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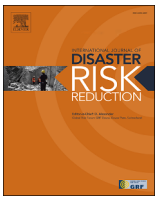

Social capital and individual well-being in the post-disaster period: The case of Hurricane Maria in Puerto Rico

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ABSTRACT

In 2017, Hurricane Maria struck the island of Puerto Rico, damaging infrastructure and dwellings, causing severe economic losses and well-being impacts, such as post-traumatic stress disorder, depression, and anxiety. In this context, cooperative behavior, trust, solidarity and community resilience are crucial components of social recovery. Still, little empirical evidence focuses on the relationship between social capital (SC) and subjective well-being (SWB) in the post-disaster period. This article estimates the relationship between SC and SWB using data from the 2018 World Values Survey wave 7 and the Puerto Rico Statistics Institute. It disentangles different components of SC using an instrumental variable (IV) approach that alleviates many empirical issues that arise in SWB-SC estimations. Given the complexity of this relationship, our approach rigorously identifies the direction and magnitude of each SC component. Results show that this relationship is diverse, since informal SC ties such as friends, neighborhood, and membership in organizations (bonding and bridging) have positive and significant effects, while the linking component, approximated by trust in government, shows a negative relationship. These results provide valuable policy recommendations focused on strengthening existing community instances that foster resilience and municipal capacity to promote social recovery.

1. Introduction

Puerto Rico was affected by Hurricane Maria in September 2017, an event that caused extensive human and material losses [1]. It has been one of the most destructive disasters in the island's history, and its consequences were felt for months after the hurricane passed [2]. Rudner [1] states that "the storm was immense, perhaps the largest recorded, with 150 mph winds and 30 inches of rain". Despite the devastation caused by the hurricane, the response of the US federal government was qualified as untimely and sometimes inadequate, resulting in a slow mobilization of resources to support victims [3]. According to Willison et al. [4], the federal response to Maria in Puerto Rico was slower and smaller in scale compared to the response to Hurricanes Harvey and Irma in Texas and Florida respectively. They suggest that the disparity in response could help explain the higher number of deaths in Puerto Rico. In the same vein, a report in 2022 by the US Commission on Civil Rights concluded that the speed and scale of federal spending in the aftermath of Hurricane Maria were inequitable compared to Hurricane Harvey.[1] The report found that federal resources were deployed faster in

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[1] The report is available here: https://www.usccr.gov/reports/2022/civil-rights-and-protections-during-federal-response-hurricanes-harvey-and-maria.

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Florida and Texas than in Puerto Rico, despite Maria being a more destructive storm. As of April 2019, the island had received only $11 billion (12%) out of an estimated $91 billion for recovery costs [5]. The report also points out that the response was insufficient due to several factors, such as Puerto Rico's Island location, difficulties in resource distribution, shortages of electricity, and the island's pre-existing economic and healthcare crises.

In this context, community-level actions from civil society were needed to bring back normalcy and enhance the well-being of their communities [1].[2] Social capital factors, like joining groups, trusting others, and having common values, led to these cooperative actions, which helped community responses to deal with common challenges and boost individual well-being [6].

There is an increasing interest in social capital research published in the disaster studies literature so far, as the interaction between individuals among social organizations to achieve common objectives leads to benefits for individuals and groups [7].[3] Researchers have found different effects and complex relationships between disasters and social capital. For instance, social capital plays a significant role in the recovery of communities affected by disasters, but the relationship is influenced by various factors such as education and income, family size, occupation, material damage suffered, stability of home, and trauma experience [8–12]. Much less attention has been paid into whether changes in the evaluation of subjective well-being (SWB) could be associated with different forms of social capital (SC) such as social trust, social connections, and volunteering in the aftermath of disasters.

This paper focuses on addressing the following questions: Did social capital influence the individual subjective well-being after Hurricane Maria in Puerto Rico? If so, what kind of social capital was related to individual well-being? To summarize, our research shows that fostering social bonds and belonging to social groups can significantly enhance individual subjective well-being (SWB).[4] Also, we find out that trust in government has a negative impact on individual's SWB.[5] We argue that this negative effect is possibly attributed to the absence of a timely federal government response and the subsequent lack of support from local governments to lead recovery efforts, particularly evident in the aftermath of the Maria event.[6]

This study makes two contributions to the literature. First, it gives new empirical evidence using subjective well-being data to determine the effect of social capital on individual's well-being in a context of disaster. It also alleviates the potential bias affecting the estimates, an empirical issue the literature has partially addressed when analyzing life satisfaction and social capital. Given the complexity of the concept of social capital, our approach provides a rigorous empirical analysis of its influence on SWB after a disaster. Second, by studying the impact of social capital on disaster recovery and exploring ways to improve it for better disaster responses, this paper gives valuable policy recommendations, in the context of one of the Island's most challenging recovery situations, Hurricane Maria in Puerto Rico [13]. This evidence can also justify initiatives that encourage community networks, trust in institutions, and community engagement.

This paper is organized as follows: Section 2 reviews the relevant literature and the context of hurricane Maria. Section 3 presents the data and variables. Section 4 proposes our empirical strategy. Section 5 mainly reports the empirical results, while section 6 discusses their relevance, limitations, and implications. Finally, conclusions and policy recommendations are drawn in Section 7.

2. Literature review

2.1. Context

Hurricane Maria struck Puerto Rico on September 20, 2017, with severe social and economic consequences for the island. The National Oceanic and Atmospheric Administration (NOAA) estimated that the financial damages of Hurricane Maria on Puerto Rico to be around $90 billion [2].[7] Hurricane Maria now ranks as the third most costly hurricane in US history, following Hurricane Katrina in 2005 and Hurricane Harvey in 2017 [2]. Some studies using historical analysis and text analysis from print newspapers have found that the devastation of Hurricane Maria exacerbated preexisting social inequalities and led to conflicts over resources and aid [13–15]. Before Hurricane Maria, Puerto Rico confronted societal disparities from historical, economic, and political determinants. These included elevated poverty ratios, noteworthy unemployment levels, and restricted opportunities for superior education and healthcare amenities [16]. The hurricane had a notable impact on society, particularly regarding the humanitarian crisis on the island. Infrastructure suffered substantial destruction, and 3.4 million people experienced a power blackout which lasted for six

[2] We refer to a community as a group of individuals, families, and organizations living in a particular geographic area who are affected by and respond to the impact of disaster together. These communities may share social, cultural, economic, and environmental connections. The joint resiliency and aptitude to manage and rebound from the catastrophe may significantly impact the comprehensive recovery process [109].

[3] This study refers social capital as the networks, norms, and trust that exist between individuals and groups within a community. The next section elaborates in detail this definition.

[4] SWB is referred to self-reported life satisfaction—in other words, individuals indicate their own judgments via evaluating their lives ([50], p. 199). Researchers often use a specific survey question to measure this concept: "How satisfied are you with your life as a whole?" This question allows researchers to measure life satisfaction and obtain an ordinal happiness scale. Therefore, this study understands life satisfaction as a measure of SWB.

[5] This study uses two types of trust, interpersonal and institutional trust. Interpersonal trust refers to the belief and confidence that individuals or communities have in one another [96]. Institutional trust refers to the confidence that individuals and communities have in the efficacy, reliability, and benevolence of formal institutions and organizations [34].

[6] This study considers the post-disaster period 8 months after the Hurricane Maria hit in Puerto Rico on September 20, 2017.

[7] The estimate includes a confidence interval of 90%, allowing for a margin of error of +/− $25.0 billion. Therefore, the actual damage is likely to be between $65.0 billion and $115.0 billion.

months.[8] Furthermore, the storm cut off the supply of drinking water and food, broke down communication networks [17], and disproportionately affected poor and marginalized communities [18].

In the aftermath of Hurricane Maria, a critical evaluation of the US federal government's response has revealed significant delays and inadequacies, drawing attention to several factors. According to Willison et al. [4], one noteworthy aspect is the impact of political dynamics on the outcomes for Puerto Rico. The study highlights how the involvement of both political parties in aid discussion and the predominant participation of Democrats in advocating for Puerto Rican aid may have shaped the overall government response. Second, the geographical separation of more than 1000 miles from the US mainland also impeded the timely transport of essential goods to the island when urgently needed [3,6]. Despite these challenges, the Federal Emergency Management Agency (FEMA) emerged as crucial player in the early response to Hurricane Maria, as documented in the "*2017 Hurricane Season FEMA After-Action Report*".[9] The report highlights the FEMA's crucial role in logistical coordination, specifically in the efficient movement and distribution of essential commodities from staging areas to survivors, and FEMA's adeptness in overcoming challenges arising from limited situational awareness caused by the loss of communications in Puerto Rico. Moreover, the report pointed out the FEMA's adaptability in an inoperable telecommunications environment. To navigate challenging circumstances, the agency demonstrated flexibility by modifying protocols on field communications, program delivery, and command and control activities.

Recognizing the urgency, the US Congress allocated $20.6 billion in CDBG-DR funds to Puerto Rico in 2018 for post-Hurricane Maria recovery. However, by the end of 2019, only 40% of the budget had been implemented.[10] The delay in budget execution can be attributed to multifaced issues, including corruption concerns, limitations in Puerto Rico's administrative capacity, and challenges in the federal government's capacity to fulfill unmet needs assessments.[11] In 2018, the Governor of Puerto Rico sought increased financial support and aid from FEMA, as indicated in a letter addressed to President Trump on August 30, 2018 [19]. Nearly two years after disaster, a significant absence of governmental initiatives addressing vulnerability reduction across the entire island still persisted, a situation extensively documented in both media outlets and academic literature [1,3,20,21].

The social consequences of Hurricane Maria in Puerto Rico highlight the critical importance of studying concepts such as social capital and well-being. The immense challenges that the island's population faced after the disaster underscored the significance of these concepts in understanding community resilience, disaster recovery, and overall societal functioning. The aftermath of Hurricane Maria vividly illustrates how social capital, encompassing networks, trust, and collaboration within communities, plays a pivotal role in shaping response efforts and long-term recovery. For instance, Talbot et al. [21] point out that social capital was crucial in mobilizing resources for the informal housing reconstruction by households in Puerto Rico after Maria. Through their social networks, households could pool building materials, labor, and financial support. This collective action helped address the scarcity of resources and enabled the reconstruction of homes. In addition, the authors highlight the role of social capital through strong social networks for rapidly disseminating of information about changing circumstances and emerging needs, enabling households to navigate the challenges and uncertainties of the post-disaster context.

Nevertheless, the post-Hurricane Maria landscape in Puerto Rico reveals an uneven distribution of social capital among communities. Delilah Roque et al. (2020) emphasize that communities fostering well-established organizations and collaborative culture had higher levels of social capital. Within the specific context of Puerto Rican neighborhoods, the authors highlight how indispensable the role of community organizations was in the recovery process, increasing community resilience. Furthermore, communities with high social capital often boast strong connections and networks with external resources, including governmental agencies and nonprofit organizations. Delilah Roque et al. (2020) observe that these connections empower communities to access external resources and support, contributing to their resilience and capacity to cope with disasters.

The concept of well-being encompasses an individual's physical, psychological, and social dimensions, providing a holistic understanding of an individual's overall health. Recent research indicates that Puerto Ricans who showed symptoms of anxiety, depression, and post-traumatic stress disorder following Hurricane Maria shared certain demographic and environmental characteristics. Specifically, individuals residing in urban areas were found to be more susceptible to heightened stressors and challenges, ultimately impacting their psychological well-being [22]. Furthermore, those who experienced significant losses, such as property damages and personal belonging, including loss of family members and friends, were identified as more prone to a decline in mental health [23]. Additionally, Vega et al. [24] highlight that older women living alone emerged as a particularly vulnerable group, facing challenges associated with isolation, loss, and coping mechanisms, contributing to their ongoing struggles with mental health.

The arguments mentioned above suggest that the societal implications of Hurricane Maria in Puerto Rico stress the imperative to explore notions such as social capital and well-being. These constructs offer valuable insights into how communities react to and recuperate from calamities, the function of social networks in crisis management, and the wider influence of disasters on individuals' psychological and social welfare. By apprehending and augmenting these facets, policymakers, scholars, and communities can collaborate towards fostering resilience, facilitating recovery, and enhancing the overall quality of life in the face of future adversities.

[8] The Washington Post made a detailed analysis using satellite data from NASA, see https://www.washingtonpost.com/graphics/2017/national/puerto-rico-hurricane-recovery/#:~:text=After%20Hurricane%20Maria%2C%20Puerto%20Rico,into%20an%20ongoing%20power%20blackout.&text=Warning%3A%20This%20graphic%20requires%20JavaScript.

[9] The report is available at: https://www.fema.gov/sites/default/files/2020-08/fema_hurricane-season-after-action-report_2017.pdf.

[10] See the Congressional Research Service for more detail: https://crsreports.congress.gov/product/pdf/IN/IN11389/1.

[11] The. United States Government Accountability Office (GAO) prepared a detailed report about better monitoring of the Community Development Block Grant program for disaster recovery (CDBG-DR). It is available at https://www.gao.gov/assets/gao-19-232.pdf.

2.2. Social capital

Nearly four decades ago, Bourdieu [25] and Coleman [26] argued that social capital is an asset (product and investment, like any other capital), made up basically of interactions and agency that opens up access to additional resources. So, it was considered a natural part of social relationships. The authors regarded that the degree of access and mobilization of resources depends on individuals' accumulation of social capital through durable social networks of more or less institutionalized relationships. Burt [27] suggests that benefits from social capital lie in better-connected people obtaining better returns. There are two perspectives that point to different sources of social capital. The collective perspective [7,25,26,28] suggests that the advantage of social capital is given by the internal strengthening of the community (such as cohesion, closeness, and trust). On the other hand, the individual perspective [29] understands that the advantage is given fundamentally by the group or individual capacity to reach and mobilize distant or non-redundant resources. Burt [27] and Watts [30] suggest that both sources of social capital are complementary. Then, these perspectives recognize two key components of social capital, social networks and trust, or what researchers identify as the structural and cognitive elements of social capital [31].

The literature on social capital in disaster studies further distinguishes bonding, bridging, and linking social capital, each including structural and cognitive components [32,33] (see Table 1 for a summary). Bonding social capital refers to the relationships and interactions within homogeneous groups or communities where individuals have similar characteristics in terms of demographic features, values, attitudes, and available resources and information [34,35]. Examples include relationships with family members, close friends, and neighbors. In the aftermath of a disaster, this kind of social capital provides social support through access to resources, information, and emotional support. Bonding allows people to find support to tackle the harmful effects of disaster and foster attitudes that enhance collaborative actions [32]. The strength of bonding networks lies in their ability to provide immediate assistance due to the existing trust and familiarity among members.

Bridging social capital is understood as relationships and connections between different social groups or individuals within diverse social circles. It facilitates the connection of group or network members to extra-local networks [34].[12] Under this type of social capital, individuals show diversity in aspects like demographics, religion, and preferences, while allowing access to resources out of their first-order contacts [32]. In the aftermath of a disaster, the importance of bridging social capital becomes noteworthy during the primary response phase, akin to bonding social capital. Communities that are affected request support from their acquaintances, social networks, and neighbors to exchange resources and collaborate. This interdependence provides them with supplementary resources and information, augmenting their resilience during the crisis [36]. In addition, Aldrich et al. [37], for the case of Hurricane Katrina, indicate that bridging social capital allowed connected communities (in terms of common identity, culture, and religion) to have earlier recoveries than communities who relied primarily on their neighborhoods.

The third type of network is the linking social capital; it involves connections and interactions between people or communities and formal institutions, government agencies, NGOs, and other organization that have power and resources [34].[13] For this study, one important connection is the trust in government, which is defined as the confidence that individuals and communities have on government's capability to effectively respond to and support them in the post-disaster period. Therefore, this study uses the individual's confidence in the national government as a proxy for linking social capital. In the context of disaster, this kind of social capital is essential because of disaster-stricken communities require external support for long-term recovery efforts. National and international NGOs, national and local governments, and community-based organizations regularly provide this support. Linking social capital allows access to resources, financial aid, and policy support in order to help in sustainable recovery and resilience building [32,34].

2.3. Social capital in the post-disaster period

In general, disaster researchers have found strong evidence at the community level of how vital strong social relationships and networks are for individuals in post-disaster recovery. Social capital can be considered a buffer against the harmful effects of disasters, fostering recovery by providing access to monetary resources (e.g., loans and property repairs) and non-monetary resources (e.g., emotional support, reciprocity, information, and trust) [38]. In the context of disaster, trust and reciprocity hold immense value as social assets that substantially augment disaster resilience and rehabilitation. Communities with high levels of social capital are prone to partake in reciprocal actions that breed solidarity and cooperation among constituents [39,40]. People that lack social connections are less likely to be rescued, seek medical assistance, take preventive measures, and receive help from others [32]. Isolated individuals may not have access to information and may not be able to mobilize resources to advocate for their needs during a crisis. Therefore, building social connections and networks within communities is important to enhance social capital and increase resilience during an emergency. Aldrich [38] employs several case studies from the 1995 earthquake in Kobe, Japan, to study social capital's role in facilitating the neighborhood recovery process using qualitative and time-series data. The author finds that social capital, measured as the number of nonprofit organizations by neighborhood, is positively related to the population recovery rate. The main argument is

[12] Bonding and bridging are not completely mutually exclusive terms. It is worth noting that groups originating from a similar background may not be identical in every aspect and may offer bridging links across generations, sexes, or educational achievements. On the other hand, groups belonging to different social strata might facilitate connections between individuals of the same age and gender who share common educational backgrounds and interests [35].

[13] In the context of disasters, "institutions" refer to formal organizations, government agencies, and established bodies that play a significant role in disaster management, response, and recovery. On the other hand, associations are grassroots groups formed by community members to address specific needs and promote community resilience [36].

Table 1
Social capital classification.

Type of social capital	Definition	Role in disaster response
Bonding	Social capital generated during interactions within homogeneous social groups.	Provides immediate crisis response, sharing resources and mutual aid among close-knit social circles.
Bridging	Social capital generated during interactions between diverse social groups.	Helps in the immediate crisis response by providing access to additional resources and support.
Linking	Social capital generated through interaction with formal institutions and organizations.	Essential for accessing external support, resources, and expertise during the recovery phase.

Source: own creation based on Aldrich [38], Aldrich [34], Aldrich and Meyer [32], and Islam and Walkerden [36].

that individuals integrated within these organizations benefit from the formal and informal social resources they provide.[14] For instance, Haines et al. [41] found that social groups, defined as collections of individuals who share common characteristics, affiliations, or identities and are impacted collectively by a disaster, were more supported after Hurricane Andrew. The bridging social capital contributed to the regeneration of the Vietnamese American community in New Orleans during the aftermath of Hurricane Katrina, through the charitable actions of local and national organizations that resulted in external resources and commercial cooperation between organizations, providing resources and labor for community members [42].

The rise of new social capital networks can be observed in the aftermath of disasters. Besides the traditional measures of social capital, such as membership in social and civic organizations, trust is also considered an essential component [25,26]. Through exchange and cooperation, trust promotes the individual and collective capacity to control uncertain and risky environments, affecting the ability to solve problems in critical and public risk contexts. Toya and Skidmore [12] show that trust is a crucial element in measuring social capital in the context of disasters. The authors found that the overall societal trust in OECD countries from 1990 through 2010 is higher after the population experience relevant disaster events, such as storms, floods, and earthquakes. Dussaillant and Guzmán [43] found that places where the initial level of trust was high, were able to strengthen new trust networks with distant family ties, and increased the interaction between affected neighbors after the 2010 Chilean earthquake. Akbar and Aldrich [8] showed that victims affected by the 2010 Pakistan flood that received support from family, friends, and neighbors during the recovery process increased their trust in them. Also, they found a loss of trust in government by victims, because of the inadequate response to meet their basic needs. However, this study uses a simple regression analysis; therefore, it might be difficult to conclude a causal impact of social capital on people's well-being affected by the disaster.

Similarly, Carlin et al. [9] argue that the government-state absence (perceived or real) at the local and national level in supporting victims can trigger the degradation of personal trust. To develop the above argument, the author focuses on interpersonal trust in the post-disaster period in the case of three powerful earthquakes, such as Salvador (2010), Haiti (2010), and Chile (2010). This argument is also supported by Nicholls and Picou [11], who found that a sample of individuals reported a negative perception of post-disaster state and federal government performance in Hurricane Katrina, which consequently caused lower political trust. Therefore, core elements of social capital, such as interpersonal trust, trust in government, and affiliation with organizations, do not remain constant in the post-disaster period.[15] Complex association systems are adaptive because they evolve and organize organically in response to environmental events or conditions. This adaptive quality is related to the resilience and ability of subsystems (e.g., personal or community networks) to adjust against threats. In terms of Lin [29], this can facilitate the emergence of collective and individual social capital since groups and individuals can take advantage of opportunities present in the networks in which they are embedded to perform beneficial exchanges. Adaptability allows rapid control in unstable environments, eventually generating collective and individual well-being.

2.4. The role social capital on subjective well-being after disaster

Disasters not only damage infrastructure and cause economic losses, but they also affect the mental health and well-being of people in the affected areas. Empirical evidence is mixed regarding the effects of disaster on SWB among people exposed to them.[16] On the one hand, exposure to disasters has profound adverse effects on SWB regularly in low-income contexts. For instance, Berlemann [44], in a study of 80 countries, found that the frequency and severity of hurricanes had higher negative impacts on self-reported life satisfaction in relatively poor countries. National income seems to act as a buffer factor, since governments provide the income necessary to compensate and support people after the exposure to disaster events [44].

[14] In the context of disaster, social formal resources are organized and provided by government agencies, NGOs, and official institutions. On the other hand, informal social resources refer to support that people and communities provide each other, for instance, volunteer networks, family, friends, and neighborhood networks. For additional detail, see Aldrich and Meyer [32].

[15] This study refers to organizations, in the context of disasters, as structured entities with specific functions and roles in disaster management. For instance, NGOs, community-based organizations, and international aid agencies. While institutions refer to formalized structures and system that facilitate the operation of organizations, for example, disaster management agencies or legal and policy structures.

[16] The notion of SWB, defined as "a person's cognitive and affective evaluations of his or her life" [110], has been applied across a diverse range of disciplines including economics, sociology, and psychology to assess the fundamental determinants that impact individuals' overall well-being. SWB is referred to self-reported life satisfaction—in other words, individuals indicate their own judgments via evaluating their lives ([50], p. 199). Researchers often use a specific survey question to measure this concept: "How satisfied are you with your life as a whole?" This question allows researchers to measure life satisfaction and obtain an ordinal happiness scale. Therefore, this study understands life satisfaction as a measure of SWB.

On the other hand, studies have suggested that people directly affected by a disaster may experience increases in SWB. Hommerich [10] conducted a study using survey data from two coastal regions significantly affected by the Japan earthquake and tsunami of 2011. The study found that trust had different effects on SWB for those affected. People affected by the disaster showed high levels of social trust and low levels of trust in governmental institutions. In general, trust positively relates to subjective well-being and is an important source for handling the adverse effects of disasters. Yamamura et al. [45] also found a positive relationship between trust and individual happiness in Japan following the 2011 disaster, suggesting that trust can reduce the shock of vulnerability to disaster on an individual's well-being. Ishino et al. [46] indicated that people reported a higher level of happiness and were more altruistic after the disaster. Additionally, Okuyama and Inaba [47] found a reduction of social interaction among people affected by the earthquake, but a positive relationship with post-disaster life satisfaction. A possible explanation for these findings is that resources, such as trust, solidarity, and altruism available within societies can be activated when the social order is altered.[17] This situation could lead to changes in SWB, since social networks and social trust can engage in cooperative behavior in the post-disaster period, inciting people to report higher levels of life satisfaction.

3. Data and variables

The primary source of data used in this research was the World Values Survey (WVS) wave 7, conducted by the Puerto Rico Statistics Institute from May to October in 2018.[18] The study was based on a multi-stage random sampling methodology, allowing for a representative representation of Puerto Rico in terms of regional and socioeconomic diversity. The original sample consisted of 1127 individuals, obtained through door-to-door survey. However, to ensure the integrity and reliability of our analysis, missing values were carefully addressed, leading to an analytical sample with a reduced size of 1076 individuals. This curation process enhanced the dataset's quality, minimized potential biases, and allowed for a more focused and robust examination of the research variables. Table 2 illustrates the distribution of both the original and analytical sample across Puerto Rico's regions. Additionally, Fig. 1 provides a visual representation of hurricane's center path and the municipalities sampled (depicted in purple).

While it is true that the availability of more immediate data following a disaster is desirable, some studies conducted in the realm of disaster recovery and social capital have indicated that the ramifications of a natural calamity on social networks and communal bonds can be intricate and undergo changes over time [34]. To get a comprehensive understanding of how social capital influences individuals' well-being post-disaster, it is recommended to initiate surveys at least several months after the event. For instance, Nakagawa and Shaw [48] on the impact of the Kobe earthquake in Japan revealed that social capital indicators measured eight months after the disaster provided valuable insights into the recovery of social networks and support systems. This study uses eight months post-disaster measures of social capital, which would allow us to observe the process of social capital rebuilding as communities stabilize and transition from emergency response to recovery and rehabilitation on the island. In addition, the WVS wave 7 is the only dataset that allows us to investigate the nature of social capital in Puerto Rico vis-a-vis the rest of the world. However, the dataset does not contain the change of direction in the individuals' perceptions about the effect of Hurricane Maria on economic values, social well-being, social capital, and confidence, among other things. It only considers the magnitude of the change relative to the different components mentioned above.

In our empirical study, the dependent variable under examination is the individual's subjective well-being (SWB). This variable is assessed through self-reported life satisfaction, where the respondents are asked to evaluate their lives [50]. The question used to measure SWB is "How satisfied are you with your life as a whole?", which is an ordinal indicator ranging between 1 and 5, where we define 1 = extreme dissatisfied and 5 = complete satisfied. Fig. 2 shows the distribution of life satisfaction in our sample. Most of the respondents rate their life satisfaction as 5, which is in line with previous studies, such as Growiec and Growiec [51] and Zhang et al. [52].

To measure the social capital variables, we adopt the conceptual framework put forward by Kyne and Aldrich [53]. This framework incorporates both cognitive and behavioral aspects of social capital. First, we use measures related to cognitive social capital, including trust in neighbors and trust in persons one knows personally. Trust in neighbors denotes the degree of confidence and conviction that individuals possess regarding their fellow community members' integrity, dependability, and benevolence, regardless of the absence of intimate personal relationships [54]. On the other hand, trust in persons known personally is a distinct form of trust that concerns the personal conviction of individuals in their immediate social circle, comprising of intimate companions, familial relations, and acquaintances with whom they share direct personal bonds. Both indicators are critical in understanding the dynamics of social capital within communities and their role in promoting resilience and well-being [34,55]. Second, we use measurements related to behavioral social capital to encompass group membership. Finally, one specific measure focuses on the connection between citizens and those in power, such as networks of trust between individuals and institutionalized government.

The following three indicators serve as proxies for measuring bonding social capital. Our first indicator of social capital gauges an individual's level of trust in his or her neighbors. Trust in neighbors is a binary variable, with a value of one assigned if the individual reports trusting most of their neighbors and zero otherwise. In the aftermath of Hurricane Maria, support from neighbors was crucial in mitigating the vulnerability caused by the closure of essential infrastructure such as supermarkets, banks, and pharmacies. Delilah

[17] Trust, solidarity, and altruism are integral resources that facilitate the advancement of community development, resilience, and overall welfare. These constituents are of utmost importance in promoting cooperation, reciprocal aid, and selfless endeavors that are imperative in surmounting obstacles, including those presented by calamities and emergencies [111].

[18] To access to the data and documentation go to https://www.worldvaluessurvey.org/WVSDocumentationWV7.jsp

The Puerto Rico Institute of Statistics created this section on data from Hurricane Maria https://estadisticas.pr/en/datos-del-huracan-maria#mapas.

Table 2
Analytic sample size by region in Puerto Rico.

Region	Total sample	Analytic sample
Center	187	182
East	194	183
Metropolitan	268	255
North	172	164
West	157	148
South	149	144
Total	1127	1076

Note: The final analytic sample contains observations from every sampled municipality. Source: Own elaboration using World Values Survey data.

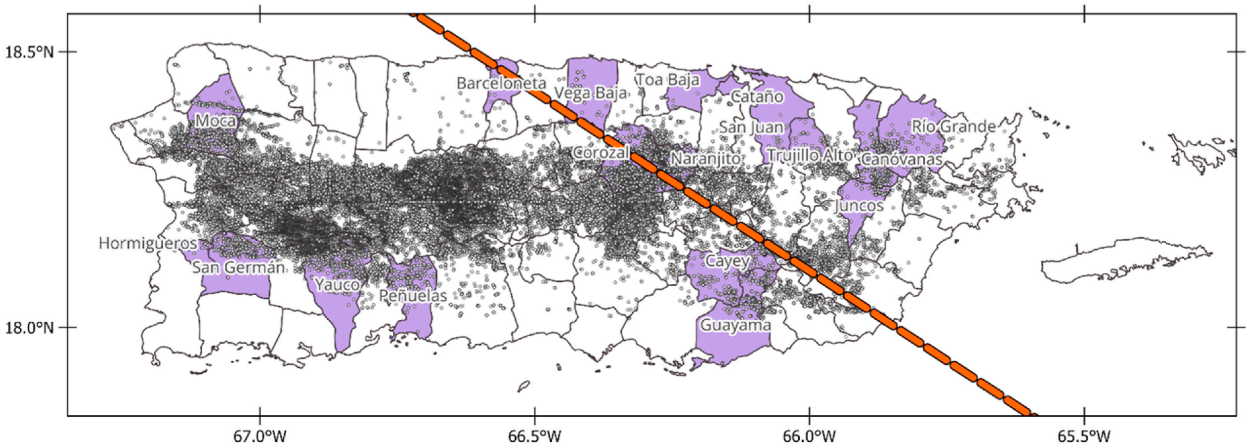

Fig. 1. Sampled municipalities, Hurricane Maria's path and recorded landslides in Puerto Rico.
Note: Grey dots represent recorded slope-failure locations [49]. Dashed line represents the Hurricane's center path. Source: Own elaboration using USGS data.

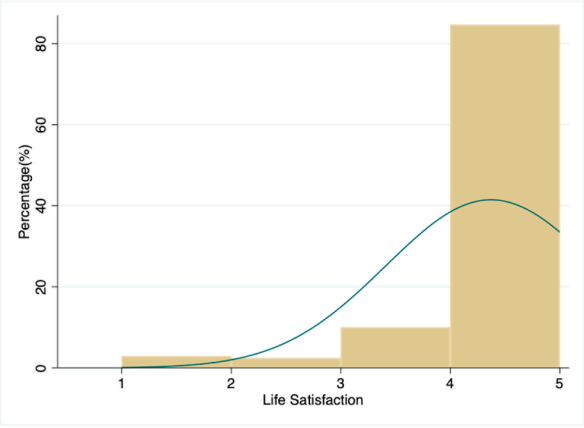

Fig. 2. The distribution of Life Satisfaction.

Roque et al. (2020) highlight that trust and active participation among community members were critical in overcoming the challenges faced by some communities during the aftermath of Hurricane Maria.

The second indicator measures an individual's trust in people he or she personally knows. Like the first indicator, trust in people is a binary variable, with a value of one assigned if the individual reports trusting people and zero otherwise. Disasters can significantly impact people's trust and reciprocity within a community [12,40,43], which are critical factors for social and economic recovery in communities.

The third indicator measures the frequency of socializing with friends or colleagues as a proxy for time investment in socializing.[19] It takes a value of one if the individual reports talking with his or her friends on a daily or weekly basis and zero otherwise. Maintain-

[19] This variable was measured by asking the following question: "For each the following sources, please indicate whether you use it to obtain information daily, weekly, monthly, less than monthly or never: Talk with friends and colleagues".

ing frequent contact with friends provides support and personal aid, especially during and after a disaster [56]. The choice of these indicators is based on the premise that informal networks, such as relationships with friends and neighbors, can provide well-being and financial support in times of adversity [57].

The next form of social tie encompasses bridging social capital, which we measure through an indicator of individual participation in voluntary organizations.[20] This variable is binary, taking a value of one if the individual reports being an active member of any of the following organizations: church, sports club, art or music group, labor union, political party, environmental organization, professional association, humanitarian or charitable organization, consumer organization, or mutual aid group. The value is zero if the individual is an inactive member or not a member of any such organizations. This measure of social capital describes groups of individuals with similar goals and allows for diversity among members in terms of demographics, religion, and preferences. It provides individuals with access to resources through their second-order contacts [32].

The last social capital variable is linking social capital, which we measure through citizens' trust in the national government. It takes a value of one if the respondent answers "a great deal" or "quite a lot" when asked about their level of trust in government and zero otherwise. The WVS only has one item about trust in government, so we restrict our analysis to the federal government. The US federal government operates in Puerto Rico through federal agencies like the FEMA, which encompasses a set of strategies, policies, and actions to respond to the disaster's impact on Puerto Rico's municipalities.[21] We consider that the role of linking social capital is important, because a society that fosters trust between citizens and government creates a positive attitude towards institutions and leads to higher levels of satisfaction among citizens [11]. The slow response from the federal US government in handling the humanitarian crisis post-disaster in Puerto Rico [3] presents an opportunity to understand further the impact of trust in government on the well-being of islanders.

Finally, we include controls for socioeconomic and demographic variables related to SWB and social capital to reduce omitted variable bias. A description of the complete set of empirical variables used in this study is available in Table 3.

4. Empirical strategy

This section describes the empirical strategy we follow to estimate the SWB – social capital relationship, and to address the potential endogeneity problems that could affect our results. The following equation can represent the empirical model of individual subjective well-being:

$$SWB^{*}_{ij} = \alpha + \boldsymbol{SC'}_{ij}\boldsymbol{\gamma} + \boldsymbol{X'_{ij}}\boldsymbol{\beta} + \boldsymbol{C'_{j}}\boldsymbol{\delta} + \varepsilon_{ij} \tag{1}$$

where the sub index i represents the individuals, and j is used for municipalities; the X vector consists of explanatory variables at individual level; SC is a vector of social capital variables, which contains five variables at individual level; C is a vector of explanatory variables at municipality level; ε_{ij} is the error term, and SWB^{*}_{ij} is the self-reported level of well-being measures based on a 5-point scale.[22]

We estimate equation (1) using an Ordered Probit model. Long [58] suggests that the ease of use, simplicity of interpretation and flexibility of ordinary least squares (OLS) justify its use with ordinal data. However, Long also notes that using linear regression with this type of data could produce biased and misleading results. Ordered choice models will estimate the coefficients of SC_{ij} with bias if $E(SC_{ij}\varepsilon_{ij}) \neq 0$, in that case, our social capital variables could face endogeneity problems. Durlauf and Fafchamps [59] argument that correlation between social capital and the error term could be different from zero due to some factors that can affect both social capital and the unobservable error term simultaneously. First, social capital possesses an inherent endogeneity, which implies its susceptibility to the influence of unobserved factors that may also affect the dependent variable in the model. For example, unobserved characteristics of communities may influence both the social capital and individual's well-being. Then, in the context of endogeneity, the error term in the model captures these unobserved characteristics, resulting in a correlation between social capital and error term. Second, social capital can operate as both an antecedent and a consequence of well-being. A higher level of social capital may promote improvements in well-being; however, high level of well-being may also bolster social capital by engendering a heightened sense of collaboration and reliance. This mutual association engenders a correlation between social capital and the error term within the model. Third, omitted variables and measurement errors are additional sources of correlation between social capital and the error term.

Considering the above arguments and the context of disasters, we develop some arguments about the potential endogeneity of our social capital measurements. First, sometimes it is not easy to differentiate the effect of social capital from other group effects on SWB. Social capital can vary between different spatial locations according to socioeconomic and environmental characteristics. Damages of physical infrastructure caused by Hurricane Maria at the municipality level, and social organizations' actions to recover and foster resilience after the disaster are likely directly correlated. Then, we cannot indicate that the social capital effect is relevant to determine individual well-being if we omit other variables like geographic, household, and individual characteristics related to SWB, therefore, in equation (1), we include these dimensions as control variables. At the individual level, we have age, sex, marital status, self-reported health, employment status, and dummy variables for the level of education. At the household level, we use dummy variables

[20] Active membership of an organizations was measured by asking the following question: "Now I am going to read out a list of voluntary organizations; for each one, could you tell me whether you are a member, an active member, an inactive member or not a member of that type of organization?"

[21] Here for more details about FEMA efforts to respond to disasters in Puerto Rico https://www.fema.gov/blog/overview-federal-efforts-prepare-and-respond-hurricane-maria.

[22] We do not observe the latent variable SWB^{*}_{ij} in the data, instead, we observe SWB_{ij} as a discrete ordinal measure of well-being.

Table 3
Descriptive statistics.

Variable (description)	Mean	SD
Outcome variable		
SWB (1 = very unsatisfied; 5 = very satisfied)	4.37	0.96
Individual controls		
Subjective health (1 = poor; 5 = excellent)	3.01	0.89
Female (yes = 1)	0.61	0.49
Age	49.79	18.34
Living with couple (yes = 1)	0.13	0.33
Primary school or below (yes = 1)	0.15	0.36
Middle school (yes = 1)	0.28	0.45
College (yes = 1)	0.57	0.50
Employed (yes = 1)	0.40	0.49
Low income (yes = 1)	0.21	0.41
Medium income (yes = 1)	0.65	0.48
High income (yes = 1)	0.14	0.34
Social capital variables		
Trust in neighbor (yes = 1)	0.31	0.46
Trust in people you personally know (yes = 1)	0.41	0.49
Active member of an organization (yes = 1)	0.48	0.50
Talk with friends (daily/weekly = 1)	0.66	0.47
Confidence in government (yes = 1)	0.47	0.50
Controls at municipal level		
Disaster recovery center at municipal level (yes = 1)	0.50	0.50
Social vulnerability index	0.45	0.25
Municipal population	31,398	45,283
Instrumental variables		
Municipality mean of trust in neighborhood	0.32	0.07
Municipality mean of trust people	0.41	0.06
Municipality mean of membership	0.48	0.09
Municipality mean of talk with friends	0.65	0.07
Municipality mean of confidence in government	0.47	0.08
Share of population with internet subscription	0.54	0.08
Observations	1076	

Data are rounded up; sources World Values Survey (WVS) 7 and Puerto Rico Instituto of Statistics.

for income. Finally, at the community level, we have a dummy variable for the presence of disaster recovery centers and the total municipal population (see Table 3).

Second, we expect to find endogeneity issues when including social capital variables like membership in organizations and measures of trust, cognitive aspects of social capital. These kinds of variables depend on unobservable individual characteristics. For instance, membership is regarded as a choice variable, and trust is related to confidence in observed behavior; such measures are defined endogenously [59]. Unobserved personality traits such as preferences, information acquisition, optimism, and individual incentives are both correlated with SWB and social capital variables. Then we could expect that $E(SC_{ij}\epsilon_{ij}) \neq 0$.

Finally, an additional concern is when the outcome variable (SWB) has a causal impact on independent variables (social capital variables), known as reverse causality. For instance, finding a positive correlation between membership in organizations and happiness does not necessarily imply that membership causes a higher level of SWB. Happy people could be more willing to interact socially or accept membership in organizational groups. Also, the individual's happiness could affect their willingness to trust or distrust another person. Then, if we do not address this problem, we will get biased coefficients [60].

We use an instrumental variable approach to address the potential endogeneity problems associated with our social capital variables. Leaving aside the group effect, this approach addresses the last two problems highlighted above. The choice of instrumental variables depends on fulfilling the condition of the exclusion restrictions; such conditions have two requirements. First, our instruments should be theoretically justified, and correlate with social capital variables, in other words, the relevance condition. Second, the instruments must be uncorrelated with unobserved factors, the orthogonal condition. These assumptions mean that an instrument would be valid if it affects SWB indirectly and only through its association with the individual social capital variables. We use the access to internet at municipal level as an instrumental variable for social capital. In addition, following D'Hombres et al. [61] and Fiorillo and Sabatini [62], we use municipality-based instruments to address endogeneity issue.

> We will argue that municipality-level internet access meets the relevance and orthogonal conditions. First, the relationship between internet accessibility and social capital has been a significant topic for social scientists. Certain scholars contend that the

Internet undermines community and social capital by curtailing in-person interactions and constraining local engagements [63]. Nevertheless, other research indicates that internet access can contribute to social capital because it increases the bonds with family members, friends, and acquaintances among close-knit social circles [64].

Research carried out in Indonesia has revealed that the accessibility of Internet positively contributes to social interactions and social capital. It has been determined that internet access is a countermeasure to the erosion of social cohesion and reinforces social networks [65].[23] The Internet functions as a medium for communication and information exchange, resulting in active participation and the augmentation of social capital [65]. Furthermore, Zhou et al. [66] argue that the internet can contribute to new forms of interaction, community, and interpersonal relationships.

Moreover, the digital divide, as highlighted by Hampton and Wellman [63], influences social interaction and information access, resulting in social capital disparities. In the same vein, Pénard and Poussing [67] indicate that the information function of the internet allows for the seamless acquisition of knowledge regarding the whereabouts and timing of social gatherings, reduces the expenses associated with reserving spaces or purchasing tickets for specific events, provides information on political and civic initiatives, and even aids in the identification of opportunities for volunteering and optimal matches to individuals' preferred social engagements. Specific dimensions of social capital, such as bonding and bridging are positively related to internet access. For example, internet access allows for the establishment of weak ties and hence for bridging social capital [68]. According to Neves and Fonseca [69], people who use the internet tend to have more bridging social capital, which refers to the resources potentially available in one's social ties. The study also found a positive relationship between social networking sites and instant messaging users and bridging social capital. Therefore, internet access and its use at the municipality level directly affect different dimensions of social capital and not directly on SWB.

To satisfy the orthogonality condition, the instrumental variable should be exogenous and have no direct effect on the outcome variable (SWB), other than its impact on the endogenous variables (social capital). Czernich et al. [70] highlight that internet access can be supported as an instrument, because it is often determined by external factors such as government policies, technological advancements, market forces, and broadband infrastructure rather than individual characteristics. In Puerto Rico, broadband penetration depends on the digital subscriber line (DSL) infrastructure. This technology has an essential role in developing infrastructure for accessing fast internet. DSL technology relies on transmitting data through the user's preexisting copper telephone line infrastructure, specifically over the voice telecommunications network [71,72]. The availability of broadband depends on the presence of a telephone infrastructure, which is a necessary but not sufficient condition.[24] Sabatini and Sarracino [72] indicate that the “local loop” is a critical factor, which refers to the distance between the end-user's telephone line and the nearest telecommunication exchange or central office. Therefore, given that internet depends mainly on local infrastructure, we find reasonable to assume that the individual SWB is not directly correlated with the internet access at municipality level.

Additionally, we use the average level of social capital at municipality level as an instrumental variable. The intuition is that mutual trust, when people trust others and feel others trust them, can increase cooperation and prosocial behavior, strengthening trust in others [61,62]. We assume that individuals who are located in the same municipality share similar experiences, then the individual and municipality level of trust are related. On the other hand, membership in organizations depends on the presence of such organizations at the municipal level. We use the average membership rate by municipality as an instrumental variable. This instrument shows the presence or absence of social networks at the aggregate level, and the strength of solidarity relationships within the municipality that influences their members’ individual sphere.

A reasonable concern might be the orthogonality condition of municipal social capital instruments. Social capital is a multidimensional concept, although the early literature in sociology did not have a consensus on which level of society is located. Coleman [26] suggests that social capital is a public good, while Fukuyama [73] indicates that social capital is private. On the other hand, the literature shows that social capital has both individual and community components [74]. Some aspects of social capital are under individual control [75], but others have little influence over societal aspects [76]. Recognizing that social capital has multiple dimensions does not imply that each dimension is independent of individual SWB. Some authors have shown that the effect of community-level social capital becomes insignificant on self-reported health and life satisfaction once individual-level social capital measurements are taken into account [62,77,78], or when additional individual controls are considered such as socio-demographic characteristics [79]. In addition, Han [80] finds that “no significant association between administrative-area level social capital variables with happiness” (p. 253). Similarly, Oshio [81] found that a substantial portion of the effect of area-level social capital on SWB is mediated by individual social capital.

The available evidence suggests that municipality social capital does not have an independent effect on individual SWB once we account for social capital at the individual level. However, this does not mean that the role of social capital at municipal level is absent. Rather, we acknowledge that social capital is situated at both the individual and municipal levels, but we presume that the former mediates the effects of the latter, thereby influencing SWB only indirectly. Although previous research might not be definitive, it generally supports the claim we are making in this article. However, further inquiry is required to accurately evaluate the relevance of social capital at individual and local levels with individual SWB.

[23] Puerto Rico and Indonesia share similarities in their disaster experiences, as both regions are susceptible to various hazards due to their geographic locations and geological characteristics. For instance, these areas are frequently affected by hurricanes, tropical cyclones, and post-disaster logistical challenges that islands typically face [13,112,113].

[24] Broadband is a high-quality internet connection. Broadband connections include wi-fi, DSLs, and fiber.

5. Empirical results

5.1. Descriptive analysis of measures

According to Table 3, the average of life satisfaction among respondents during the 2018 survey period was 4.37, indicating a high rate of satisfaction with life. The distribution of life satisfaction, as shown in Fig. 2, is consistent with previous studies addressed by Growiec and Growiec [51] and Zhang et al. [52]. The average age of respondents in Puerto Rico was 50 years, and the majority of those surveyed (57 percent) has a college degree or higher. Women made up 61 percent of the survey respondents. Only 40% of respondents were employed. The majority of households had a medium income (65%).

The data shows that 31 percent of respondents on average reported trusting their neighbors, while 41 percent reported trusting people they knew personally. Additionally, 48 percent of respondents reported being members of at least one organization. A majority of those surveyed (60 percent) reported talking with their friends or colleagues daily or weekly.[25] However, only 47% of respondents reported trusting the government. The instrumental variables have similar mean regarding the individual social capital variables, but the standard deviation was notably different.

5.2. Determinants of self-perceived life satisfaction

The results of subjective well-being (SWB) estimations are presented in Table 4 and Fig. 3.[26] The first column in Table 4 shows the results of the Ordered Probit (Oprobit) estimation, while the second column presents the instrumental Ordered Probit (IV-Oprobit) estimates. The average marginal effects are reported for both estimates across the sample.

Before examining the impact of social capital variables on SWB, Table 4 summarizes the marginal effects of individual, household, and municipal variables on SWB. No significant difference was found between men and women in terms of well-being. The probability of reporting high levels of life satisfaction increases as individuals report better health, which is in line with previous studies by Diener et al. [82] and Das et al. [83]. Age is positively related to well-being, with the age group of 51–70 years having a higher probability of reporting high levels of well-being compared to those under 30. Also, we find no significant differences between the age group of 70 up and those under 30.[27] Those who live with a partner are more likely to report high levels of well-being. For instance, the IV-Oprobit estimates in column 2 shows that living with a partner is associated with a 6% increase in the likelihood of being very satisfied with life, compared to those who are single or divorced. Education is a critical predictor of SWB. A middle-school certificate increases the probability of reporting high levels of life satisfaction, and this likelihood increases even more for individuals with a primary-school certificate compared to those with undergraduate degrees. This finding is supported by Felici and Agarwala [84], who found that people living in deprived areas in the United Kingdom with less education often report higher levels of life satisfaction.

At the household level, income is a crucial factor in determining life satisfaction.[28] It has been found that household income has a strong and positive impact on SWB. Individuals living in high-income households are more likely to report higher levels of satisfaction with their lives compared to those in low-income households. On average, people in high-income households have a higher probability (9%) of reporting high levels of life satisfaction than those in low-income households. This finding is consistent with the results of previous studies by Tay et al. [85] and Kahneman and Deaton [86], who both conclude that higher income contributes to greater life satisfaction.

It is worth noting that the aggregate-level characteristics of municipalities have a significant impact on well-being. Our results indicate that individuals living in municipalities with disaster recovery centers (DRCs) were found to have a 5% higher probability of reporting being very satisfied with their lives compared to those living in municipalities without. DRCs provide access to services and resources that aid in the response and recovery process after a disaster.[29] Manandhar et al. [87] highlight the importance of the presence of public, private, and non-governmental organizations in ensuring an effective post-disaster recovery process. However, the unequal distribution of disaster recovery assistance across regions, such as documented by Emrich et al. [88] in the case of the United States, can have a significant impact on the recovery processes. This inequality can exacerbate the negative impacts of a disaster on vulnerable populations if they receive a lower amount of aid [89]. As shown in Table 3, 50% of the municipalities under study have recovery centers, therefore it is possible that there is an unequal distribution of well-being effects across the island.

Estimates correspond to the average marginal change across observations using an Ordered Probit and IV-Ordered Probit model on the probability of SWB $= 5$. Standard error for the average marginal changes were computed by Delta Method. We draw 95% confidence intervals.

[25] After a disaster like a hurricane, conversations with friends and colleagues can change due to the emotional impact. Tragic events, such as disasters, can leave individuals shaken and worried, affecting their focus. Such events can strain interpersonal relationships, leading to increased conflicts, disagreements with friends and colleagues. People might also become withdrawn or disengaged from social activities. The above reasons could be some explanations of the low percentage of people having daily or weekly conversations.

[26] Caycho-Rodríguez et al. [114] indicate for a sample of 12 Latin American countries that SWB is invariant across the sample of these countries. In addition, they say that differences in the SWB scores are related to differences in well-being and not in another characteristic of the scale. Therefore, we do not hope for a difference in how people understand the meaning of subjective well-being (or *bienestar* in Spanish).

[27] The age-well-being relationship is more complex than U-shape. Our findings show that the relationship is positive and grows throughout midlife and get a peak around 51–70 years.

[28] In the WVS, income is often categorized into three groups. High-income individuals are those who earn more than the average income. Medium-income individuals fall between the high- and low-income categories. These individuals earn an income that is closer to the national average. Low-income individuals are those who earn less than the national average income.

[29] The DRCs were strategically located across the island to provide accessible assistance and support to the affected communities. Some general criteria that are typically considered for the location of DRCs in post-disaster scenarios: proximity to affected areas, population density, and safety and infrastructure.

Table 4
Marginal effects. Ordered Probit and IV-Ordered Probit models on the probability of being very satisfied with life.

	SWB(Oprobit)	SWB(IV-Oprobit)
Trust in neighbors	0.121***	0.362***
	(0.041)	(0.054)
Trust people	−0.026	0.198***
	(0.030)	(0.056)
Membership	−0.024	0.216***
	(0.028)	(0.037)
Talk with friend	0.025	0.302***
	(0.048)	(0.070)
Trust in government	0.006	−0.231***
	(0.021)	(0.039)
Ref. group: Very poor health		
Poor health	0.319***	0.114**
	(0.058)	(0.057)
Fair health	0.424***	0.152**
	(0.074)	(0.066)
Good health	0.514***	0.211***
	(0.056)	(0.060)
Very good health	0.077	0.129
	(0.092)	(0.089)
Female	0.022	0.013
	(0.033)	(0.022)
Ref. group: < 31 years		
31–50 years	0.011	0.001
	(0.041)	(0.033)
51–70 years	0.096***	0.066**
	(0.036)	(0.034)
+70 years	0.080	0.050
	(0.053)	(0.038)
Living with a partner	0.105***	0.056*
	(0.034)	(0.030)
Ref. group: High school		
Primary school or below	0.093***	0.084***
	(0.032)	(0.031)
Middle school	0.079**	0.052*
	(0.035)	(0.031)
Employed	−0.032	−0.026
	(0.021)	(0.021)
Ref. group: Low income		
Middle income	Middle income	Middle income
High income	High income	High income
Recovery center	Recovery center	Recovery center
Population	Population	Population
Wald first stage		
chi-squared Statistics Trust in neighbors		178.351
p value		0.000
chi-squared Statistics Trust people		110.912
p value		0.000
chi-squared Statistics Membership		108.086
p value		0.000
chi-squared Statistics Talk with friend		182.870
p value		0.000
chi-squared Statistics Trust in government		193.312
p value		0.000
Test of endogeneity		
Ho: Trust in neighbors is exogenous		13.359
p value		0.000
Ho: Trust people is exogenous		7.929
p value		0.005

(*continued on next page*)

Table 4 (*continued*)

	SWB(Oprobit)	SWB(IV-Oprobit)
Ho: Membership is exogenous		14.516
p value		0.000
Ho: Talk with friend is exogenous		24.125
p value		0.002
Ho: Trust in government		24.125
p value		0.000
Test of exclusion		
Ho: Instruments are valid		8.360
p value		0.213
Observations	1076	1076

Estimates correspond to the average marginal effect using an ordered probit model on the probability of SWB = 5. Standard errors clustered at municipal level were used in the ordered probit model, where the standard error for the marginal effects in parentheses were obtained by Delta Method.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

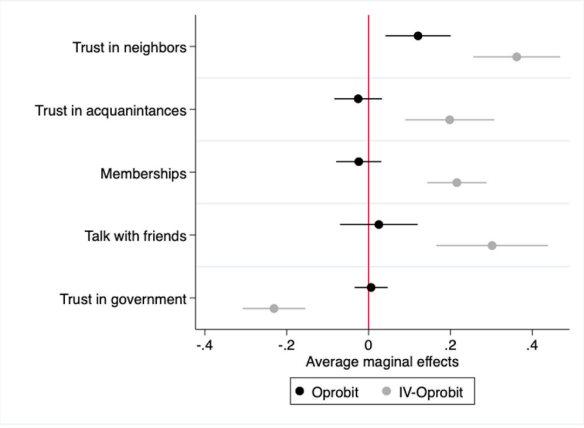

Fig. 3. Marginal effects Oprobit and IV-Oprobit on Pr(SWB = Very satisfied).

5.3. Are social capital variables endogenous?

Our focus is on the impact of social capital on self-reported life satisfaction. We concentrate our analysis on the coefficients that explain trust in neighbors, trust in people, memberships, talking with friends, and trust in government. As shown in Column 1 of Table 4 (and also depicted in Fig. 3 – Ordered Probit), only one of our five social capital indicators is significantly related to being very satisfied with life - trust in neighbors, which has a positive association. The remaining variables are not statistically significant, but these correlations should not be interpreted as causal relationships. As a reminder, we use the share of the population with internet subscriptions at the municipal level and the average level of social capital within the municipality as instruments for each social capital variable. The instrumental variable estimates for our dependent variable using the IV-Ordered Probit model are presented in column 2 of Table 4 and Fig. 3 (IV-Oprobit). The bottom of the table shows the results of tests assessing the validity of our instrumental variable estimators. In addition, Figure A1 shows that our results are robust to different sample sizes to get marginal effects. In this case, we got the average marginal change on the probability of SWB = 1 (very unsatisfied).

The first test we execute is the relevance of instrumental variables. The bottom of Table 4 shows the χ^2-test statistics with the null hypothesis of joint non-significance of instruments in the first stage regression. For IV-Ordered Probit models, which are estimated by Maximum Likelihood, the weak-instrument test is executed by testing the significance of instrument in the reduced form equation, which is estimated with the SWB equation. The instrumental variable coefficients are significantly different from zero at a confidence level of 1%. The χ^2-statistics for the joint significance of the instruments are big enough to be considered valid.[30] The second test is the overidentification restriction test, which does not reject the null hypothesis that instruments are valid at 5%; our instruments are not directly correlated with SWB. Following Kan [90], we estimate the next model:

$$SWB_{ij}^{*} = \alpha + \boldsymbol{Z}_j'\lambda + \boldsymbol{X}_{ij}'\boldsymbol{\beta} + \boldsymbol{C}_j'\boldsymbol{\delta} + \varepsilon_{ij}, \quad (2)$$

and test the null hypothesis $H_0 : \boldsymbol{\lambda} = 0$. This test is used to validate the exclusion restriction, $\text{cov}(\boldsymbol{Z}_j, \varepsilon_{ij}) = 0$.

[30] To use the rule of thumb criterion of Staiger and Stock [115], Kan [90] suggests the following:
$\tau_F = \frac{\tau_z}{K} \sim F(K, \infty)$, which has degree of freedom $\{K, \infty\}$.
Where τ is the 2-statistic from the first stage and K is the number of instruments (two instruments for each endogenous variable). The F-statistic F computed for each social capital variable is over the threshold of 10 indicated by Staiger and Stock. This indicates that our instruments are not weak.

The endogeneity tests lead us to rejection of the null hypothesis that each social capital variable is exogenous. To determine whether a variable is endogenous for IV-Ordered Probit model, we use the test $H_0 : \rho = 0$, where the indicates the correlation between the error terms of the SWB's and social capital's equation. Regarding non-rejection of the endogeneity test, non-rejection of the validity, and non-weak instruments, in addition to the theoretical arguments described in the previous section, we could suggest that our instruments are reasonably good.

Having addressed the endogeneity issue, and confirmed the validity of the instruments, we then examined the coefficients associated with the social capital variables. The results of the endogeneity correction revealed varying magnitudes and signs for the five variables. Furthermore, we include in Table A1 as an additional control the social vulnerability index (SVI) at municipal level to assess the sensibility of our estimates. The coefficients of social capital variables hold the statistical significance and the magnitude in the instrumental variable estimations; therefore, our estimates our robust to the inclusion of SVI, which illustrates the relative social vulnerability of communities to respond to and recover from disasters.[31]

The results show a positive and significant association between trust in neighbors and SWB. The estimated average marginal effect increased from 12.1 percentage points to 36.2 percentage points, which indicates that correcting for endogeneity increased the probability of respondents reporting being very satisfied with life when people trust their neighbors. Similarly, trusting people you know personally was found to increase the likelihood of being very satisfied with life by 19.8 percentage points after correcting for endogeneity. Talking with friends and being an active member of organizations were also positively and significantly linked to self-reported life satisfaction, increasing the probability of being very satisfied with life by 30.2 and 21.6 percentage points, respectively. However, trust in government was found to have a negative and significant effect on well-being. After addressing endogeneity, the average marginal effect decreased from 0.6 percentage points to −23.1 percentage points, meaning that individuals who trust the government are less likely to report high levels of life satisfaction.

6. Discussion

If we take reverse causality into account, it is possible that happier individuals may be more likely to engage in social activities or exhibit trust or distrust towards others, leading to an overestimation of the impact of social capital on well-being. After controlling for endogeneity, we expect to see smaller, not larger, estimates. However, the findings of Yamamura [91] provide evidence to support our findings. The author found that unemployed individuals have a greater incentive to invest in informal social capital in their neighborhood due to lower opportunity costs for establishing social connections and the positive impact on well-being from these relationships and networks. This situation could result in underestimating the relationship between social capital and subjective well-being because unhappy workers are less productive and more likely to be unemployed [92]. Furthermore, social relationships and support have a direct impact on mental health and happiness [93]. Hence, individuals with a lower level of well-being are more likely to maintain social networks.

According to Akbar and Aldrich [8], disaster recovery is the final stage of disaster management, and life satisfaction is a crucial component of recovery. Then, any component of social capital related to individual SWB has important implications for individual and community resilience. This research finds that the impact of social capital on well-being is diverse, similarly Villalonga-Olives and Kawachi [94] point out that social capital can have both positive and negative impacts on well-being. The results showed that bonding and bridging social capital had a positive and statistically significant effect on self-reported life satisfaction. On the other hand, linking social capital, measured as trust in government, had a negative and significant impact.

Bonding social capital, which includes trust in neighbors and trust in people individuals personally know, played a significant role in shaping SWB in the post-disaster period. In the aftermath of Maria, individuals that relied on their immediate social networks, including neighbors and personal connections, reported higher levels of SWB. Some social capital functions can explain this finding. First, trust in neighbors and personal connection could provide emotional support, reducing feelings of isolation and anxiety during the aftermath of hurricane. This makes sense if we consider that people with strong ties of trust are more likely to receive emotional support, and a sense of solidarity from those around them (Glanville, 2018). Second, in the post-disaster period trustworthy neighbors and personal connections could have served as valuable sources of information about accessible resources, safety precautions, and the recovery process in general. Individuals with confidence in their network are more inclined to receive precise and prompt information, increasing their capacity to make well-informed decisions (Cohen and Wills, 1985). Third, people who trust their neighbors and close social circle are more willing to share supplies, shelter, and resources, ensuring to meet community members' basic needs [95]. Our results are consistent with Delilah Roque et al. (2020), who found that individuals supported each other by borrowing and using resources within the community, such as diggers, bulldozers, and related machinery from neighbors who worked in the agricultural and construction industries. This finding implies that bonding social capital facilitates resource sharing and collective actions to support recovery.

Bridging social capital, measured as involvement in voluntary organizations, positively affected the individual's SWB in the post-disaster period. Engaging in voluntary organizations fosters a sense of belonging to the community, mutual support, and cooperation, all of which are important for enhancing well-being after such crises. This result can be explained for the following reasons. First, voluntary organizations are platforms to connect with like-minded individuals who share a common purpose. They can give individuals a sense of purpose and meaning, which adds to their overall well-being [96]. Second, engaging with voluntary organizations promotes access to nonredundant and heterogeneous resources needed in the recovery process [27]. Our results suggest that individuals

[31] The SVI goes to from zero to one, with higher values indicating grater vulnerability. For a more detailed description of SVI, visit https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2016.html.

with a wide bridging network can gain access to resources beyond their immediate community, which is entirely relevant if the bonding social capital is not helpful enough to get access to these resources since the immediate community is facing similar crises [36].

Linking social capital, represented by trust in the government, negatively affected the individual SWB after Hurricane Maria. Trust in government can significantly impact individuals' perception of safety, security, and access to resources during a crisis. However, when the government's response fails to meet collective and individual expectations, it can lead to significant adverse consequences that affect well-being. For instance, in situations characterized by a slow and insufficient governmental reaction, the government's confidence could be eroded, resulting in a decline in trust for the governmental organization that is in charge of disaster control [97]. Similarly, some reports have acknowledged that the absence of trust between disaster managers and communities can block rather than facilitate local efforts to establish bonding ties concerning top-down mitigation [98,99]. In Puerto Rico, two factors contributed to slower disaster recovery. Firstly, the federal US government's response could have been inadequate and delayed, resulting in a slow mobilization of resources to support the victims [3,16]. Secondly, Benach et al. [16] argued that the hurricane exposed and reinforced long-standing socio-economic vulnerabilities on the island. As a result, these conditions create distrust in different government layers, as Miller and Rivera [100] pointed out.

We encountered several limitations in our analysis. Firstly, the World Values Survey data typically covers a broad range of topics, which could interfere with our ability to obtain more specific and detailed measurements. For example, Akbar and Aldrich [8] suggest that post-disaster life recovery involves life adjustment, life satisfaction, and perception of future disasters, while we only have one measurement. As a result, this paper does not address a full analysis of the effect of social capital variables on the recovery disaster cycle. However, by an identification strategy, this study partially overcame this limitation, which allows the analysis to draw conclusions about the relationship between different dimensions of social capital and individual's well-being. Second, we use an instrumental variable approach to account for the potential endogeneity of cross-sectional data; although, we hope that future researchers could be able to access longitudinal data to take into account the possibility of unobserved variation that can affect the outcomes. Finally, we do not identify transmission mechanisms, which is beyond the scope of our investigation. More efforts are needed to investigate the mechanisms that link social capital and SWB, so we could identify what type of social capital activates the SWB-protective mechanisms of social support in a post-disaster context.

Despite these limitations, the findings of this study have important policy implications for promoting well-being. First, bonding social capital is a strong and persistent predictor of SWB. Therefore, efforts to establish trustworthy relationships among friends, families, and neighbors hold significant importance, particularly in the context of disasters. For instance, implementing training programs that enhance communication, cooperation, and support among neighbors and close-knit communities can harness the power of bonding social capital for enhanced well-being. Second, voluntary organization membership has a profound impact on individual SWB. The above relationship is largely contingent upon trust [31]. Therefore, merely encouraging membership in voluntary organizations is not enough a policy recommendation; resources must be allocated towards building and sustaining trust among members of these organizations. For example, municipalities can facilitate community centers encouraging open conversations on community well-being, trust, cooperation, networks, emergency management, vulnerabilities, and disaster risk reduction. This circumstance presents the opportunity to initiate relationships with local and national governments and recognize each faction's distinctive capabilities when a disaster strikes, sharing their strengths and weaknesses openly with the community. Finally, the government should implement measures that enhance and expand communities' social capital and trust reserves. The aim is to promote a culture of trust in communities, which would, in turn, improve the efficacy of response operations. Notably, the trust between disaster managers and communities is of particular significance in maintaining the linking connections through which local networks can access broader sources of information and assistance [98,99].

7. Conclusions

Although undesirable and tragic, the aftermath of Hurricane Maria in Puerto Rico has offered a unique opportunity to study the role of social capital on subjective well-being. The storm caused significant human and material losses and is considered the most catastrophic event in the island's history [1,2]. This study explored the relationship between social capital and individual life satisfaction in the aftermath of the hurricane. Using data from the World Values Survey (WVS) wave 7 and the Puerto Rico Statistics Institute, we employ an instrumental variable approach to rigorously address this relationship, finding positive impacts on bridging and bonding social capital, while the linking component, associated with government trust, showed a negative relationship with life satisfaction. This study makes a contribution to the disaster studies literature by providing empirical evidence of the role of social capital on individual well-being. To our knowledge, this is the first article that studies the empirical relationship between these variables in the context of Hurricane Maria.

The policy implications from our findings are threefold. First, we highlight that timely responses from governments and institutions could make a huge difference in well-being for affected populations. As we have shown with our results, trust in government is negatively associated with well-being impacts. In other words, we could say that trusting an ineffective government made people unhappier. Appropriate and timely crisis responses, good governance, and proper disaster risk reduction (DRR) planning practices are all policies that would avoid scenarios of mistrust and state capacity erosion [9,101]. Most importantly, public and private initiatives that foster social capital within specific community organizations should consider funding for DRR training and awareness, as fostering existing ties within these groups could significantly increase outreach, preparedness and effectiveness more easily than without them.

The literature argues that in the aftermath of a disaster, social capital, which encompasses community networks and trust, plays a crucial role when conventional systems like governments and markets fail in resource allocation [39]. However, relying on social cap-

ital alone is not enough for achieving a comprehensive disaster recovery and build resilience in the face of a disaster Nakagawa and Shaw [48]. Our results confirm that bonding and bridging social capital show a positive relationship with SWB, as opposed to the linking component. Nurturing weak ties within and between communities could enhance generalized trust [102], leading to the development of cooperative behaviors and social identities. This process can bring resource management capacity [103,104], which is absolutely critical in the context of post-disaster scenarios. Our policy recommendations are in line with Rosas et al., 2021, where municipal capacity for community involvement could be a crucial and more attainable way of bringing both parts of social capital together, increasing resilience and preparedness, avoiding potential traps such as the excessive bureaucratization, interference with community efforts, archaic rules, and organizational inflexibilities [87].

Third, our results accentuate the question of who would benefit from these insights and results, and how to improve well-being in increasingly hazardous scenarios. We argue that policymakers should not overlook well-being impacts for affected populations, as their assessment could be effectively used to quantify impacts with valuation techniques [105–107]. Jensen and Tiwari [108] argue that these estimates make the total costs of disasters much higher than traditional direct valuation techniques. Quantifying well-being after disasters with better individual data that includes post-traumatic, depression, and complete SWB scales, could be used as a policy tool to focus resources where they are most needed. As a corollary, this data availability could also be used to tailor appropriate evidence-based policies as part of DRR planning for future emergencies, enhancing the interactions between hazards, institutions and governance [108].

In addition, it is important to consider that the responsibility for quantifying post-disaster well-being in Puerto Rico, following events like hurricane Maria, should be shared between the government and researchers. The government holds a critical role in coordinating disaster response, relief efforts, and policies. However, researchers also play a crucial role in assessing the long-term effects on the well-being of the affected population through comprehensive studies. The government should collaborate with local and international researchers to conduct thorough assessments of the physical, mental, social, and economic impacts of the disaster. These assessments should involve surveys, interviews, and data collection to accurately quantify the extent of the well-being disruptions. Additionally, researchers can provide independent analysis and insights, which can contribute to evidence-based decision-making for future recovery strategies.

In the Puerto Rican context, a practical application could involve the establishment of interdisciplinary teams consisting of government officials, social scientists, public health experts, and economists. This collaborative effort will ensure that a holistic evaluation is conducted, which can result in effective policy recommendations. On the other hand, theoretical implications include improving disaster preparedness, social resilience, and community support systems. These implications can be practically addressed by investing in resilient infrastructure, healthcare systems, and mental health services.

CRediT authorship contribution statement

Gustavo Ahumada: Writing - review & editing, Writing - original draft, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.. **Roberto Cantillan:** Validation, Investigation, Conceptualization. **Benjamin Jara:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A

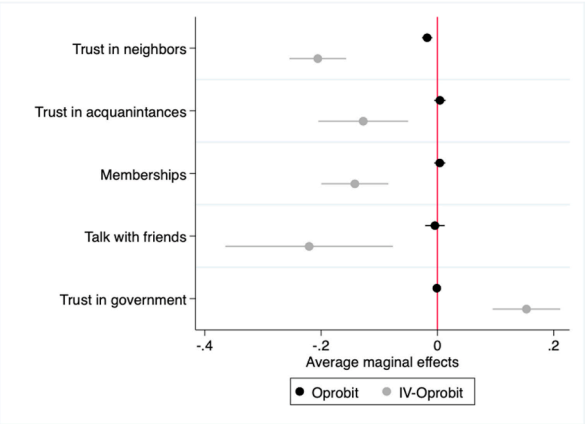

Fig. A1. Marginal effects Oprobit and IV-Oprobit on Pr(SWB = Very unsatisfied).

Estimates correspond to the average marginal change across observations using an Ordered Probit and IV-Ordered Probit model on the probability of SWB = 1. Standard error for the average marginal changes were computed by Delta Method. We draw 95% confidence intervals.

Table A1
Marginal effects Oprobit and IV-Oprobit on Pr(SWB = Very satisfied) with additional control (social vulnerability index)

	SWB(Oprobit)	SWB(IV-Oprobit)
Trust neighborhood	0.119***	0.340***
	(0.041)	(0.044)
Trust people	−0.027	0.118**
	(0.030)	(0.058)
Membership	−0.024	0.230***
	(0.029)	(0.031)
Talk with friend	0.028	0.379***
	(0.048)	(0.039)
Trust in government	0.009	−0.215***
	(0.020)	(0.047)
Ref. group: Very poor health	ref.	ref.
Poor health	0.321***	0.099*
	(0.058)	(0.050)
Fair health	0.426***	0.131**
	(0.074)	(0.053)
Good health	0.515***	0.195***
	(0.055)	(0.050)
Very good health	0.078	0.099
	(0.092)	(0.083)
Female	0.022	0.018
	(0.032)	(0.020)
Ref. group: < 31 years	ref.	ref.
31–50 years	0.012	0.007
	(0.041)	(0.033)
51–70 years	0.101***	0.074**
	(0.036)	(0.033)
+70 years	0.084	0.067*
	(0.052)	(0.039)
Living with a partner	0.104***	0.046
	(0.035)	(0.030)
Ref. group: High school		
Primary school or below	0.090***	0.086***
	(0.032)	(0.028)
Middle school	0.080**	0.047
	(0.035)	(0.032)
Employed	−0.031	−0.025
	(0.021)	(0.020)

(*continued on next page*)

Table A1 (*continued*)

	SWB(Oprobit)	SWB(IV-Oprobit)
Ref. group: Low income		
Middle income	0.020	0.040*
	(0.028)	(0.023)
High income	0.099*	0.085**
	(0.056)	(0.042)
Recovery center	0.061**	0.045***
	(0.025)	(0.007)
Population	−0.000**	−0.000***
	(0.000)	(0.000)
Social vulnerability	−0.082*	−0.025
	(0.042)	(0.019)
Wald first stage		
χ^2- Statistics Trust neighborhood		178.351
p value		0.000
χ^2- Statistics Trust people		110.912
p value		0.000
χ^2- Statistics Membership		108.086
χ^2- Statistics Talk with friend		182.870
p value		0.000
χ^2- Statistics Trust in government		193.312
p value		0.000
Test of endogeneity		
Ho: Trust neighborhood is exogenous		13.359
p value		0.000
Ho: Trust people is exogenous		7.929
p value		0.005
Ho: Membership is exogenous		14.516
p value		0.000
Ho: Talk with friend is exogenous		24.125
p value		0.002
Ho: Trust in government		24.125
p value		0.000
Test of exclusion		
Ho: Instruments are valid		7.940
p value		0.242
Observations	1076	1076

Estimates correspond to the average marginal effect using an ordered probit model on the probability of SWB = 5. Standard errors clustered at municipal level were used in the ordered probit model, where the standard error for the marginal effects in parentheses were obtained by Delta Method.
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

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