Montero and Piña 2016). That is, as the number of movements increases, so does the crime rate. It is important to distinguish between a crime pattern and a crime trend: the former is characterized by intense frequency and shorter duration, and is limited to a specific set of reported crimes; a trend is a persistent, long-term change, which is useful when studying the levels and magnitude of criminal activity but does not examine similarities between specific cases.

Regarding the perpetration of crimes in the Metropolitan Region (MR), statistics show that the MR has the highest number of cases classified as crimes of major social significance, reaching 43.37% of the national total. This is much higher than the rest of the regions (CEAD 2023). This could be attributable to several factors, including population density and the availability of opportunities to commit crimes. For example, it is home to the five most densely populated communes in Chile. It is also home to more than 40% of the country's population (Censo 2017). An understanding of the concept of "communes"—which refers to the smallest administrative divisions in Chile—is crucial for understanding local crime patterns. For an international audience, communes can be likened to municipalities or boroughs, each with its own local government and administrative responsibilities.

This is where our research becomes relevant. Despite the existing studies, there is no previous research that focuses specifically on the phenomenon of the displacement flow of offenders in Chile. This lack of previous studies on the topic highlights the relevance and necessity of our contribution. By addressing this gap in knowledge, our study could provide a deeper understanding of this phenomenon and its implications, which can be valuable in informing and improving crime-prevention policies.

This study aims to further explore the phenomenon of the displacement flow of offenders in the MR. We aim to examine the factors associated with the flow of offenders and the consequences of these displacements. Our theoretical approach is based on several assumptions. First, we conjecture that offender displacement is not a random phenomenon but is influenced by certain factors. Second, we assume that such displacement has significant consequences for both individuals and society at large, as it might increase crime rates in the destination region.

In this context, we pose the following hypothesis: "The rate of crimes committed in the Metropolitan Region of Chile by offenders from other regions is influenced by socio-demographic characteristics, gender and educational level, and also other variables such as place, type of crime and region of origin of offender". Consequently, these factors will be the covariates that we will use in our models.

Our theoretical approach is grounded on rational choice theory (Cornish and Clarke 1986) and routine activities theory (Cohen and Felson 1979). Rational choice theory posits that people make rational decisions about where to commit crimes by evaluating the potential costs and benefits. This theory was chosen because it provides a framework for understanding how people weigh their options before engaging in criminal activity. Routine activities theory, on the other hand, suggests that the likelihood of a crime occurring is contingent upon the convergence in time and space of a motivated person intending to engage in crime, a suitable target, and the absence of a capable guardian. This theory was selected as it highlights the situational aspects that can influence criminal behavior and is particularly relevant for examining patterns of criminal displacement.

In the context of the present study, rational choice theory manifests in the decision of offenders to move towards the Metropolitan Region, where they might perceive that there may be greater criminal opportunities due to the concentration of goods and people. Similarly, routine activity theory explains how daily travel patterns and transport infrastructure facilitate criminal mobility. These theoretical frameworks provide a solid foundation for analyzing the patterns of the apprehension and displacement of people engaging in crime in the RM.

In this paper, we propose that we use data from a variety of official sources, including police records and population census surveys, which we will detail in the next section. Our methodological approach, detailed in Section 2.2, incorporates a variety of quantitative techniques to analyze the data and test our hypothesis. We believe that this approach will allow us to gain a deeper and more nuanced understanding of the phenomenon of offender displacement flows in the MR.

We hope that this article will contribute significantly to the existing literature, illuminate hitherto under-explored aspects of the displacement of offenders of crime, and provide valuable information for crime-prevention, -control, and -reduction policies and practices. Our research has the potential to fill a gap in the current scientific knowledge and provide a new perspective on a phenomenon with significant implications for society.

In this article, we first present the data sources and covariates used in the study. We then detail the materials and methods employed, including the data analysis steps and the statistical models applied. The results of our analysis are subsequently presented, followed by a discussion that interprets these findings within the context of the theoretical frameworks utilized. The article concludes with a summary of the main findings, their implications for policy and practice, and suggestions for future research.

2. Materials and Methods

2.1. Data

The offender data were obtained from the Centre for Crime Studies and Analysis (CEAD) of the Undersecretary for Crime Prevention, under the Interior Ministry and Public Security of Chile (CEAD 2023). Specifically, these refer to the movement of offenders from the communes of the different Chilean regions to the Metropolitan Region (MR) in the five-year period between 2015 and 2019. Events registered after 2019 have not been considered since the imposed mobility restrictions due to the recent COVID-19 global pandemic would undoubtedly alter the study.

The database contains 268,522 records on 12 variables, including the origin and destination communes, region of origin, distance between communes, place of crime, type of crime, date variables (year, month, day of the week, day of the month), gender of the offender, and educational level of the offender. These variables provide the essential information to study the offender flow.

The different categories of categorical variables are detailed below. Table 1 shows the 16 Chilean *regions*, defined after the last administrative division of 2021, together with their abbreviations and populations.

The *places* where crimes are originally committed consist of 94 categories, which have been reduced to 4 in Table 2; these account for 90% of the records. None of the remaining amount to more than 1% of the total. Examples of other locations of crimes that have not been included in the table include, among others, metro stations, pharmacies, restaurants, and hospitals. These categories were excluded from the primary analysis to maintain clarity and focus on the most prevalent types of crimes.

Table 3 lists the crimes analyzed, categorized as either crimes against persons (e.g., homicide, injuries, robbery with intimidation) or crimes against property (e.g., thefts, vehicle theft, burglary). The frequencies of each type of crime were recorded, with crimes against property being more prevalent. In the text, we differentiate between these two categories by noting that crimes against persons typically involve direct physical harm or threat, whereas crimes against property involve the unlawful taking or damage of someone's belongings.

Table 1. Regions of Chile.

Region	Abbreviation	Population
Tarapacá	TA	330,558
Antofagasta	AN	607,534
Atacama	AT	286,168
Coquimbo	CO	757,586
Valparaíso	VA	1,815,902
Libertador General Bernardo O'Higgins	LI	914,555
Maule	ML	1,044,950
Biobío	BI	1,556,805
La Araucanía	AR	957,224
Los Lagos	LL	828,708
Aysén del General Carlos Ibáñez del Campo	AI	103,158
Magallanes y de la Antártica Chilena	MA	166,533
Metropolitana de Santiago	MR	7,112,808
Los Ríos	LR	384,837
Arica y Parinacota	AP	226,068
Ñuble	NB	480,609

Table 2. The four most frequent places in which crimes are committed.

Categories	Count	Percentage
Public road	75,887	28.32
Supermarkets	75,303	28.10
Commercial premises	67,581	25.22
Private home	20,626	7.70

Table 3. Crimes and their frequencies.

Crime	Count
Homicide	500
Injuries	44,534
Robbery with intimidation	14,915
Robbery with violence	6552
Robbery by surprise	10,807
Rape	14,336
Thefts	143,330
Other robbery with force	2565
Vehicle theft	1814
Burglary in an inhabited place	7182
Burglary in a non-inhabited place	16,815
Theft of or from a vehicle	2941

The *education* variable has four categories: illiterate, basic, secondary, and higher. Finally, the *year* variable is also categorical; every year corresponds to one category, from 2015 to 2019. For these three variables, Table 4 shows their counts.

Table 4. Counts for gender, education, and year.

Variable	Categories	Count
Gender	Woman	73,504
	Man	194,830
Education	Illiterate	412
	Basic	53,642
	Secondary	163,899
	Higher	13,084
Year	2015	56,559
	2016	51,640
	2017	51,232
	2018	52,463
	2019	56,628

Data Analysis

As stated in the Introduction, the objective of this study is to describe and analyze the flow of offenders from each region to the MR. Firstly, the data are filtered to exclude offenders coming from the MR. Then we count the crimes for each combination of the different categories of the following variables: *year*, *education*, *gender*, *crime*, *place*, and *region*. The resulting file consists of 3600 rows and 7 columns. The number of rows results from the combination of all categories involved, taking into account that the level of education has been reduced to three categories because there are only four people who were illiterate among the people in this dataset after filtering. In order to correct in the subsequent models for the effect that the population could have on the contribution of offenders, we considered the population of each region obtained from the Census of Chile (Vargas 2021), corresponding to the year 2017, which was the last national census published. Table 5 shows part of the final file.

Table 5. Partial reproduction of the table on the flow of offenders moving to the MR.

Year	Education	Gender	Against	Place	Region	Count	Population
2015	Basic	Women	People	Public road	TA	0	330,558
2015	Secondary	Women	People	Public road	TA	0	330,558
2015	Higher	Women	People	Public road	TA	0	330,558
2015	Basic	Men	People	Public road	TA	1	330,558
2015	Secondary	Men	People	Public road	TA	2	330,558
2015	Higher	Men	People	Public road	TA	0	330,558
...	...	...	...	...	...	...	...
2015	Basic	Men	People	Supermarkets	ML	0	1,044,950
2015	Secondary	Men	People	Supermarkets	ML	8	1,044,950
2015	Higher	Men	People	Supermarkets	ML	0	1,044,950
2015	Basic	Women	Property	Supermarkets	ML	2	1,044,950
2015	Secondary	Women	Property	Supermarkets	ML	2	1,044,950

2.2. Models

The random variable that is commonly used to describe a phenomenon that counts the number of occurrences of a certain event is the Poisson variable, named after the French mathematician who introduced it in 1837 (Poisson 1837). Its probability function is given by:

$$f_X(x) = \begin{cases} \dfrac{e^{-\lambda}\lambda^x}{x!}, & if\ x \in D_X \\ 0, & \text{otherwise,} \end{cases}$$

where λ is its defining parameter and $D_X = \{0, 1, 2, 3, \ldots\}$ its support. Its properties and characteristics can be found in any classical text on probability (Feller 1968; Gnedenko 1976). An interesting property of this variable is that its mean and its variance are equal and equal to its parameter, $\mu_X = \sigma_X^2 = \lambda$. Fitting a linear model to count data can be performed using a general linear model (GLM) with the log function as a link. The log–linear Poisson model is:

$$\log \mu_i = \sum_{j=1}^{p} \beta_j x_{ij} \quad or \quad \log \boldsymbol{\beta}\mathbf{X}, \tag{1}$$

where $x_1, x_2, \ldots, x_p$ are the p covariates with which we want to explain the phenomenon and the subscript i refers to the i-th element of the set of observations.

The problem arises when the necessary equality between mean and variance is not met, which occurs more frequently than desired and usually with greater variance than expected, giving rise to what is known as over-dispersion. An alternative random variable, with equal support to the Poisson, is the Negative Binomial (NB). In a context of independent Bernoulli trials with success probability π, the NB variable describes the number of trials needed to achieve the first r successes. Its probability function is:

$$f_Y(y) = \begin{cases} \binom{r+y-1}{y} \pi^r (1-\pi)^y, & if\ y \geq 0 \\ 0, & \text{otherwise.} \end{cases}$$

where π and r are the parameters that define it. Their mean and variance are not equal, in particular, $\mu_Y = \frac{r(1-\pi)}{\pi}$ and $\sigma_Y^2 = \frac{r(1-\pi)}{\pi^2}$.

However, alternatively, the NB can also be obtained as the marginal distribution of the mixture of a Poisson of parameter λ, which in turn is distributed as a Gamma with mean $E(\lambda) = \mu$ and parameter of form $k > 0$. The probability function of the NB takes the following form:

$$f_Y(y) = \begin{cases} \frac{\Gamma(y+k)}{\Gamma(k)\Gamma(y+1)} \left(\frac{\mu}{\mu+k}\right)^y \left(\frac{\mu}{\mu+k}\right)^k, & if\ y \geq 0 \\ 0, & \text{otherwise.} \end{cases}$$

Mean and variance are now worth $E(Y) = \mu$ and $sigma_Y^2 = \mu + \phi^2$, with $\phi = 1/k$. The latter expression reveals a way to circumvent the over-dispersion problem. As for the GLM for NB, the log link is used as in the log–linear Poisson model and its expression coincides with (1). Details about the GLM Poisson and NB models can be found in Agresti (2015). The R programming language (R Core Team 2022) has been used for the proposed analysis.

3. Results

The choice of regression model for describing the flow of offenders from each region to the MR will depend on the presence or absence of over-dispersion in the counts in Table 5, as indicated in the previous section. Over-dispersion is present according to Lambda test of Cameron and Trivedi (1990), and we must fit the model using the NB. On the other hand, in a previous modeling, the year variable has turned out to be non-significant, so it is excluded from the model. Two models have been run, the first with regions plus control measures, whose expression is

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count = region + education + gender + against
+ place + offset(log(population)),
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and the second model, with just the control measures, whose expression is

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count = education + gender + against
+ place + offset(log(population)),
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just to determine whether there are changes in the control measures.

The result of the adjustment is shown in Table 6 under the columns *model 1* and *model 2*. There is consistency between with regard to control measures in the sense that the signs of the coefficients are the same and their values are very similar. However, if we look at the goodness-of-fit measures and perform an ANOVA test with both models, the differences between them are significant in favor of model 1 ($\chi^2_{14} = 136.64$ and p-value = 0.000). Therefore, the details of the results that are discussed in the following sections are based on model 1, the one that contains the regions.

Table 6. NB model fitting results. Significant *p*-values are denoted by *

	Model 1			**Model 2**		
Variable	**Coefficient**	**exp(Coef)**	***p*-Value**	**Coefficient**	**exp(Coef)**	***p*-Value**
Secondary	1.2689	1.1867	3.2763	0.0000 *		
Higher	−0.9797	0.3754	0.0000 *	−0.8376	0.4327	0.0000 *
Men	1.1532	3.1683	0.0000 *	0.9990	2.7156	0.0000 *
Against property	1.0369	2.8205	0.0000 *	1.0011	2.7213	0.0000 *
Supermarkets	−0.5142	0.5980	0.0002 *	−0.5593	0.5716	0.0002 *
Commercial premises	−0.3136	0.7308	0.0207 *	−0.3287	0.7199	0.0251 *
Private home	−1.5617	0.2098	0.0000 *	−1.4845	0.2266	0.0000 *
regionAN	0.0583	1.0600	0.8434			
regionAT	−0.0278	0.9726	0.9306			
regionCO	0.6552	1.9255	0.0199 *			
regionVA	1.4357	4.2026	0.0000 *			
regionLI	1.1822	3.2615	0.0000 *			
regionML	0.3639	1.4389	0.1955			
regionBI	0.4358	1.5462	0.1147			
regionAR	0.4264	1.5317	0.1298			
regionLL	−0.3629	0.6957	0.2228			
regionAI	−0.8638	0.4216	0.0594 *			
regionMA	−1.2630	0.2828	0.0048 *			
regionLR	0.1022	1.1076	0.7380			
regionAP	−0.4781	0.6200	0.1754			
regionNB	0.1621	1.1760	0.5867			
LogLik		−1282			−1350	
AIC		2609.68			2718.30	
R^2		0.4894			0.3986	

4. Conclusions

The conclusions of this paper are drawn from the results shown in Table 6. We should consider that, since these are categorical variables, the coefficients use the absent category in each variable as a reference. Specifically, if we recall that the NB regression model (1) adjusts the logarithm of the flow of offenders, the increase or decrease factor of the flow is the exponential of the corresponding coefficient, exp $coef$.

Looking at the fit of the model without years, we see that, with respect to the *basic* level of education, the flow is higher for those with a *secondary* level of education and lower for those with a *higher* education. Specifically, the medium level presents a flow that is 3.55 times greater than the *basic* level; or, if preferred, an increase of $255\%(3.55 - 1) = 2.55$. For the *higher* level, the decrease is $62\%(0.38 - 1) = 0.62$. All this is working from the assumption that all other variables remain unchanged. This first conclusion is in line with what has been previously postulated by authors such as Huang (2016) and Millán-Valenzuela and Pérez-Archundia (2019), who point out that the relationship between delinquency and education crosses over when reaching the baccalaureate level; this is corroborated by Lasierra (2006); Nateras et al. (2017); Ortega (2010); Trajtenberg and Eisner

(2015), who attribute a higher prevalence of crime commission to people with lower levels of education (illiterate and basic).

Men are much more likely to engage in crime than women, with a rate of engagement that is higher by 217%$(3.17 - 1 = 2.17)$. As for the classification of crimes, crimes against property more likely to be committed, with an increase of 182%$(2.8 - 1) = 1.82$ compared to crimes against persons. There is more consensus on this result, with researchers such as Hayslett-McCall et al. (2008); Rengert (2004); Sanders et al. (2017) confirming our assumption.

According to Brantingham (2012), a crime will occur in a specific place that fits the crime pattern of a particular person, as they are more likely to feel comfortable and safe enough to engage in crime in these locations; this provokes a process of the location of targets. Thus, the public road reference category in the model is where displaced offenders are most likely to carry out their crimes. The other three categories have lower proliferation—lower by 40% in *supermarkets*, 27% in *commercial premises*, and 79% in *private homes*.

The interpretation of the coefficients associated with the regions will stick to those that are significantly different from zero. They correspond to the regions of Coquimbo (CO), Valparaíso (VA), Libertador O'Higgins (LI), Aysén (AI), and Magallanes (MA). The first three have positive coefficients, which implies an increase in the flow of offenders from the reference region, Taparacá (TA). Particularly important are the increases in VA, 320%$(4.2 - 1) = 3.20$, and LI, 226%$(3.26 - 1) = 2.26$. This should be noted because we believe it helps to interpret the result in which all three regions are neighbors of the MR, and VA is the second most populated area in Chile. The other two regions, AI and MA, with negative coefficients, show reductions of 58% and 72%, respectively, with respect to TA. These two regions are the least populated and the furthest from the MR. These results are to be expected according to several studies, including those developed by Ackerman and Rossmo (2015); Townsley et al. (2015); Vandeviver et al. (2015).

The above conclusions allow us to define an approximate profile of a person who travels to the MR to commit crimes: they are likely to be a man, with a secondary level of education, with a preference for engaging in criminal acts on public roads and mainly against property, and he is likely to mainly come from neighboring regions such as VA, LI, and CO.

5. Discussion

The findings of this study on the displacement flow of offenders in the Metropolitan Region (MR) of Chile align with and expand upon the existing literature in several key areas. Previous research, such as that by Wiles and Costello (2000) and Vandeviver et al. (2015), has highlighted the importance of socio-demographic factors in influencing criminal behavior and movement patterns. Our results corroborate these findings, demonstrating that factors like educational level, gender, and type of crime significantly affect the displacement of offenders to the MR. Specifically, our study finds that offenders with lower educational levels and men are more likely to commit crimes in the MR, which is consistent with the literature, suggesting that lower educational attainment is associated with higher crime rates (Huang 2016; Millán-Valenzuela and Pérez-Archundia 2019).

There are multiple implications of these findings. For policymakers, understanding that offender displacement is influenced by these factors can inform more targeted crime-prevention strategies. For instance, educational interventions could be a key component in reducing crime rates. Additionally, our study suggests the necessity for region-specific crime prevention measures, as the characteristics of people engaging in crime differ by their region of origin. This can help in tailoring law enforcement resources more effectively and in designing community programs that address the root causes of criminal behavior in different regions.

For future research, our findings highlight the need for more detailed data collection, particularly regarding the timing of crimes. More precise information about when crimes occur could provide deeper insights into the patterns of offender displacement and help identify specific times when interventions might be most effective. Furthermore, exploring the impact of macroeconomic factors on crime displacement could offer a broader understanding of the underlying drivers of criminal behavior.

Several limitations of this study could have influenced the results. First, the exclusion of the weekday variable due to database size constraints may have overlooked important temporal patterns in crime displacement. Second, the lack of detailed timing information about the crimes limits our ability to fully understand the temporal dynamics of offender movement. These limitations suggest that, while our findings are robust within the scope of the available data, they could be further refined with more comprehensive data collection. Another limitation to be taken into account with regard to the application of the results is that, since our model is not longitudinal, its conclusions cannot be extended in that sense.

To address these limitations, future studies should aim to incorporate more granular temporal data, including the specific times of day when crimes are committed. This would involve expanding the data collection framework to include variables that capture these details without compromising the applicability of the models used. Additionally, integrating advanced data analytical techniques, such as machine learning, could help in managing larger datasets and uncovering more complex patterns in the data.

Expanding the geographic scope of future studies to include multiple metropolitan regions could also provide comparative insights that enhance our understanding of offender displacement on a national or even international level. Finally, collaborative efforts between researchers and law enforcement agencies could facilitate the sharing of more detailed and timely data, thereby improving the accuracy and relevance of the research findings.

In conclusion, this study contributes to the existing literature by providing a detailed analysis of the factors influencing the displacement flow of offenders in the MR of Chile; while the findings are in line with previous studies, they also underscore the importance of addressing the identified limitations through more comprehensive data collection and advanced analytical methods. These improvements can enhance our understanding of criminal behavior and support the development of more effective crime-prevention strategies.

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