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Group Size and Social Capital Impact on Free Riding Behavior in Padang's Self-Guards Managed Railway Crossing

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ABSTRACT

An unguarded railway level crossing in Padang, Indonesia, presents a critical safety risk. This study investigates how community group size, social capital, and duration of residence in the neighborhood interact to influence collective action for shared safety. The collective action takes the form of conscious participation in an initiative to finance railway crossing guards, provided by and for the community. Using two-stage probit regression, the analysis uses the duration of residence in the neighborhood as an instrumental variable for social capital to address potential endogeneity. Not necessarily, the longer residents live in the neighborhood, the greater the willingness to participate. It is possible that living longer in an area leads to a decline in social capital due to economic stagnation and social fragmentation. Especially in disadvantaged neighborhoods. These dynamics illustrate the complex interactions between the duration of residence, group size, and social capital. These interactions will lead to a wide variety of responses in maintaining grassroots safety efforts.

1. INTRODUCTION

Railway level crossings are the most hazardous locations where roads and railways meet. This critical intersection needs strict safety measures to minimize accidents and ensure the community is safe. However, in Indonesia's Padang, these crossings have seen disturbing increases in incident trends. Recent figures from the BTP Sumbagbar Railway Engineering Centre show that, between 2017 and 2022, 123 accidents occurred there, leading to 16 deaths, 49 injuries, and 39 minor injuries [1]. Risk is made worse by the swift increase of incidents in 2023, with 29 total accidents within a year, resulting in grief as all resulted in fatalities and many people were injured as well. This situation illustrates the urgent need for local safety initiatives integrated with transportation planning [2].

One of the main problems that contributes to the grievous number of accidents is the spread of illegal or unregistered level crossings. Out of the 388 crossings that were counted, only 42 reported guard presence, while 58 were registered with no guarding presence, and a staggering 288 were illegal crossings [3]. This situation grows more aggravated when level crossings and residential neighborhoods are considered in the region of Padang. Of the 30 residential locations, whose areas are cut across by railway lines, only 11 have guards who are provided by the residents, while 19 do not have guards. These spontaneous safety interventions show similarities to cooperative grassroots risk governance frameworks [4].

This scenario poses a significant risk to residents and road users. The prevalence of unlicensed or unguarded level crossings in Padang's residential areas forced local communities to adopt self-managed safety initiatives. Residents organized and funded railway crossing guards to reduce risks in this high-traffic area. This reflects a pattern of collective problem-solving in high-risk areas. In line with the broader findings on community participation in improving safety [5]. The challenge of unguarded level crossings is not unique to Padang. Research from other urban settings confirms that community collaboration is a valuable supplement to official transport safety systems [4, 6].

However, these grassroots efforts are often undermined by the problem of free-rider. In this context, "free-rider" benefits from safety improvements provided by publicly-funded safety officers but does not contribute financially to their maintenance. This has been discussed extensively in public goods literature. Free-riders tend to increase with group size [7] in the absence of mutual obligations [8, 9]. Additionally, behavioral research shows that free-riding is more likely when individuals perceive low personal gain or reduced visibility of their actions within a group [10]. Social cohesion can counteract the dilution of responsibility within a larger group. As such, it can encourage greater commitment to collective safety.

Several argue that as group size increases, monitoring individual contributions becomes more difficult, leading to more opt-outs [7]. Another supports this view, stating that larger communities face unique constraints due to the dispersion of responsibilities among residents [11]. In

contrast, other studies have challenged this perspective. They propose that strong social networks within a community can ward off opt-outs [5]. This, in turn, can foster a greater sense of responsibility among residents [12], especially where trust networks are dense [13].

In residential areas, the effectiveness of community-managed safety measures depends not only on the size and composition of the group. Various internal social dynamics also determine the provision of informal railway crossing guards. These dynamics include social capital, neighborhood cohesion, and household characteristics [14]. Social capital plays an important role in addressing the issue of free-riding in community-driven safety initiatives [15]. Defined as the shared networks, trust, and norms that facilitate cooperation, it enables communities to mobilize resources at the grassroots level and fosters accountability [13, 16].

Research emphasizes the potential of social networks to complement technological solutions in transportation safety systems. It highlights their importance in encouraging collective action. Inclusive and cohesive environments, supported by strong social capital, are better equipped to sustain safety initiatives. Even in the face of resource limitations and increasing group size [5, 17]. Conversely, weak social capital may exacerbate free-rider behavior [18].

The residents may feel less obligated to contribute when trust and cooperation are lacking. Residents of a residential area who tend to stay for a longer period tend to develop deeper relationships with their community. This potentially fosters a stronger sense of attachment and responsibility [19]. These residents are more likely to participate in neighborhood activities. They have a higher intention to support public goods, and contribute to common goals [20, 21].

In contrast, newcomers or temporary populations may not have the time or opportunity to integrate into the community. This ultimately results in lower levels of participation and a greater tendency to jump on the bandwagon [22]. However, the positive impact of length of residence on social capital is not universal. Furthermore, in disadvantaged or declining neighborhoods, prolonged exposure to adverse conditions such as economic stagnation [23], social fragmentation, and psychological distress [24]. All of these conditions can weaken trust, reduce participation, and erode social cohesion [18].

Related to the concept of community size discussed earlier, the complexity of interactions is exacerbated. It is true that smaller groups–close relationships and more frequent interactions–facilitate effective monitoring and informal enforcement mechanisms [11]. This potentially reduces the prevalence of free-riding [12]. In contrast, larger groups face significant challenges in sustaining collective action due to increased anonymity and reduced accountability [17]. Nonetheless, strong endogenous social capital can mitigate these challenges by fostering norms of reciprocity and shared responsibility [15].

This is what enables larger communities to sustain collaborative efforts. The findings highlight the duality of the length of residence as a potential driver and inhibitor of community contributions [24]. Even if most of the members of these larger communities live in communities with strong social capital built up over a long period of residence, this potentially facilitates the act of contributing collectively [19]. What emerges more strongly are the positive effects of length of residence. The reverse is also true [20].

The length of residency also plays a pivotal role in shaping social capital and its relationship to collective action. The study finds that longer durations of stay in disadvantaged neighborhoods are associated with reduced social capital [23]. Impact, weakening its membership in social clusters. This suggests that prolonged residence in such areas leads to social fragmentation [25]. Further erodes the strength of community ties and hampers collective action. These findings are in line with recent research on neighborhood dynamics. It emphasizes that longer residency in deprived areas can foster disengagement rather than cohesion [18].

These dynamics underscore the importance of understanding how social capital, group size, and length of stay interact to shape contributions to grassroots initiatives. Particularly in high-risk contexts such as unguarded railroad crossings. While there is substantial research on social capital and the provision of public goods, limited attention has been paid to how these dynamics work. It specifically affects community-driven safety measures at railroad crossings [2]. Existing studies often focus on traditional public goods, such as parks or roads. It ignored the unique challenges posed by high-risk safety initiatives in residential areas.

This study addresses this gap by examining the role of exogenous social capital and group size in moderating the impact of length of residence on contributions to self-funded railway crossing guards in Padang. Technically using two-stage probit regression, this study investigates how factors such as neighborhood cohesion and length of residence shape participation in community safety initiatives. Based on collective action theory, the study hypothesized that group size strengthens the relationship between social capital and contribution, with length of residence acting as an important moderating factor.

2. LITERATURE REVIEW

2.1 Group size behavior in railway crossing safety

The dynamics of community group size and free-rider behavior in the context of railway crossing safety pose unique challenges and opportunities. Large groups (communities) can face coordination issues, communication barriers, and free-rider tendencies. This, in turn, hinders collective action and jeopardizes the safety of citizens. This aligns with Olson's theory of collective action. He suggests that as group size increases, the incentive for any single individual to contribute diminishes due to the diffusion of responsibility [7]. Recent studies in the context of urban security confirm that larger group sizes reduce monitoring capabilities. This, in turn, increases anonymity and thus decreases accountability [10, 11].

In contrast, smaller communities can benefit from stronger social ties, shared norms, and greater accountability [15]. This would facilitate collective decision-making and resource mobilization. Such benefits have been observed in studies analyzing the effects of community scale and cohesion on cooperation. Especially in safety-related community tasks [5]. Researchers explored the impact of urbanization on railway safety in residential areas. Furthermore, they explained the role of community size, demographic composition, and infrastructure development in shaping safety. Their study emphasizes the need for a tailored approach to address safety challenges [2].

The research considered the diverse contexts and dynamics present in different communities. Understanding the complex

dynamics of community size allows policymakers and community leaders to develop targeted interventions. This is aimed at improving railroad crossing safety. Especially citizen-driven safety initiatives at railroad crossings.

These self-help initiatives have attracted the attention of researchers who want to understand the factors that influence participation, cooperation and sustained engagement among citizen members [25]. The research underscores the importance of community engagement, stakeholder collaboration and participatory decision-making processes. These processes foster a sense of ownership and responsibility for safety [17].

Furthermore, investigated the phenomenon of free-rider behavior in community safety initiatives [9]. They proposed a conceptual framework to explain individual motivations, incentives and deterrents [26]. Based on the free-rider phenomenon and some of its deterrents, this research has identified strategies to encourage cooperation [8]. Correspondingly, it enhances collective accountability and responsibility within the community. The results of this study underscore the need for targeted interventions to address the factors underlying free-rider behavior. Some of these include social norms, trust, and perceptions of fairness [10, 13].

2.2 Free-rider tendencies in public goods delivery

The concept of free-rider behavior significantly impacts the provision of public goods and collective action. Scholars have provided a comprehensive theoretical framework for understanding free-riding in both organizational and community contexts. They demonstrate how individual incentives often conflict with collective goals [9]. A dynamic clearly observable in Padang's railway crossing guard initiatives.

Yong and Choy [10] offer particularly relevant insights through their evolutionary game-theoretic approach to COVID-19 safety compliance. Their results show how free-riding arises when individual benefits outweigh perceived costs. This mirrors our observations in Padang, where residents weigh personal costs against community safety benefits. Barrett and Raskoff [8] further enrich this discussion by examining the moral dimensions of free-riding in collective action scenarios, providing a philosophical framework for understanding resident participation decisions.

Free-riders pose a challenge to initiatives aimed at addressing shared problems or improving welfare for and based on the community. The behavior of taking advantage of collective goods without contributing still emerges, especially in residential areas. Especially when safety provisions at railroad crossings are very important. Recent transportation studies confirm that infrastructure safety that relies on community efforts is particularly vulnerable to non-contribution in low-trust environments [2, 6].

In residential areas adjacent to railway crossings, safety provisions are particularly important due to the increasing trend of urbanization. explores community-driven safety initiatives in these areas. Proximity to hazards, such as railroad crossings, can foster urgency and collective efforts among residents. Although these responses may be unevenly distributed, as seen in studies on community-based safety programs in vulnerable urban areas [5, 17]. Therefore, it is important to emphasize the importance of addressing free-rider tendencies. All of which are essential for maintaining effective safety provisions.

While community-driven initiatives offer hope, sustaining collective efforts presents challenges. The voluntary nature of these efforts, coupled with the absence of enforcement mechanisms [22]. This combination risks exacerbating free-rider tendencies. These conditions underscore the complexities associated with maintaining consistent contributions from citizens. The results may diminish the effectiveness of safety.

Research on reciprocity and voluntary contributions to public goods highlights the role of social norms, trust and altruism in reducing free-rider tendencies [13, 15, 27]. Through experimental games and real-world examples, researchers examine the willingness of individuals to cooperate. Not only that, they also illustrate how individuals' contributions to public goods are influenced by social context, perceptions of fairness, and expectations of reciprocity. In addition, research on the governance of common pool resources underscores the importance of institutional arrangements and collective action in addressing collective dilemmas.

2.3 Exogenous social capital moderated by length of stay in contribution

Social capital, characterized by networks, norms, and trust that facilitate collective action, is a cornerstone of community cohesion and engagement. Its development stems from both personal and systemic influences. Specifically, the length of residence in a neighborhood has emerged as a significant determinant [19, 20]. Studies have shown that both bonding and bridging social capital are influenced by how long residents live in and interact within a community [17].

Recent studies emphasize the dual nature of length of stay [18]. They show how it can foster or erode social capital depending on contextual environmental conditions and individual characteristics [24]. This review synthesizes recent findings on how social capital interacts with length of residence to moderate contributions to community initiatives. It focuses on the positive and negative impacts shaped by neighborhood dynamics. The length of residence in a neighborhood creates opportunities for individuals to build trust [14]. Furthermore, establishing relationships and participating in communal activities [21].

Residents with a long duration often have a stronger connection to their community. As such, this encourages higher levels of bonding and bridging social capital [16]. This engagement contributes to neighborhood stability, collective action, and a shared sense of responsibility for public goods [28]. However, the length of stay does not unilaterally increase social capital. The effect is mediated by neighborhood conditions.

A positive neighborhood with strong economic stability, security, and social services is likely to reinforce the benefits of long-term residence. This will facilitate higher levels of cooperation and trust among neighbors [19]. Conversely, in disadvantaged or declining neighborhoods, the relationship between length of stay and social capital may turn negative [17]. Prolonged exposure to economic stagnation, social fragmentation, or physical decay erodes trust.

Next, it diminishes participation in community activities. Such environments exacerbate disengagement and isolation, weakening both bonding and bridging social capital. Additionally, adverse neighborhood conditions may perpetuate stress and mistrust [23]. In the end, it undermines

collective action and limits the development of meaningful social networks [29]. Figure 1 below presents different types of level railroad crossings. It provides a visual context for the various infrastructure risks that shape the community-driven safety response discussed above.

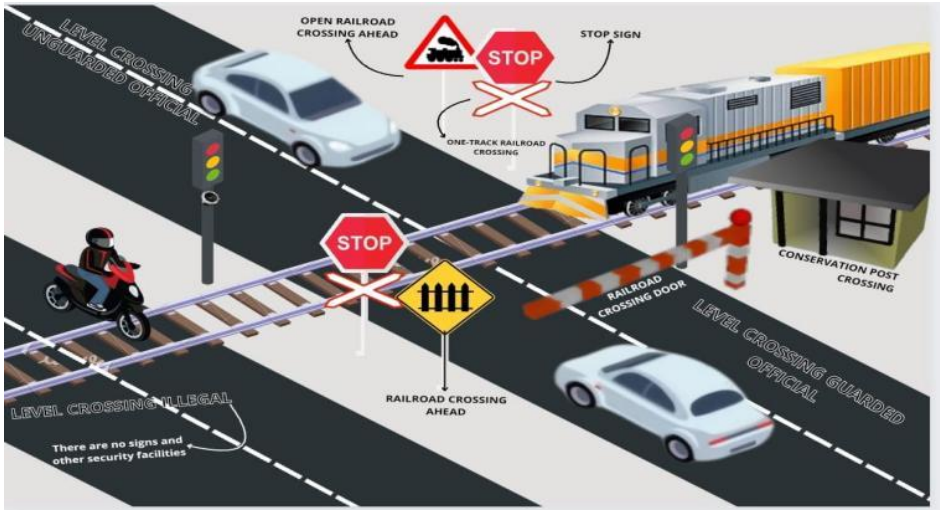

Figure 1. Some classifications of level railroad crossings
Source: Author

3. METHODOLOGY

The research design of this study is structured to investigate the dynamics of free-rider behavior concerning the provision of public goods, particularly in the context of railway crossing safety, within the urban setting of Padang city. The research focused on three main sub-districts in Padang that are predominantly traversed by level railway crossings: Padang Timur, Padang Utara, and Koto Tangah. These areas have a significant number of new residential developments intersected by railway tracks.

Koto Tangah sub-district is particularly notable, as it has the largest population among the sub-districts. Given the substantial population and extensive railway crossings in Koto Tangah, this area was chosen for a detailed study. The residential areas in Koto Tangah, as observed through Google Earth, are characterized by long stretches of railway tracks passing through them. To narrow down the sample, the analysis was further focused on individual neighborhood within these areas. The use of satellite and participatory mapping tools has been widely used in transport studies where official data is scarce [4].

Some neighborhoods in Koto Tangah have multiple residential areas intersected by railway tracks. In selecting specific neighborhood, those closest to the railway tracks were prioritized. Due to the unavailability of official data neighborhood intersected by railway tracks, we collected data through our resources. This data collection involved taking photos using Google Earth to generate maps of residential areas, railway tracks, and the locations of level crossings.

Neighborhoods were stratified based on demographic characteristics, socioeconomic status, and proximity to railroad crossings. Specifically, we categorized individuals as free-rider enthusiasts or avoiders based on their contributions towards self-help railway crossing guards. Only neighborhoods with level railroad crossings that residents pay for and have unofficial crossing guards were included in the study. We excluded residents who did not contribute and neighborhoods without resident-provided or PT KAI (Kereta Api Indonesia)-provided crossing guards.

This stratification ensures a diverse sample, allowing for broader generalizations about free-rider behavior in various contexts. Within each stratum, a systematic random sampling technique was used to select 20 households. This method minimizes selection bias and ensures each household has an equal chance of being included in the study. Each neighborhood was carefully selected to represent Padang's diverse urban landscape. This took into account factors such as population density, economic diversity, and the prevalence of unofficial railroad crossings [5].

3.1. Measurement of variables

Dependent Variable (Y). The dependent variable used in this study is the tendency of free riders. Categorizing free rider tendencies based on contribution behavior facilitates the assessment of individual involvement in collective endeavors. Free rider tendencies use dummy variables. Using dummy variables to operationalize free rider tendencies allows for quantitative analysis of individual behavior within the community.

The operationalization of free-rider behavior draws from the conceptual framework in the *International Encyclopedia of Ethics*, which distinguishes between passive and active free-riding [30]. That is a distinction reflected in our binary classification of contribution behaviors. In addition, Kantian perspectives offer normative reasoning on why participation in communal safety efforts is a moral obligation [31].

If a person's contribution is below the average contribution of residents of each housing, it is categorized as low, and then given a value of 1. Where the person can be categorized as tending to behave free rider (free rider lover). Conversely, if a person's contribution is above the average contribution of residents of each housing, it is categorized as high, then given a value of 0. Where the person can be categorized as tending to behave not free-rider (free-rider averter). Previous studies show that communal norms reduce free-riding. Previous research has shown that communal norms significantly reduce

free riding behavior. This supports the inclusion of social factors in behavioral modeling [8, 15]. By discerning between low and high contributors, the study captures variances in behavior and perceptions concerning collective action and public goods provision.

Main Independent Variables (X) is group size, operationalized as the average household size within the residential area. Researchers often employ various measures, including demographic data, social network structures, and qualitative insights, to assess group size accurately. Group or community size refers to the number of individuals within a social unit, such as a neighborhood or organization. Researchers assess group size using various measures, including demographic data and social network structures. The definition and operationalization of community size directly impact the analysis and interpretation of free-rider tendencies in safety initiatives at railway crossings [11]. So, in this case, the group size is derived from the average family size in each residential area, and serves as a variable. This variable, representing the number of family members in sampled households, reflects the community's scale [10].

Our measurement of social capital builds upon a rigorous examination of homeownership's effects on social capital formation [16]. Their findings validate our use of residency duration as a proxy for social capital accumulation [28]. Particularly, their demonstration of how stable housing tenure strengthens community ties and collective action capacity. The concept of social capital is widely recognized as the networks, norms, and trust that facilitate coordination and cooperation for mutual benefit.

Scholars have argued that individuals who live in a community for a longer period tend to accumulate more social capital through social interactions and the establishment of trust-based relationships. The length of stay in a neighborhood is positively correlated with the formation of more stable and stronger social ties [19]. It is essential for collective action and social cohesion. Other researchers argue that residents who have lived relatively long in a neighborhood often participate more actively in community organizations. They essentially engage in volunteer work and contribute to the social fabric of their community [21].

This participation helps individuals integrate into social networks. In turn enhances their social capital. Individuals who stay longer in one place are more likely to develop personal relationships with neighbors. Then, participate in local events and build mutual trust that reinforces community bonds [14]. In contrast, short-term residents may face barriers in accumulating social capital because of a lack of stability in relationships and social connections. Communities with higher turnover rates often experience lower levels of social capital [23].

The research employs Binary Probit Regression as the primary data analysis method. This is chosen due to the nature of the data, where the dependent variable is non-metric and the independent variables are a mix of continuous and categorical. Probit regression is suitable for binary outcomes, making it ideal for predicting the probability of free-rider behavior based on various independent variables. The Probit regression model is represented as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_{2+} \beta_i \sum_{i}^{n} X_i + \varepsilon_i \quad (1)$$

Other control variables are shown below in Table 1.

Table 1. Data variables

Description	Variable	Indicator	Obs	Mean	Std. Dev.	Min	Max
Number of contributions towards railway crossing guards	de_free0	Someone whose contribution is below the average is categorized as low tendency (free rider lover)	220	0.35	0.478	0	1
	de_free1	Someone whose contribution is above the average is categorized as high tendency (free rider averter)	220	0.65	0.478	0	1
Average number of household members	Group Size	average	220	3.045	0.727	1.7	4.45
Score of social capital which divided into 3 cluster	1.Soc_cap	Lower cluster	220	0.273	0.446	0	1
	2.Soc_cap	Medium cluster	220	0.364	0.482	0	1
	3.Soc_cap	High cluster	220	0.364	0.482	0	1
Gender of Head of Household	Gender1	male	220	0.591	0.493	0	1
	Gender0	female	220	0.409	0.493	0	1
Highest level of education of Head of Household	EducLevel1	Elementary School	220	0.045	0.209	0	1
	EducLevel2	Junior High School	220	0.095	0.295	0	1
	EducLevel3	Senior High School	220	0.473	0.5	0	1
	EducLevel4	Diploma	220	0.132	0.339	0	1
	EducLevel5	Bachelor	220	0.255	0.437	0	1
Age of Head of Household	Age	Years	220	46.345	10.23	26	75
Home ownership	Home Ownership1	own	220	0.691	0.463	0	1
	Home Ownership2	rent	220	0.295	0.457	0	1
	Home Ownership3	family-owned	220	0.014	0.116	0	1
Length of time has lived in the housing	Length of Residence	Years	220	12.927	7.664	1	40
Total income of the household transformed	ln_income	Ln (Logarithm)	220	15.465	0.483	14.509	16.524

Source: Author's calculation

3.2 Stage probit regression

Using the duration of residency in a neighborhood as an instrumental variable (IV) is a theoretically grounded and empirically robust approach to analyzing the interplay between social capital, group size, and collective action. Residency duration is a natural proxy for social capital. Longer-term residents tend to form stronger trust networks, deeper social ties, and greater accountability within their communities [16].

These dynamics significantly enhance participation in public goods provision. The public good such as community-driven safety initiatives at railway crossings. Its provision may be by facilitating sustained engagement and reducing free-riding behavior. Empirical evidence supports this relationship. It highlights how extended tenure in a neighborhood strengthens social cohesion and fosters norms of reciprocity and shared responsibility [27].

The relevance of residency duration as an IV lies in its strong correlation with social capital. However, this relationship is not uniform across contexts. In stable and affluent neighborhoods, long-term residency generally enhances collective action. Thus, creating environments conducive to community safety efforts. Conversely, in disadvantaged or declining neighborhoods, prolonged exposure to adverse conditions such as economic stagnation or social fragmentation. It can erode trust, reduce participation, and weaken social cohesion [29].

This dual nature of residency duration is a potential enhancer and inhibitor of social capital. It will provide a nuanced lens for examining variations in collective behavior. Residency duration is also exogenous to the specific outcome of free-riding behavior, satisfying the exclusion restriction criterion for IV validity. While it influences social capital, it is not directly determined by individual decisions to participate in or free-ride on community safety initiatives. Instead, residency duration is shaped by external factors such as housing markets, employment opportunities, and family dynamics [32]. Those facts are unrelated to free-riding behavior. Furthermore, residency duration affects free-riding only indirectly through its impact on social capital, ensuring the instrument's validity.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 (X_2 = X_z) + \beta_i \sum_{i}^{n} X_i + \varepsilon_i \qquad (2)$$

where, β_2 represents the coefficient predicted social capital (X_2) from residency duration variable (X_z). A significant coefficient confirms that social capital, instrumented by residency duration, influences the likelihood of participation or free-riding.

4. RESULTS AND FINDINGS

Our results are in line with theoretical expectations. Larger community group sizes are associated with higher free-rider behavior. Indeed, there is a temptation to create an environment where free-riders can easily avoid detection. Empirical confirmation of this theoretical conjecture adds empirical weight to economic and sociological theory. Specifically related to collective action and the provision of public goods in fragmented urban environments [10].

The regression results in columns 1 to 7 reveal the relationship between key variables and their impact on collective action. The coefficient of the group size variable consistently remains positive and significant across columns. Its magnitude ranges from 0.336 to 0.394. This indicates that as group size increases, so does the potential for collective action [11]. However, the strength of the effect decreases slightly when we move from column 1 (0.373) to column 7 (0.340). So while larger groups can mobilize, they also encourage freer behavior [5].

The coefficient of the gender variable fluctuates from 0.0377 to 0.139 across columns. However, it remains statistically insignificant in all models. This suggests that gender does not have a strong influence on participation in collective action. Although previous literature has shown mixed results depending on cultural or contextual factors. However, the lack of significance may indicate gender-neutral dynamics in this particular situation [19].

Education, measured in several categories, generally shows a negative coefficient. This finding indicates that higher levels of education are associated with lower participation in collective action. This negative relationship is consistent across all columns. Although none of the coefficients are statistically significant. This finding challenges the assumption that education always drives community engagement [26]. Might be community stability or the specific characteristics of the collective action are more relevant factors in influencing participation.

Age shows a significant positive relationship with collective action in columns 2 to 4. The magnitude of the coefficient ranges from 0.0213 to 0.0220. This is in line with the findings of Fraser [23], who suggests that older individuals are more likely to contribute to collective efforts. This could be due to a greater sense of community responsibility or past experience in similar initiatives. The importance of age across specifications highlights its role in driving community-driven initiatives.

For home ownership, the impact is inconsistent. While the coefficients in columns 6 and 7 are positive (0.253 and 0.273), this variable becomes insignificant in columns 2 and 3. This pattern suggests that home ownership plays an important role in motivating community engagement. The effect appears to depend on socioeconomic conditions and neighborhood characteristics. The observed variability likely stems from economic stratification. Research studies suggest that homeowners in more stable neighborhoods show greater participation in safety initiatives compared to those in economically disadvantaged areas [24].

Finally, income (ln_eng) in column 7 shows a negative, but statistically insignificant coefficient (-0.251). This aligns with Radin's [33] perspective that income alone does not guarantee greater civic participation. Especially in stratified neighborhoods where high-income individuals may feel detached from local issues. He argues that income does not necessarily correlate with increased citizen engagement. Especially when there is a large income gap within the society. The negative sign here suggests that higher-income individuals may contribute less in collective action.

4.1 Extended regression

The analysis of the benchmark regression model and the extended regression model (Table 2 and Table 3) reveals some significant points. Social capital, group size, and demographic

factors affect collective contributions. The model that includes social capital provides a better understanding of the dynamics that drive participation in community safety initiatives. In an extended model, this increases the explanatory power. Research has emphasized the important role of trust and norms in amplifying or attenuating the effects of structural variables such as group size [9].

Table 2. Benchmark regression (no social capital)

Variables	de_free1	de_free2	de_free3	de_free4	de_free5	de_free6
Group_size	0.373***	0.364***	0.394***	0.359***	0.336**	0.340**
	(0.120)	(0.129)	(0.132)	(0.134)	(0.135)	(0.136)
Gender		0.0377	0.0679	0.139	0.137	0.139
		(0.190)	(0.196)	(0.201)	(0.203)	(0.203)
EducLevel 2			-0.583	-0.471	-0.478	-0.520
			(0.544)	(0.561)	(0.557)	(0.568)
EducLevel 3			-0.241	-0.171	-0.173	-0.208
			(0.485)	(0.501)	(0.496)	(0.508)
EducLevel 4			-0.464	-0.329	-0.333	-0.280
			(0.526)	(0.543)	(0.538)	(0.550)
EducLevel 5			-0.699	-0.658	-0.678	-0.639
			(0.496)	(0.510)	(0.505)	(0.517)
Age				0.0215**	0.0213**	0.0220**
				(0.00928)	(0.00933)	(0.00938)
2.Home_own					0.253	0.273
					(0.203)	(0.203)
3.Home_own					-0.463	-0.499
					(0.750)	(0.759)
ln_income						-0.251
						(0.201)
Constant	-0.740**	-0.735**	-0.425	-1.423*	-1.397*	2.447
	(0.373)	(0.373)	(0.603)	(0.751)	(0.751)	(3.161)
Observations	220	220	220	220	220	220

Source: Author's calculation

Table 3. Extended regression (social capital adding)

Variables	de_free1	de_free2	de_free3	de_free4	de_free5	de_free6
1.Soc_cap	0.162	0.164	0.197	0.142	0.143	0.163
	(0.211)	(0.212)	(0.215)	(0.218)	(0.219)	(0.220)
2.Soc_cap	0.742***	0.749***	0.846***	0.830***	0.823***	0.846***
	(0.224)	(0.226)	(0.235)	(0.238)	(0.244)	(0.246)
Group_size	0.369***	0.381***	0.426***	0.394***	0.377***	0.386***
	(0.121)	(0.130)	(0.135)	(0.137)	(0.138)	(0.139)
Gender		-0.049	-0.024	0.041	0.027	0.025
		(0.196)	(0.203)	(0.208)	(0.211)	(0.211)
EducLevel 2			-0.597	-0.480	-0.481	-0.537
			(0.571)	(0.589)	(0.586)	(0.602)
EducLevel 3			-0.183	-0.0991	-0.0851	-0.129
			(0.509)	(0.527)	(0.523)	(0.540)
EducLevel 4			-0.557	-0.410	-0.406	-0.346
			(0.550)	(0.568)	(0.565)	(0.582)
EducLevel 5			-0.755	-0.711	-0.719	-0.678
			(0.520)	(0.535)	(0.532)	(0.548)
Age				0.0213**	0.0207**	0.0213**
				(0.00963)	(0.00966)	(0.00972)
2.Home_own					0.114	0.137
					(0.212)	(0.212)
3.Home_own					-0.660	-0.708
					(0.736)	(0.744)
ln_income						-0.297
						(0.209)
Constant	-0.975**	-0.984**	-0.752	-1.726**	-1.667**	2.866
	(0.389)	(0.391)	(0.632)	(0.783)	(0.783)	(3.283)
Observations	220	220	220	220	220	220

Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1

Source: Authors' calculation

In both models, group size consistently shows a positive relationship with the probability of contribution. The magnitude of the coefficient increases slightly in the expanded model (from 0.336-0.373 in the baseline model (Table 2) to 0.369-0.426 in the expanded model (Table 3)). This suggests that including social capital strengthens the effect of group size. This may be due to its moderating role in enhancing collective action. Recent studies highlight the moderating role

of social capital in improving group coordination and reducing free-rider behavior.

The inclusion of social capital in the extended model on Table 3 introduces an important variable. The significant and positive coefficient of the second category of social capital (2.soc_cap, moderate level), with coefficients ranging from 0.742 to 0.846, underscores the importance of trust and community cohesion in promoting collective contributions. This is in line with theoretical perspectives on the role of trust in reducing transaction costs and mitigating free-rider behavior [20]. In contrast, the first category of social capital (1.soc_cap) has a smaller impact, although its positive sign is in line with expectations.

Gender shows variation in sign and remains statistically insignificant in both models. This indicates a limited influence on contribution behavior. While education level generally has a negative relationship with the probability of contribution. Nonetheless, the significance level remains low in both models. This suggests that while education affects the level of social capital, its impact on contribution is likely mediated by other factors such as trust or group dynamics. Age also consistently shows a small but positive effect. However, it remains significant in both models. This means that its relevance as a predictor of contribution is strong.

Home ownership shows mixed impacts. Generally, the coefficients are insignificant in both models. While the second category of home ownership shows a positive relationship. The third category remains negative. This heterogeneity reflects findings that housing stability impacts community engagement differently based on housing tenure and condition [32]. Similarly, the log-transformation of income (ln_income) has a negative coefficient. However, it is not significant in either model.

4.2 Two-stage probit regression

Table 4 presents the results of the two-stage probit regression model using length of stay as an instrumental variable for social capital. The coefficient of social capital (instrumented) ranges from 1.127 to 1.294 and is significant in all models. This confirms that social capital has a strong influence on collective contributions, supporting theories of embeddedness and reciprocal behavior.

Group size in this model is weaker than in the single-stage regression (Ordinary Probit in Tables 2 and 3), with coefficients between 0.209 and 0.238. In fact, some of them lose statistical significance (columns 1 to 4). This suggests that the role of group size is partly mediated by social capital, i.e., trust and networks developed through extended periods of cohabitation. As such, in communities with high social capital, group size may exert less negative pressure on cooperation.

Education remains insignificant, with mixed signs. Interestingly, age now loses significance, perhaps due to collinearity with residency length. Gender remains insignificant, while home ownership shows a slight positive effect only for the second category. This again reflects that the influence of demographic and economic variables is conditional on contextual social structures and norms.

Social capital, represented by membership in social groups, is influenced by group size and length of stay. The use of length of residence as an instrumental variable in the two-stage probit regression overcomes potential endogeneity issues. This premise is an important methodological consideration in urban studies. Research has shown that instrumental variables can help isolate causal relationships between individual characteristics and neighborhood context.

Table 4. 2-stage probit regression (length of stay)

Variables	de_free1	de_free2	de_free3	de_free4	de_free5	de_free6
Soc_cap	1.127***	1.166***	1.244***	1.247***	1.280***	1.294***
	(0.210)	(0.190)	(0.122)	(0.0936)	(0.0848)	(0.0765)
Group_size	0.209	0.247	0.244	0.238*	0.230*	0.222*
	(0.159)	(0.159)	(0.165)	(0.132)	(0.131)	(0.130)
Gender		-0.243	-0.209	-0.218	-0.264	-0.270
		(0.175)	(0.169)	(0.172)	(0.170)	(0.167)
EducLevel 2			-0.245	-0.246	-0.199	-0.201
			(0.479)	(0.457)	(0.448)	(0.447)
EducLevel 3			0.0958	0.0943	0.163	0.154
			(0.398)	(0.395)	(0.384)	(0.383)
EducLevel 4			-0.381	-0.379	-0.343	-0.267
			(0.446)	(0.434)	(0.424)	(0.422)
EducLevel 5			-0.394	-0.411	-0.334	-0.258
			(0.455)	(0.424)	(0.419)	(0.414)
Age				0.00172	-0.00072	-0.00107
				(0.00905)	(0.00903)	(0.00888)
2.Home_own					-0.321*	-0.314*
					(0.176)	(0.174)
3.Home_own					-0.798	-0.816
					(0.627)	(0.626)
ln_income						-0.229
						(0.169)
Constant	-1.370***	-1.399***	-1.384***	-1.436**	-1.283*	-1.283*
	(0.344)	(0.346)	(0.500)	(0.669)	(0.666)	(0.666)
Obs	220	220	220	220	220	220

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Authors' calculation

Citizen group size significantly affects free-rider behavior. Larger groups lead to reduced individual contributions to community safety efforts. As groups get larger, accountability weakens, and free-rider behavior increases [7]. This

potentially reduces the effectiveness of collective action. This finding is consistent with collective action theory, which states that in large groups, individual incentives to contribute are reduced. As such, this leads to suboptimal outcomes. This study suggests that although social capital encourages participation, the effect is weaker in larger groups. In such groups, individuals may feel less responsible for maintaining the collective good. Then ultimately, it may be detrimental to community-driven safety efforts [8].

Length of stay also plays an important role in shaping social capital and its relationship with collective action. This study found that a longer duration of residence in disadvantaged neighborhoods was associated with reduced social capital. In addition, it also led to weaker levels of membership in social groups. This suggests that prolonged residence in such areas leads to social fragmentation. This erodes the strength of community ties and inhibits collective action. These findings are in line with recent research on neighborhood dynamics.

They emphasize that longer stays in deprived areas can promote disunity rather than cohesion [18]. In contrast, longer stays in more stable neighborhoods tend to strengthen social capital by building trust [24]. As such, it can facilitate communication and encourage participation in collective action. This double effect underscores the importance of neighborhood stability in promoting or inhibiting social cohesion.

5. CONCLUSIONS

This study investigates free-rider behavior in community-managed railway crossing safety initiatives. It found complex interactions between group size, social capital, and duration of residence in the neighborhood. The findings were obtained from ordinary probit, extended probit, and 2-stage probit regression models. The findings also speak of a consistent positive relationship between group size, social capital, and free-rider propensity. This provides new insights into the dynamics of collective action.

A larger community (citizen group) size was found to exacerbate free-rider behavior. This positive relationship persisted across all models. This suggests the importance of tailored interventions to address coordination challenges in larger communities. Social capital, measured through social trust, emerged as a significant factor. Social capital showed a positive relationship with free-rider tendencies. While trust and cohesion are typically associated with cooperation, our findings highlight their dual role in community settings. Fostering collaboration also reduces monitoring, which facilitates the potential for free-riding.

The inclusion of residency duration as an instrumental variable in the two-stage probit model provided robust insights into the endogenous role of social capital. Lengthier residency in disadvantaged neighborhoods was associated with declining social capital. Thus, weakening collective efforts. Meanwhile, stable or affluent neighborhoods benefited from stronger networks and increased participation. These findings underscore the critical role of context in shaping social behaviors.

The shift from ordinary probit to two-stage probit regression highlights the importance of addressing endogeneity when analyzing social behaviors. By controlling for the reciprocal effects of trust and participation, this approach provided more accurate estimates of the relationship between social capital, group size, and free-riding. The findings also confirm that demographic characteristics like education, while significant, are mediated by underlying relational factors.

Policymakers should consider implementing a framework that promotes transparency and accountability in safety initiatives. An initiative that is directly led by the community. For example, establishing small, task-specific committees with clearly defined roles and responsibilities can help reduce free-rider behavior. In addition, providing housing incentives or subsidies in stable neighborhoods can encourage residents to stay for the long term. This is expected to foster stronger social capital and collective action. These measures aim to address systemic challenges in sustaining community-driven safety measures.

Meanwhile, community leaders can play an important role by organizing regular events. These could be neighborhood meetings or collaborative projects, to strengthen social bonds and trust among residents. Activities like these are especially important in larger communities. Especially where anonymity often weakens individual accountability. Establish peer monitoring mechanisms. It is expected that fellow citizens monitor and report on their contributions to safety efforts. This will reduce the prevalence of free-rider behavior. These efforts collectively build a sense of ownership and responsibility. It will also strengthen the sustainability of grassroots initiatives.

Urban planners should prioritize integrating safety features into residential areas. These include pedestrian crossings and measures to reduce traffic build-up near railways. Proactive planning can reduce reliance on community-based interventions, which are often vulnerable to collective action challenges. In addition, planners should use comprehensive and up-to-date data sets beyond Google Earth imagery. This planning ensures accurate assessment of at-risk areas. Collaborate with local governments to map informal development and high-risk areas. This improves planning outcomes and ensures a more targeted approach.

Collaboration between public and private entities can strengthen transportation safety and community well-being. For example, joint funding of safety measures, such as hiring crossing guards or installing warning systems, can ease the financial burden on residents. Education campaigns that emphasize the benefits of collective action and the costs of free-rider behavior can also motivate greater participation in safety initiatives. These efforts, combined with customized strategies for policymakers, community leaders and urban planners. Ultimately, they aim to translate research findings into actionable solutions. Together, these efforts provide a comprehensive framework for improving transportation safety and promoting community well-being.

Finally, policies must account for the dual effects of residency duration. Revitalization efforts in disadvantaged neighborhoods should prioritize rebuilding trust and cohesion through inclusive community programs. Conversely, in stable neighborhoods, promoting long-term residency through housing incentives and community development initiatives can strengthen social capital and enhance collective action participation. These tailored approaches align with the importance of addressing contextual variables to foster sustainable community engagement.

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