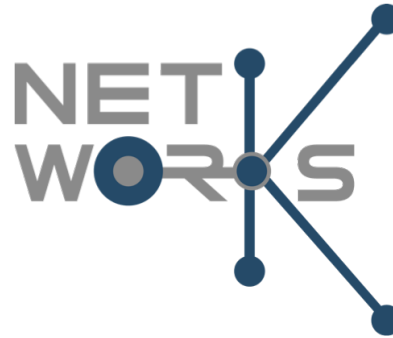


Juan Pablo Cárdenas

SERVICIOS INFORMÁTICOS, INVESTIGACIONES
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Avenida Angamos 451 Casa A. Reñaca
Viña del Mar, Chile



2nd Year REPORT (FINAL)

N629092012060: EARLY WARNING SIGNALS IN SOCIAL CRITICAL EPISODES

Major Goals

Technical goals for second year and percentage of completion (*p.c.*)

- 1.- Computational codes for harvesting and storing data received from online social media APIs (*p.c.*: 100%).
- 2.- Data extraction (*p.c.*: 100%).
- 3.- Data storage (*p.c.*: 100%).
- 4.- Algorithms for the real-time construction of user and thematic networks obtained from online social networks (*p.c.*: 100%).
- 5.- Algorithms for the analysis of user and thematic networks (*p.c.*: 100%).
- 6.- Algorithms for the harvesting and analysis of information published by online media. (*p.c.*: 100%)
- 7.- Analysis and Experiments. (*p.c.*: 100%)
- 8.- Theoretical interpretation of the results (*p.c.*: 100%).

Research goals

- 1.- Theoretical proposal on Social Crises and their relationship with social complexity. The Chilean case.
 - 1.1.- Mapping between the information reported by the mass media and the information circulating on online social networks.

REPORT DOCUMENTATION PAGE

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14. ABSTRACT
The adaptive nature of the social system allows it to overcome the challenges imposed by its environment as well as to overcome those internal pressures. This adaptive process is associated with an increase in its internal complexity which has a cost for the social system since it must be managed, otherwise, it can trigger social unrest and crisis processes. In this project, we explore the close relationship between adaptation, social complexity, and crisis. Our results suggest that despite the loss of order in systems going through a crisis, there would be an emergence of new complex ephemeral structures of information which seem to be early-warnings signals of profound social transformations.

15. SUBJECT TERMS
social crises, complexity, complex systems, early-warnings signals

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U	U	U	UU	38	19b. TELEPHONE NUMBER (Include area code) 56-9-94893710

2.- Theoretical proposal on social polarization and its relationship with language that flows in online social networks.

2.1.- Polarization metric for digital society.

Accomplishments Under Goals

During the first year of the project, all of the proposed goals were achieved (see the INTERIM PROGRESS REPORT submitted for the first year attached to this document).

During the second year, we continue to use the computer system created for the harvesting, processing and analysis of information that circulates in digital media (online social networks and traditional media). The analysis of the data collected was carried out by implementing a series of ad-hoc quantitative/ qualitative metrics developed to quantify the relationship between digital society and material society.

The research of this second year focused on 2 lines: (i) a theoretical proposal on the origin of Social Crises and their relationship with social complexity, accompanied by empirical evidence. (ii) a theoretical proposal on social polarization and its relationship with language that flows in online social networks.

The first line of research analyzed 1208 events that occurred between October and November 2019 associated with the Chilean social outbreak. Our analysis considered the agents identified in these events, those affected by these events, as well as a characterization of the events. In addition, we look for some correlation between these events with Twitter activity on those.

The result (In: <https://www.hindawi.com/journals/complexity/2022/8980913/> and attached in this document) confirmed what we had already observed during the first year of the project: a deep and nontrivial relationship between digital and material worlds. Perhaps the most important result refers to the leading role of language, its meaning, and symbolism in the development of social transformation processes linked to the complexity of the social system and its adaptive nature.

Research Article

Digital Outburst: The Expression of a Social Crisis through Online Social Networks

Juan Pablo Cárdenas ^{1,2} **Carolina Urbina** ³ **Gerardo Vidal** ^{2,4} **Gastón Olivares** ^{1,2}
and Miguel Fuentes ^{2,5,6,7}

¹*Net-Works, Viña Del Mar, Chile*

²*Complex Society Lab, Viña Del Mar, Chile*

³*Escuela de Psicología, Pontificia Universidad Católica de Valparaíso, Viña Del Mar, Chile*

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⁶*Santa Fe Institute, Santa Fe, NM, USA*

⁷*Instituto de Sistemas Complejos de Valparaíso, Valparaíso, Chile*

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Received 2 November 2021; Accepted 3 March 2022; Published 30 March 2022

The second line of research, a theoretical proposal on social polarization and associated metrics (still in development), understands social polarization as a state of the social system resulting from a simplification of a larger problem to be solved.

Thus, faced with a major social problem, society simplifies the solution into few options (two in the extreme case). This simplification could be observed in the use of language, according to our hypothesis. Thus, in a polarized society, we could observe how some opinions join other similar ones, forming a few clusters. In this way, we are again approaching the problem from the language, and not from the actors. Our preliminary results are promising, as can be seen in Figure 1. During the moments of high polarization, few “bags” group words related to “political” messages that circulate in online social networks.

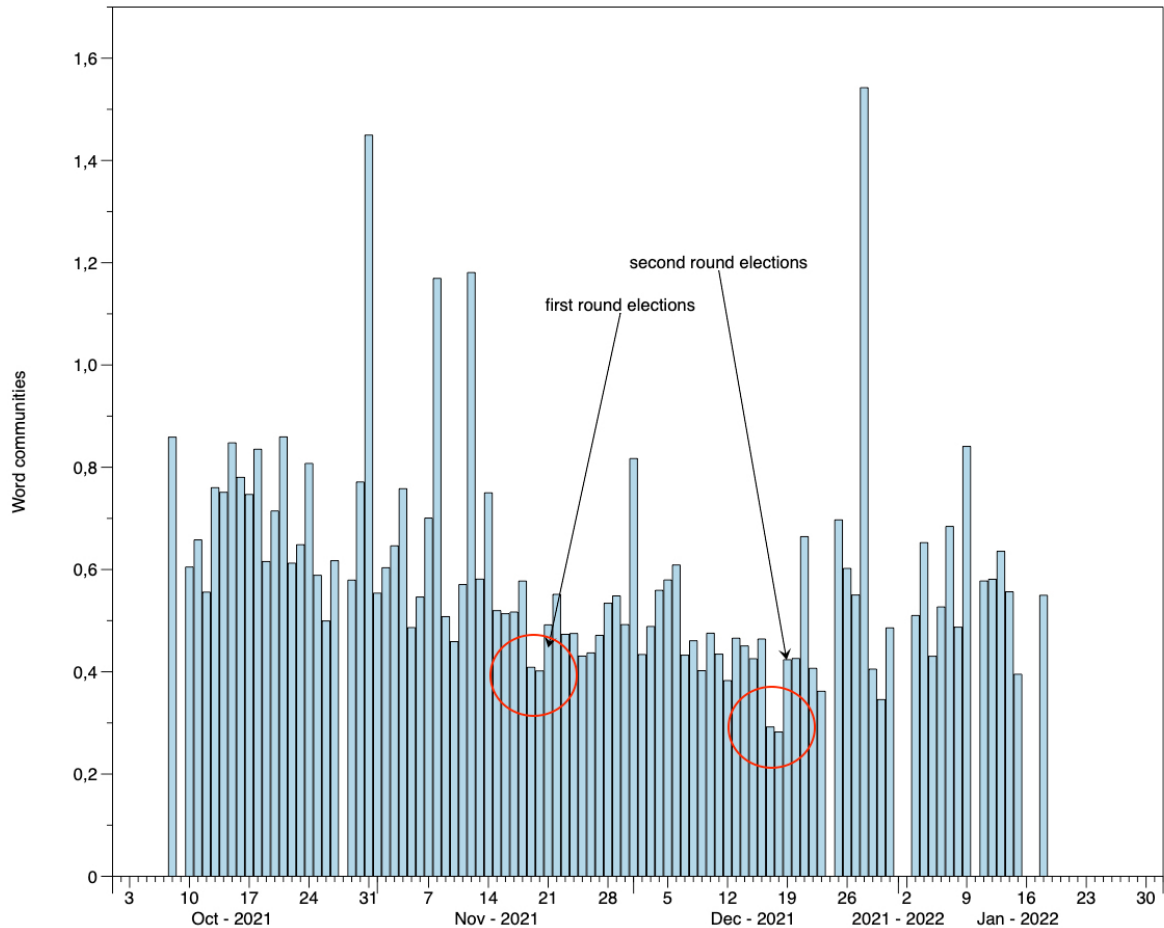


Figure 1. Number of word clusters (normalized) obtained from the community detection of word networks extracted from messages that circulate daily on online social networks.

Plans Next Period

Nothing to Report

Results Dissemination

Workshop:

Title: "Social Crises and Climate Change"

Speaker: J.P. Cárdenas, Miguel A. Fuentes, G. Vidal.

Place and Date: Viña del Mar, Chile. August 08, 2022

Honors and Awards

Nothing to Report

Training Opportunities

Nothing to Report

Technology Transfer

Nothing to Report

Participants

Name	Role	Months
Miguel Fuentes	Co-Investigator	12
Gastón Olivares	Co-Investigator	12
Carolina Urbina	Co-Investigator	12
Gerardo Vidal	Co-Investigator	12
Fernanda Morales	Other Professional	1
Juan Pablo Cárdenas	PD/PI	12
René Curín	Technician	4
Waldo Ancacoy	Technician	2

1st Year REPORT - INTERIM PROGRESS REPORT

(previously submitted to <https://extranet.aro.army.mil>)

N629092012060 : TITLE: EARLY WARNING SIGNALS IN SOCIAL CRITICAL EPISODES. Project focused on detecting early-warnings signals of social crises.

Reporting Period: JUN 16, 2020 to JUN 15, 2021

Date Received: 2021-06-08 09:36:06.0

Submitter: Juan Crdenas

Distribution Statement: Approved for public release; distribution is unlimited.

Major Goals

Technical goals

1.- Computational codes for harvesting and storing data received from online social media APIs (percentage of completion: 100%) 2.- Data extraction (percentage of completion: 50% (first year (100%)) 3.- Data storage (percentage of completion: 50% (first year (100%)) 4.- Algorithms for the real-time construction of user and thematic networks obtained from online social networks (percentage of completion: 100%). 5.- Algorithms for the analysis of user and thematic networks (percentage of completion: 50% (first year (100%)). 6.- Algorithms for the harvesting and analysis of information published by online media. (percentage of completion: 100%) 7.- Analysis and Experiments (percentage of completion: 50% (first year (100%))

Research goals

- 1.- Complexity Metrics for user and thematic networks.
- 2.- Polarization metric for digital society.
- 3.- Mapping between the information reported by the online media and the information circulating on online social networks.
- 3.- Potential metric for the detection of early warning signals of social crises in online social networks.
- 3.1 Order, Disequilibrium and Diversity (ODD) metric for thematic networks. 3.2 Nesting metric in second-order adjacency matrices for thematic networks.

Accomplishments Under Goals

During the first year of the project, all of the proposed goals were achieved.

A computer system was created for the harvesting, processing and analysis of information that circulates in digital media (online social networks and traditional media). This made it possible to fulfill the first objective of this project corresponding to the development of an automatic computer system for the analysis of digital information.

The analysis of the data collected was carried out by implementing a series of ad-hoc metrics developed to quantify the relationship between digital society and material society and thus detect early warning signs of social crises.

Our preliminary results suggest a close relationship between the digital society and the material society. On the other hand, it seems that a series of thematic organization phenomena in online social networks would operate as early warning signs of social crises. This last result seems to be quite hopeful but we must continue to deepen its understanding. It is for this reason that we are working on understanding what is behind the organization of topics (Twitter hashtags). For this we are investigating other metrics (eg., nesting in topic networks) and also in the sociological interpretation behind the "discourse" that this networks represent.

Finally, in a work in progress, we are analyzing 1208 events that occurred between October and November 2019 associated with the Chilean social outbreak. Our analysis considers the agents identified in these events, those affected by these events, as well as a characterization of these events. In addition to characterizing the outbreak, we are connecting these events with Twitter activity on those days in search of a correlation between the activity of material and digital society.

Plans Next Period

Nothing to Report

Results Dissemination

Workshop: Ciclo de charlas sobre FILOSOFÍA Y ENTORNO 2021 / ISCV / UV

Organizer: Instituto de Sistemas Complejos de Valparaíso (ISCV) and Universidad de Valparaíso (UV).

Title: "Detección de alerta temprana en sistemas sociales"

Speaker: Miguel A. Fuentes (Co-Investigator of the project)

Place and Date: Valparaíso, Chile. June 22, 2021

Honors and Awards

Nothing to Report

Training Opportunities

Nothing to Report

Technology Transfer

Nothing to Report

Participants

Name	Role	Person Months
Fuentes, Miguel	Co-Investigator	12

Olivares, Gastón	Co-Investigator	12
Urbina, Carolina	Co-Investigator	12
Vidal, Gerardo	Co-Investigator	12
Morales, Fernanda	Other Professional	1
Cárdenas, Juan	PD/PI	12
Cornejo, Camilo	Technician	4

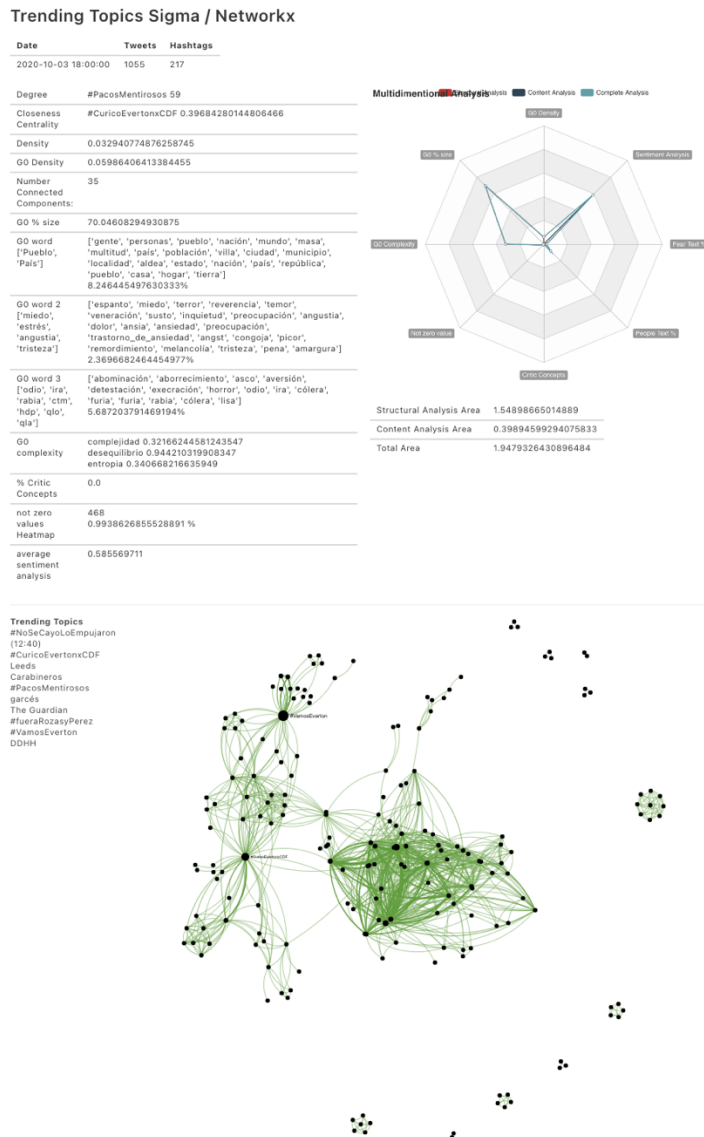
EARLY WARNING SIGNALS IN SOCIAL CRITICAL EPISODES

Contract Number: N629092012060

Report Attachment

I.- Web Laboratory:

We developed a web laboratory for real-time harvesting and analysis of Twitter activity. This system has been active since the beginning of the project in search of early warning signals of social crises.



The image shows the analysis for a particular time and day. Different measurements are applied to the objects (networks) to be analyzed.

The result of this analysis was the publication:

J.P. Cárdenas, G. Olivares, G. Vidal, C. Urbina, M. Fuentes: The structure of online information behind Social Crises. Frontiers in Physics, 9(650648), 2021. doi.org/10.3389/fphy.2021.6506487

II.- Social crisis in Chile: quantitative and qualitative analysis of associated events.

We analyze 1208 events that occurred between *October and November 2019* associated with the Chilean social outbreak. Our analysis considers the agents identified in these events, those affected by these events, as well as a characterization of these events.

A	B	C	D	E	F	G	H	I	J
fecha (X)	Agente/Sector Social	Agente específico (quien ejerce la acción)	Territorio principal	Afectado (a quien afecta el evento)	Tipo de relación (agente-afectado)	Descripción del evento (X) (en rojo acción) Frases polémicas no.	Tipo de evento	Análisis del Discurso (Sistema de valoración) de frases polémicas (1.entidad/ 2.actitud afecto, juicio, apreciación/ 3.compromiso/4.gradación)	Fuente (X)
04-oct-19	Gobierno	Panel expertos del Transporte Público	Stgo	Ciudadanía	Conflictiva	Se define alta precios transantiago y metro	Aumento costo de vida		Ruiz, 2020; Emol; Cnr;CHV
06-oct-19	Gobierno	Juan Andrés Fontaine (Min. Economía)	stgo	Ciudadanía	Provocativa	Comienza a regir alta precios transantiago y metro	Aumento costo de vida		Ruiz, 2020; Emol;
06-oct-19	Gobierno	Felipe Larraín (Min. Hacienda)	stgo	Ciudadanía	Provocativa	"Quien madrugue puede pagar menos"	Frase polémica		Ruiz, 2020
06-oct-19	Gobierno	Estudiantes secundarios Instituto Nacional	stgo	Ciudadanía	Provocativa	"Precio flores bajó"	Frase polémica		Ruiz, 2020
7-oct-19	Ciudadanía	Estudiantes secundarios Instituto Nacional	Stgo	Servicios	Conflictiva	Estudiantes IN primera evasión masiva del Metro	Movilización social		Emol;
7-oct-19	Gobierno	Juan Andrés Fontaine (Min. Economía)	stgo	Ciudadanía	Provocativa	"Quien madrugue puede ser ayudado a través de una tarifa más baja"	Frase polémica		CNN
7-oct-19	Ciudadanía		Stgo	Servicios	Conflictiva	"El transporte no es bueno"	Frase polémica		Cooperativa
8-oct-19	Ciudadanía		RRSS	Gobierno	Conflictiva	Revelaciones a sígnos de Ministro de economía sobre levantarse más temprano por alta en el metro. Diversas reacciones en redes sociales desperió la propuesta del ministro de Economía ante la tarifa del metro a \$30	Frase polémica		CNN
14-oct-19	Ciudadanía	Estudiantes secundarios de diferentes liceo tradicionales de Stgo.	stgo	Servicios	Conflictiva	Evasiones masivas de Metro	Movilización social		Ruiz, 2020; Emol;
15-oct-19	Gobierno	Gloria Hutt	stgo	Ciudadanía	Provocativa	"No tienen argumento, se mantiene nueva tarifa Metro"	Frase polémica		Ruiz, 2020
15-oct-19	Ciudadanía	Estudiantes secundarios de diferentes liceos tradicionales de Stgo.	Stgo	Ciudadanía	Conflictiva	Evasiones masivas de Metro	Movilización social		CNN
15-oct-19	Servicios	Metro	Stgo	Ciudadanía	Conflictiva	Metro anuncia acciones legales por evasiones masivas	Movilización social		CNN
15-oct-19	Servicios	Louis de Grange (Presidente directorio metro)	Stgo			"Y eso no es evasión, es violencia"			Cooperativa
15-oct-19	Ciudadanía	Estudiantes secundarios de diferentes liceos tradicionales de Stgo.	Stgo			Segundo día de evasiones masivas y protestas en Metro.			Cooperativa
17-oct-19	Gobierno	Panel Expertos	Stgo	Ciudadanía	Provocativa	"Si sube la comida no hacen tanta protesta"	Frase polémica		Emol;

In addition to characterizing the outbreak, we connect these events with Twitter activity on those days in search of a correlation between the activity of material and digital society.

The result of this analysis was the publication:

J.P. Cárdenas, C. Urbina, G. Vidal, G. Olivares, M. Fuentes: Digital Outburst: The Expression of a Social Crisis through Online Social Networks. Complexity, 2022(8980913), doi.org/10.1155/2022/8980913.

III.- Dissemination of results:

Ciclo de charlas sobre FILOSOFÍA Y ENTORNO ISCV / UV

PROGRAMA SEMESTRAL

23 /3 18hrs *Ronald Durán* (UPLA) “Ética, tecnología y obsolescencia”

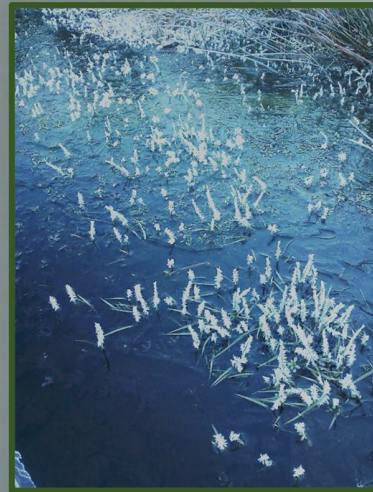
30/3 18hrs *Elisa Calleja* (UNAM) “La utilidad de experimentar con el genoma heredable animal antes de hacerlo en seres humanos”

abril *Oscar Orellana* (UTFSM) “Tiempo cuantitativo vs. tiempo cualitativo: consecuencias sociales, económicas y ambientales.”

abril *Tamara Contador* (UMAG) “Filosofía ambiental de Campo: Una integración de ciencias y ética ambiental para contribuir a la conservación biocultural”

mayo *Pamela Reyes* (WISC) “Activismo juvenil y transformación social”

junio *Miguel Fuentes* (SFI) “Detección de alerta temprana en sistemas sociales”



Proyectos FONDECYT:
N. 11180624 y N. 1181414

para información e inscripciones, escribir a
Esteban Céspedes, estebancespedes@aol.com

Workshop:

Title: “Social Crises and Climate Change”

Speaker: J.P. Cárdenas, Miguel A. Fuentes, G. Vidal.

Place and Date: Viña del Mar, Chile. August 08, 2022



The Structure of Online Information Behind Social Crises

Juan Pablo Cárdenas^{1,2}, Gastón Olivares^{1,2,3}, Gerardo Vidal^{2,4}, Carolina Urbina⁵ and Miguel Fuentes^{2,6,7*}

¹Net-Works, Viña del Mar, Chile, ²Complex Society Lab., Viña del Mar, Chile, ³Grupo de Sistemas Complejos, Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas, Universidad Politécnica de Madrid, Madrid, Spain, ⁴Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile, ⁵Psicología, Facultad de Educación y Ciencias Sociales, Universidad Andrés Bello, Viña del Mar, Chile, ⁶Instituto de Investigaciones Filosóficas, Buenos Aires, Argentina, ⁷Santa Fe Institute, Santa Fe, NM, United States

The adaptive nature of the social system allows it to overcome the challenges imposed by its environment as well as to overcome those internal pressures. This adaptive process is associated with an increase in complexity manifested in a greater diversity of its components, new forms of organization, among other transformations. However, these adaptations have a cost and need to be administered, otherwise, they can trigger social unrest and crisis processes. Currently, the adaptive process of social systems has been accelerated and magnified by the emergence of information technologies. In this work, we explore the close relationship between adaptation, complexity, and crisis, showing its expression in a digital social environment, although with some particularities. Specifically, we have observed expected behaviors, such as the polarization of society and negative sentiment of messages during times of crisis, however, our results show something interesting. Despite the loss of order in the social organization questioned by the crisis, we observe the emergence of new complex ephemeral structures of information which seem to be early-warnings signals of profound social transformations.

Keywords: social crises, complexity, social networks, polarization, thematic networks, early-warning

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1 INTRODUCTION

Society evolves with increasing complexity [1]. As a Complex adaptive system, it is constantly gathering information, restructuring and adapting for its survival. However, it is the same acquired complexity which enables the occurrence of events where the social organization is questioned due to its failure to manage it, giving rise to the phenomenon of social crises [2, 3], affecting fields of politics, economy, and society in general. On the other hand, it is the same complexity which limits the prediction of crises events since there is no clear relation between its precursors and final magnitude.

To face the limits of prediction, and other characteristics of this kind of complex and collective phenomenon, during recent decades Complexity Theory has been providing models with more complete meanings and theoretical coherence for social systems [4, 5]. Human (collective) behavior, and social crises in particular, are many times decentralized processes that emerge as the result of a bottom-up process where social links play an important role, in much the same way that social rules may govern complexity in the society.

Although social crises have accompanied humanity since its origins [2, 6–8], for some years we have witnessed a series of social crisis events of a global nature, of great magnitude and more frequent than in past decades, which could have its origin in the arise of the so-called Networked Society [9] due to the increase in social complexity given the emergence of information technologies and the

Internet, which has broken down geographical barriers, strengthened globalization and significantly increased social interaction as well as the flow of information [10]. It is for this reason that today, online social networks such as Twitter among others, have become a projection of material¹ interactions, sharing signs and developing their own particularities, taking on an unusual role in the development, and even the genesis of some of these social crisis events [11].

In this work we propose a methodology to observe and describe these common signs between the *material society* and *digital society* behavior that occurs in times of crisis. Our objective seeks to clarify the relationship between these two “societies”, where society expresses itself in the manifestation of this type of phenomenon. To achieve this, we have analyzed the Twitter activity of Chilean society, which has experienced for several years, and in particular since October 2019, an acute social crisis which presents in the near future a series of challenges (as the creation of a new Constitution). We have analyzed the activity in the online microblog from two perspectives: users and content, with the aim to approach the phenomena of crisis from those who participate in this, but also from the content or information that they use. To do this, we are using Network and Information theories in order to detect changes (decrease, conservation or increase) in the complexity of the online social system.

We started our analysis from the basis that any critical social moment presents a state of “maturation” [4], a kind of increase in social temperature. It is for this reason that we daily monitor the “hot” topics that circulate on Twitter for a specific territory (*i.e.*, Chilean Trending Topics in the case of this study), harvesting the tweets associated with them in order to construct and analyze networks of users and topics in addition to other typical measures for analysis of this type (*e.i.*, sentimental analysis, polarization, etc.). Thus, we pretend to obtain a multidimensional metric that characterizes the digital society in moments of critical behavior.

The work is structured as follows. In **Section 2** we present the characteristics of the phenomenon of social crises described from traditional sociological and psychological theory. **Section 3** describes the methodology developed to achieve the objectives of this work. The results of our study are shown in **Section 4**. Finally, in **Section 5** we sum up the highlights and present some concluding remarks.

2 SOCIAL CRISES. A BRIEF VIEW FROM SOCIAL SCIENCES

Few concepts refer to such diverse connotations as crisis, to the point that it ends up being used to denote various situations, among them very different in scope, depth, and effects. However, the idea of associating the crisis with “something” (a space, a property, an interest, an affectation, etc.) that is perceived, understood, intuited, etc., as “critical”, seems to be a point in common in many of the definitions. Furthermore, it seems clear

that any of these definitions consider the phenomenon as a “process” which, according to [12] for example, occurs in stages: integration, disintegration, rupture and reintegration.

From sociological theory [12–23], social crises have three properties that define them as such: 1) the conjunctural desectorization of the social space, 2) structural uncertainty and, 3) the processes of deobjectivation; all selective, observable and with a given trend.

The conjunctural desectorization of the social space means that, given the critical conjuncture of the social system, its formal structure is diluted, admitting subtle frontiers of sectoral differentiation, which hinders the interaction of the actors and their sectoral logic, together with the decompartmentalization from the themes that are now released to broader spaces of intervention. Likewise, there is a reduction in the autonomy of the actors and a displacement of the arenas of confrontation, generating a loosening of the links between arenas and issues of confrontation. All this determines serious difficulties for the realization of the calculations that the actors must carry out in anticipation of the effects of their eventual plays, installing a determining factor in the possibility of their success or failure. Thus arises the inability to perform adequate evaluations for the management of the crisis. In psychological terms, the usual styles of resolution are not enough to face the phenomenon, whose scope is mediated by the severity of the events, their unexpected nature and the degree of perceived risk [24].

A second property is structural uncertainty and it manifests itself both as loss and/or confusion of those pre-existing *reference indices*², collapsing traditional definitions and generating loss of effectiveness of the evaluation instruments used in moments of a routine situation (*i.e.*, non-crisis state). This can cause important skidding of certain crises, driven by polarization dynamics in the plays and behaviors of the actors, also accompanied by certain psychological modifications that are expressed in this. In emotional terms, the mediation of the emotional meaning of the crisis is collective [25]. Although narratives become personal through a narrative “engagement”, these emotions motivate social actions. In cognitive terms, the crisis is associated with a confirmation bias (*i.e.*, a tendency to discard opinions inconsistent with one’s own), motivated reasoning (believing that one’s opinion is the best of all and ignoring opposing data) [26], or the priming effect, related to the predisposition to associate certain ideas and stimuli according to those that temporality precede it [27].

Finally, a third property refers to processes of deobjectification of the relations both between sectors and also between actors and sectors, being one of the most interesting vulnerabilities of political systems, generating certain states of liberation in the phenomena of multisectoral mobilizations, or “madness” or “creative effervescence” and in the actors certain behaviors assigned to “collusive transactions” as a formula to obtain certain control of the dynamics that the critical juncture (crisis) acquires.

¹We use the concept of *Material* to refer to those traditional face-to-face human relationships.

²In non-crisis contexts, they are what the different actors in these social systems use to live together.

However, the focus of our concern is whether the digital environment of social interaction represents, in moments of critical juncture, the multiplicity of properties and characteristics described by the theory of social sciences. This is linked to the idea of how far the digital society is a projection of the material society or if the material one is an effect or consequence of the digital society. Furthermore, is it possible to think that the digital society constructs autonomous phenomena and properties in its dynamics, distancing itself from being just a reflection of the social material system, which could rather be insinuated as an autonomous creative capacity that would even allow anticipating the concretion of realities exposed real world.

These questions place us in the identification and reading of the behavior that Twitter has in the face of a critical juncture that unfolds in real time in both types of society, and places us in the analysis of multiple metrics built to try to identify some of these characteristics and get closer to infer something from what is proposed in these questions.

For the Chilean context it is important to highlight that 82% of inhabitants have Internet connection, and 79% of them use online social networks where Twitter stands as one of the most widely used social network, surpassed only by Facebook [28]. As [29] suggests, the country's "digital elite" participates in Twitter, attracting 13% of its population.

The foregoing shows that one of the characteristics associated with crises, such as the displacement of the arenas of confrontation, allow us to understand why online social networks have become a space for the expression of multiple and diverse actors who not only debate about associated ideas but also, they judge, legitimize, approve, reject, confront or construct new realities that affect the game, and move the social system to critical thresholds, thus generating the emergence of its own dynamic.

The structural uncertainty of the crisis is also manifested in online social networks where new reference appear. In fact, traditional referents do not have the exclusive role that they used to have when referring to critical social situations on digital platforms. On the other hand, the loss of sectoral logic, typical of the crisis, is also observed in the digital social environment where any user can comment on any topic, as well as disseminate the associated information much more efficiently.

Finally, the evident social polarization generated by online social networks [30] is another of the characteristics of the crises described by the social sciences that manifests itself in digital environments. In fact [31] suggests that online social networks generate individual political alignments that shape personal consumption of apparently non-political products. On the other hand [32] associate digital polarization with a lower semantic diversity of the subjects treated by individuals and a greater lexical diversity. That is, in polarized digital environments, few issues are discussed but in multiple ways.

While it is true that there are these and other similarities between material and digital societies during a crisis phenomena, we must not forget that the social digital environment has its own rules that generate its own particularities. Among these, the immediacy in the availability of information, the accelerated

flow of it, the possibility of anonymity when commenting on the situations and the existence of thematic connecting vehicles such as *hashtags*, among others, stand out.

3 METHODS

3.1 Context Research

We have developed our work analyzing the digital activity of Chilean people in a context of deep social crisis. In fact, Chile has not been immune to the unstable social behavior manifested by different countries around the world.

Despite his young age (little more than 200 years), the history of Chile has been characterized by various social crises that have determined changes and transformations in the organization of its social, political and economic systems. According to Kenneth [33], the state of stability, or *routine situation* [13], that characterize the country since the end of the military dictatorship in 1990, began to change to a new state of crisis, or *fluid critical conjuncture* [13], with the so-called "Penguin Revolution" in 2006, when thousands of students and their supporters took the streets to protest inequalities and lack of quality in Chilean education. This challenge to the sociopolitical scenario was extended and reach high instability between 2011 and 2012 with the so-called "Student Movement", which highlighted several challenges of the Chilean educational system along with a series of other demands against institutionalism, authorities and their decisions, as well as diverse social, political, economic, environmental and health issues, among others. Starting a logic situation, a climate, a *prégnance* [34] in Chile, which floods the system and manifests itself through a series of critical projections, which seem at first sight to be unrelated, but which form part of the same process. All these conditions seem to converge in October 2019 in a highly unstable generalized scenario with typical characteristics of a sociopolitical crisis such as those faced by the country at other times in its history.

Considering the current crisis scenario that Chile is going through, we have developed a multidimensional analysis to detect signals of crisis that appear in the digital society that are in resonance with signals of the social material crisis.

3.2 Data Harvesting and Networks Construction

From August 27th to October 26th, 2020, we daily monitor Twitter in the search of Chilean Trending Topics, harvesting three times each day (morning, evening and night) the tweets associated with these trending topics. The data, extracted automatically using the Twitter API³, corresponds to 453,564 Chilean tweets (*i.e.*, eliminating foreigners) during the entire period. In each harvest of Trending Topics the average of tweets collected was 4,183.5.

³GET Trends Place API: <https://developer.twitter.com/en/docs/twitter-api/v1/trends/trends-for-location/api-reference/get-trends-place>

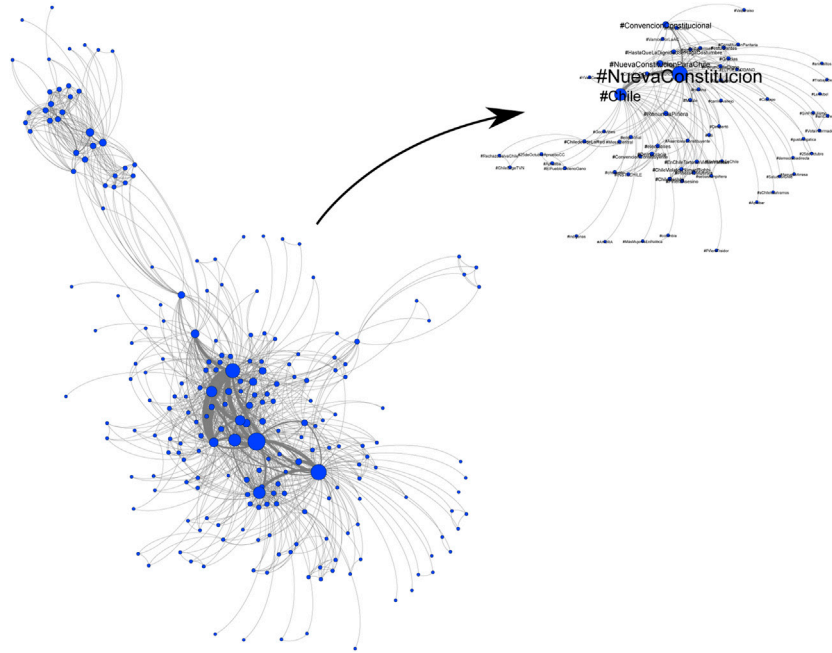


FIGURE 1 | Thematic Network, T . *Left*: Giant Connected Component of T generated in October 2, 2020. Nodes correspond to *hashtags* linked with others by co-occurrence in tweets. *Upper right*: subset of T displaying node labels.

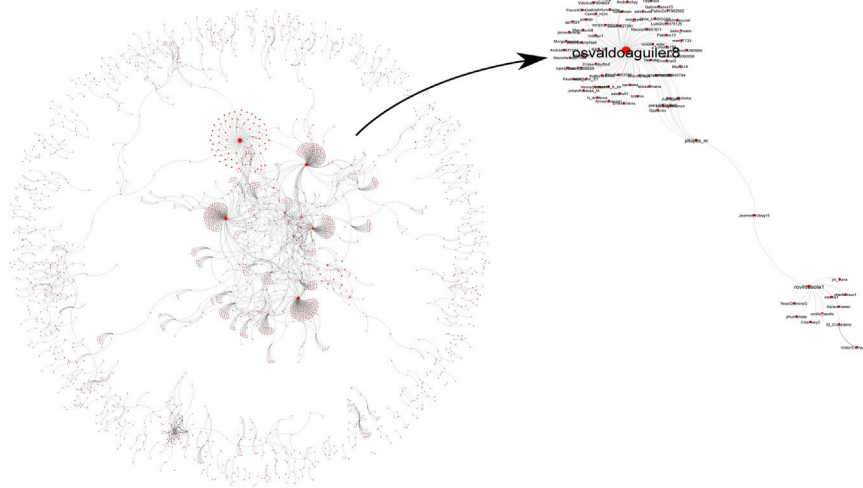


FIGURE 2 | *Left*: Retweet network, U_{rt} generated in October 2, 2020. Each node corresponds to a user linked with others by the action of retweeting. *Upper right*: subset of U_{rt} displaying node labels.

Using the information of these tweets we construct two types of networks: thematic and users.

3.2.1 Thematic Networks

$T(H, L)$ correspond to networks composed by H *hashtags* and L edges between them. In the thematic network T an undirected link between *hashtag* h_i and h_j is created when they appear together in the same tweet. Thus $T(t)$ corresponds to the topic

network at harvest time t composed by all the co-occurrent *hashtags* during t (**Figure 1**). The amount of tweets collected that contained *hashtags* to build this type of network was 204,795 (45.15%).

3.2.2 Users Networks

We will call $U(P, L)$ to the networks composed by P people and L edges between them. We define three types of networks U : reply,

mention and retweet networks. In the reply network, U_r , a directed link from user i to j is generated when p_i responds a tweet posted by p_j . Thus, the $U_r(t)$ corresponds to the reply network at harvest time t composed by all the users that respond to others during t . The mention network, U_m , is similar but considers mentions instead responses. Finally, in the retweet network U_{rt} , a directed link from user i to j is generated when p_i retweets a message from p_j . As well as the previous networks, $U_{rt}(t)$ corresponds to the retweet network at harvest time t composed by all the users that retweet to other users during t (Figure 2).

3.3 Characterizing the Digital World, New Metrics

We have analyzed various metrics, some of them are completely new following the ideas of the concept of a crisis developed and discussed in the previous sections. We have separated this measures into two subsets: structural and content metrics.

Structural metrics correspond to a set of measures that depend exclusively on the structure and topology of the networks that are being analyzed. Specifically, we have considered the following structural measures: network complexity, normalized conditional degree matrix (NCD matrix), and polarization. For the content metrics we have considered the presence of critical concepts, sentiment analysis on messages, and duration for trending topics. Local metrics such as ratio *followers/friends* for Twitter users was also used in this work.

3.3.1 Structural Metrics

We have applied a series of analyzes to T and U networks, focusing our attention on the Giant Connected Component for each harvest. A brief description of these measures is presented below.

Giant connected component (GCC): is the basic structure of networks T and U analyzed in this work due to the importance in percolation processes [35, 36]. It corresponds to a sub-structure of a network that contains the major proportion of nodes where between each pair of nodes there is a path.

Complexity: the Complexity of T networks is defined by [37] as the product between the network entropy S and network disequilibrium Q according to the following equation

$$C(P) = S(P)Q(P, P_e) \in [0, 1] \tag{1}$$

where entropy is based on the assessment of probabilities to jump between nodes when randomly traveling through the network. Thus, the entropy S_i for each node i is computed based on the distribution P_i with entries $p_{i \rightarrow j}$ that give the uniformly distributed probability to jump from node i to node j along an edge between them in exactly one step. For example, if the i is connected to three nodes, then P_i will be one third, for details see [37]. The network entropy S corresponds to the average normalized entropy taken over all nodes i according to

$$S(P) = \frac{1}{N \log(N-1)} \sum_i S_i(P_i) \in [0, 1] \tag{2}$$

where N corresponds to the total number of nodes of the GCC.

On the other hand, the disequilibrium Q is measured in terms of the Jensen-Shannon divergence [38], taking as a reference network the Erdős-Rényi network, see Eq. 3. Q takes low values for systems that are close to equilibrium and high values for ordered systems according to

$$Q_i(P_i, P_{i,e}) = Q_0 \{ S_i[0.5(P_i + P_{e,i})] - 0.5[S_i(P) + S_i(P_{e,i})] \} \tag{3}$$

where $Q_0 = 1/\log(2)$ to ensure $Q_i \in [0, 1]$. The probability distribution P_i again denotes the probabilities to jump between neighboring nodes i and j when randomly traveling through the network, as in Eq. 2. $P_{e,i}$ denotes the same but for a random system (e.g., Erdős-Rényi network). Thus, Q is computed as the mean of all per-nodes values Q_i according to

$$Q(P, P_e) = \frac{1}{N} \sum_i Q_i(P_i, P_{i,e}) \tag{4}$$

where N corresponds to the total number of nodes of the GCC network.

Conditional degree matrix (CD matrix): when studying social networks, we have been able to verify, as already indicated in [39, 40], that metrics referring to local properties (such as the degree of a node) do not capture the general richness of network topology. One way to further characterize the structural properties of the studied networks T is to define the conditional degree matrix, Q_i , for the degree of each node:

$$P_{k,j} = \frac{N_{k,j}}{N_t} \tag{5}$$

where $N_{k,j}$ if the number of nodes in the network with degree k connected to nodes with degree j . While N_t is the total number of degree's connections ensuring the normalization property

$$\sum_{k,j} P_{k,j} = 1 \tag{6}$$

Using the proposed probabilities, similar metrics to those mentioned above can be defined: entropy, disequilibrium and complexity.

Important for this work is the definition of the actual domain of this probability matrix, i.e. what array elements of $P_{k,j}$ are not null. We will call Ω the total number of elements $P_{k,j} > 0$. Indeed, omega will be a metric that will be very useful to give an idea of the type of existing connections between nodes.

The important insight of this matrix, $P_{k,j}$, is the possibility to explore the characteristic of the node and its environment (its near neighborhood). That is, the importance is expressed in terms of disseminating information. The rows of the matrix then show the probability that nodes with a given degree connect with other nodes in the network and their importance in the network will be weighed by the frequency of occurrence of these connections.

Polarization: another metric used in this work was the polarization of Twitter users in U networks for each time interval analyzed. To infer the opinion of the users participating on the Twitter conversation and measure the resulting polarization we use the methodology introduced in [41]. This methodology develops a model to estimate the

opinions of users who interact on a social network from a minority of hubs whose opinion is known. This model has already been used in [42] to measure the political polarization of Twitter users in the Chilean presidential elections of 2018. In our case, the two elites of users with opposing opinions have been selected automatically, assigning n nodes from the two largest communities obtained through the greedy modularity communities algorithm. The model is initialized by assigning an opinion value X of -1 or 1 to each elite and initial value $X = 0$ to each listener. The opinion of each listener is iteratively updated as the mean opinion value of her outgoing neighbors. Thus the opinion at time step, t , of a given listener i , is given by the following expression:

$$X_i(t+1) = \frac{\sum_j A_{ij} X_j(t)}{k_i^{\text{out}}} \quad (7)$$

where A_{ij} represents the elements of the network adjacency matrix, which is 1 if there is a link from j to i , and k_i^{out} corresponds to her out-degree. The process is repeated until all nodes converge to their respective X_i value, lying in the range $-1 \leq X_i \leq 1$. Thus, the results of the model are given in a density distribution of nodes' opinion values $P(X)$. In our case the network of the model is represented by the retweet network, reply network and mention network independently. We generate a network for each harvest and the corresponding adjacency matrix for each harvest is given by the following equation:

$$A_{ij} = \begin{cases} 1 & \text{if } i \text{ retweet } j \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

Polarization was calculated for each harvest obtaining a measure from the resulting density distribution of nodes' opinion values $P(X)$. The polarization is given by the following expression:

$$\rho = (1 - |\Delta A|)d \quad (9)$$

where

$$|\Delta A| = |P(X > 0) - P(X < 0)| \quad (10)$$

and $2d$ is the distance between positive and negative average opinions.

This formula gives $\rho = 1$ when the distribution is perfectly polarized. In this case the opinion distribution function is two Dirac delta centered at -1 and $+1$, respectively. Conversely, $\rho = 0$ means that the opinions are not polarized at all. *Ratio Followers/Friends*: we use the amount of *followers* and *friends* of users who participated in twitter during the harvests in order to classify them into groups according to the ratio between both quantities: commons (Followers/Friends ≈ 1), followers (Followers/Friends < 1) and leaders (Followers/Friends $\gg 1$). The ratio [followers/friends] have been used as a measure to classify users on Twitter in [43, 44] given its ability to classify the user profile according to their historical activity on this social network, what we are looking for in this study. Due to the dynamism of communications in Twitter, this classification does not seek to classify users according to their daily or recent activity in which they could have a high/low level of connectivity or a high/low centrality in the network.

3.3.2 Content Metrics

Sentiment analysis: is an automatic task of massive classification of documents, which focuses on cataloging the documents according to the positive or negative connotation of the language used in it. We have used the python sentiment-spanish library [45] to infer the positive and negative sentiments of each tweet harvested. This library uses a convolutional neural network to predict the feelings of words in Spanish. This model was trained using more than 800,000 user reviews from various websites, such as eBay and Film affinity. This library delivers sentiment values between 0 and 1. In this work, values closer to 1 indicate negativity of the message and values closer to 0 indicate positivity of the message.

Presence of specific words: we quantified the presence of words "charged" of anger, fear and social critical relevance for Chilean context. In this case, we used the NLTK corpus WordNet in order to increase the probability of finding words of this type.

Topic relevance: we developed a web-crawler to extract from Trendialia.com the duration (hours) of trending topics analyzed in each harvest. This metric denotes the importance of the topics analyzed in the Chilean context.

3.3.3 Order, Disequilibrium and Diversity (ODD)

In order to capture the order, disequilibrium, diversity of T networks analyzed, as well as the topic importance, we introduce the metric *ODD* that combine them according to the following equation

$$ODD = C * \Omega * \Delta^a \quad (11)$$

where C corresponds to the Complexity of the T network (Eq. 1), Ω corresponds to the total number of T network nodes $P_{k_j} > 0$ normalized by N^2 (Eq. 5), and Δ to the duration in hours of the trending topics analyzed weighted by a parameter.

3.3.4 Metrics and Social Theory

Finally, the metrics proposed in this section try to quantify some expressions of the properties described in Section 2. Table 1 shows our proposal about the relation between these metrics and the theory behind social crises.

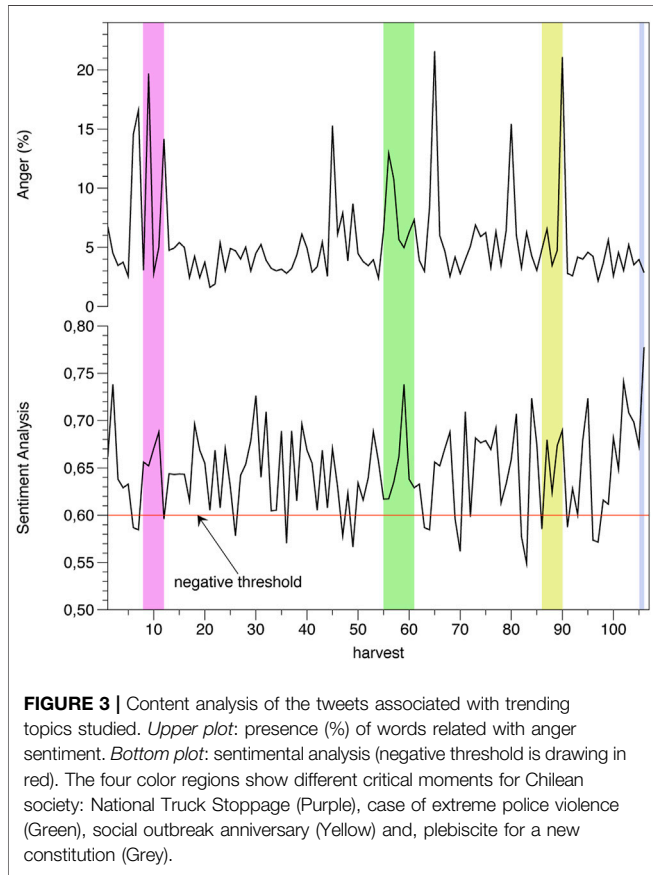
4 RESULTS

It seems to be clear which are the characteristics associated with the phenomenon of the crisis, at least from the social sciences point of view. However, it is not entirely clear in those disciplines, what are the conditions that allow its manifestation. We are not referring only to precursors or early-warning signals, where there is practically unexplored terrain, but to those contexts which appear as multiple and unclear. The problem of detecting early warnings in social networks has been investigated in various ways, and even in this work we present different perspectives, from a sociological and qualitative point of views, using network theory and complexity tools.

Berestycki et al. [4] show that before the social explosions associated with crisis, society needs to be "ripe", charged with negativity and violence. This behavior is manifested in the case of our study. Figure 3 shows the analysis of the messages associated with the trending topics of the moment, issued by Chilean Twitter users.

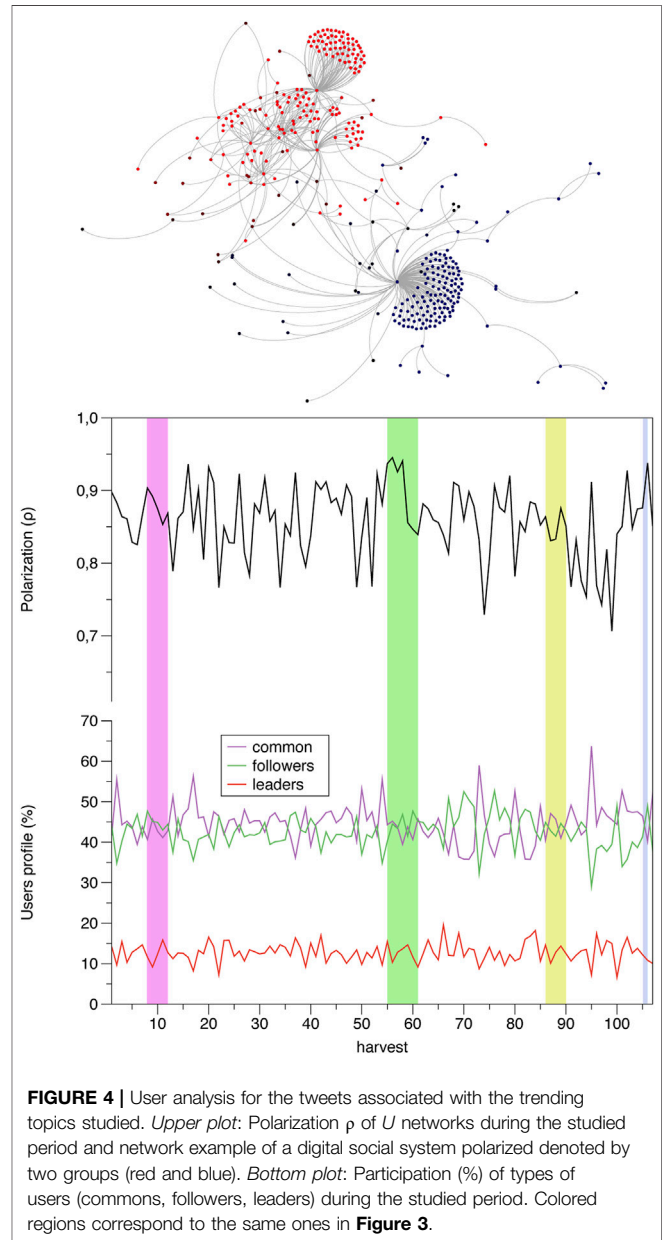
TABLE 1 | Scope of action of the metrics proposed in relation to the properties of social crises described in **Section 2:** Desectorization of social space (DSS), Structural uncertainty (SU), and Processes of deobjectivation (PD).

Crisis	Complexity	NCD matrix	Polar.	Ratio F./F.	Sent. Analysis	Word presence	TT relevance
Property	(structural)	(structural)	(structural)	(local)	(content)	(content)	(content)
DSS	X	X		X			
SU	X	X	X	X	X	X	
PD	X				X	X	X

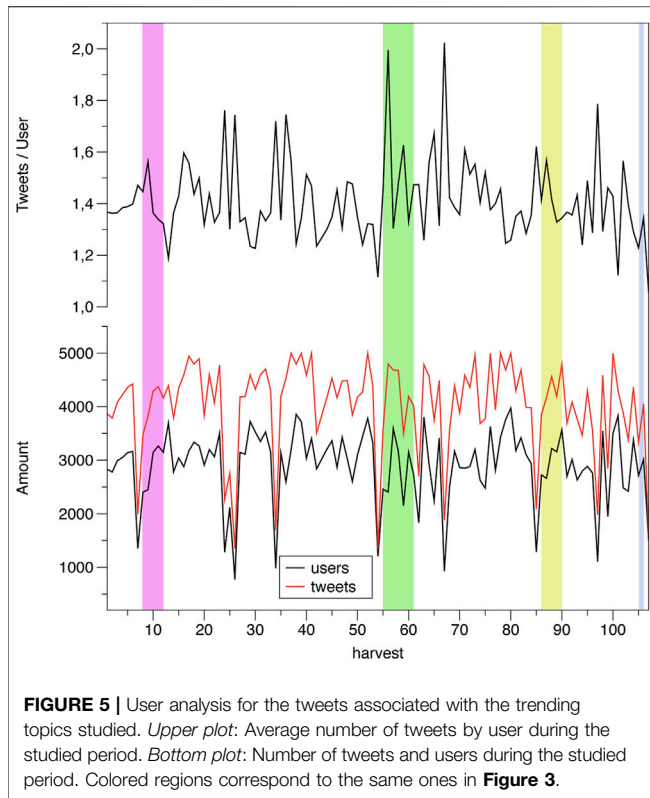


The result of the sentiment analysis of the messages seems be fairly obvious for crisis situations: messages are usually negative in character. In addition, the result is complemented with the analysis of the presence of words full of anger for the Chilean context, which in some cases coincide with moments of high tension in Chilean society marked with four vertical stripes of color: National Truck Stoppage (Purple), case of extreme police violence (Green), social outbreak anniversary (Yellow) and, plebiscite for a new constitution (Grey). The width of vertical stripes denotes the duration (*i.e.*, significant presence) of the events in Twitter.

This negative verbal context coincides with a highly polarized digital society (upper plot of **Figure 4**), highlighting the tension between conservatives and progressives regarding the future of the country. It can be seen that, like the sentiment analysis, user polarization of *U* networks was high throughout the period of analysis.



Something similar happens with the distribution of participating user types, which does not vary during the period. Notwithstanding the foregoing, it is interesting to note that during the entire period, those leading users are



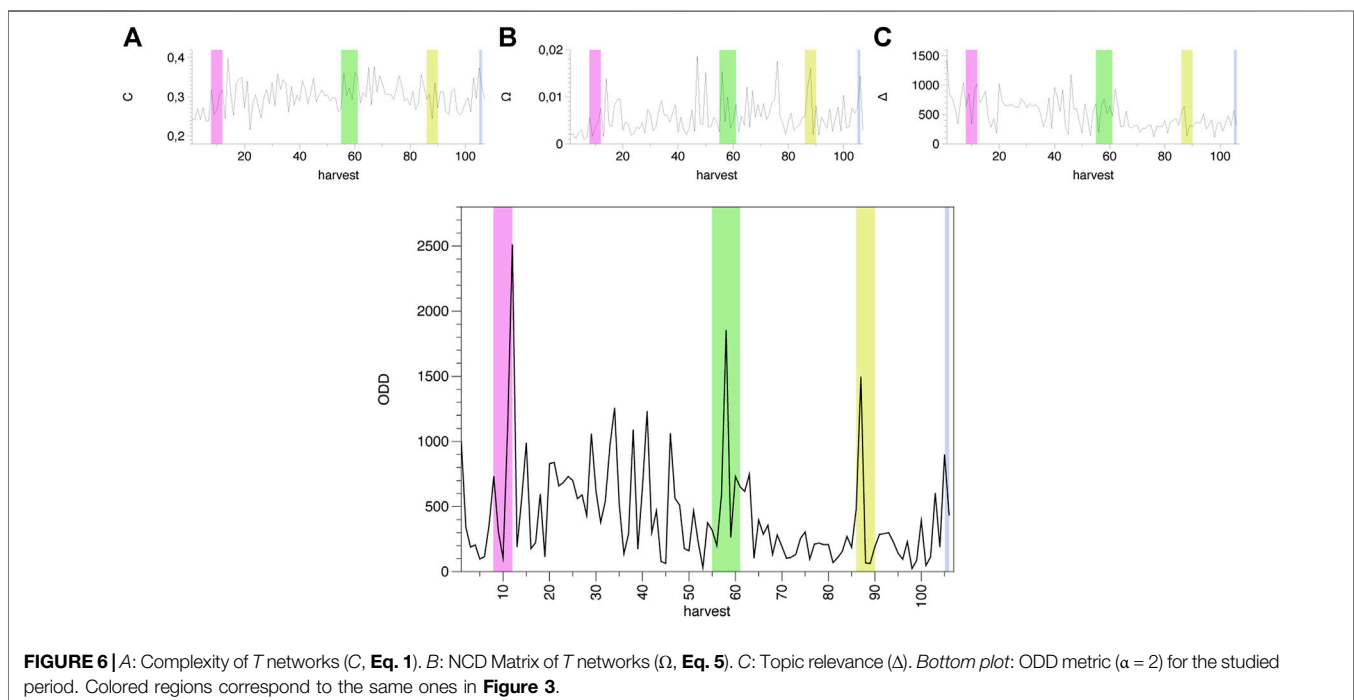
not opinion leaders (Followers/Friends $\gg 1$) but rather the vast majority are common users (Followers/Friends ≈ 1). It is important to note that we can rule out spammers in our analysis since these users generally have a very small followers/friends ratio ($\ll 1$) [44].

A polarized society, and negative and violent verbal language, seem to reflect the state of a society [46]. But, do they allow us to forewarn a crisis or a critical moment for the society? Apparently not. The results show minimal variations in these parameters during the period studied, even during those moments of high social tension manifested by the material and digital society, which had important consequences.

It would seem suggestive to think that these moments of high tension are associated with greater activity in the digital society, however, this is not the case either. **Figure 5** (lower plot) shows that during these moments the number of users as well as tweets associated with the hot topics of the moment, do not show variations either. Nothing special is observed in user activity either. The average number of tweets by user does not match the critical moments that society experienced either.

At this moment our results about structural properties of thematic networks T become relevant. Upper plots of **Figure 6** show the Complexity (A plot), NCD Matrix (B plot) and the interest (hours) generated by the trending topics obtained in each harvest (C plot), for the thematic networks T during the period studied. Fluctuations can be observed in all cases during the period studied, which in some cases coincide with moments of high social tension.

What is relevant appears when considering these measures in order to rescue broad changes in the structural complexity of thematic networks. Thus, by combining the entropy of the thematic system, its structural disequilibrium, its diversity in terms of connectivity, and its impact, four major fluctuations are clearly appreciated in this constructed metric ODD, which coincide with periods of high social unrest in the country (color mark) that resulted in important social transformations. That is, during critical moments, and in particular before they manifest themselves in the material society, thematic networks become more complex, with a high degree of order, far from structural equilibrium and with a wide diversity in the connectivity between these themes.



5 CONCLUSIONS

This work explored the digital behavior of Chilean society in the midst of a deep social crisis. The analysis of the messages associated with the main trending topics used by Chilean Twitter users, suggest that the crisis that the country is experiencing is expressed not only in the so-called *material society* through multiple expressions, but is also expressed in the *digital society* in which the inhabitants of the country communicate preferentially for the treatment of these and other issues.

The results show that the digital activity of Twitter reflects the tension of events that occurred in the material society, while the digital activity “feeds” this tension. Consequently, this relationship is clearly reciprocal. Nevertheless, our results suggest that digital activity would allow alerting about critical events with the potential to generate social transformations. For example, the first critical moment detected in our analysis (pink region in Results section figures) resulted in the accusation and subsequent departure of the prime minister of Chilean government [47]. The second moment (green region) had consequences for the restructuring of the national police, the arrest of several people and even threats towards judges investigating the case associated with the event [48]. The third moment (yellow region) was the anniversary of the so-called “social outbreak” associated with several riots around the country [49], and the fourth moment (grey region) resulted in a historic vote that meant rewriting the national constitution [50].

Traditionally, online social network analysis focuses on users and sentiment analysis of the messages. However, in this work we don't observe a strong correlation between the activity intensity of users and critical moments (Figure 5), nor with the polarization (upper plot of Figure 4), or the usage of negative/violent language that remains constant throughout the period studied (Figure 3). What our results show is that at critical moments preferably common and follower users share information (bottom plot of Figure 4), taking away the traditional role of the media and other echo chambers. Nevertheless, the most important result of our work is that the organization of information, posted by these kind of users, seems to be the key to anticipating critical events with the potential to generate social transformations. In fact, the increase in the order, disequilibrium and diversity of hot topics relationships, seem to be a signal of the beginning of a critical moment with unexpected results, at least that is what our results show for a polarized digital society that communicates with violent and negative language.

The novel proposed methodology, based on the analysis of thematic networks, allows us to observe the aforementioned reciprocal relationship between digital and material societies. Thus, from our perspective, users become only agents for the transmission of information forming a decentralized collective that generates and

maintains the energy associated with information related to critical events. In critical moments, the information (topics) is organized in a non-trivial way and it seems to capture the social tension as well as its subsequent relaxation (Figure 6). Thus, the thematic networks T would allow access to representations and ideas about reality at a particular moment. These networks would self-organize through the emergence and dynamics of hot topics as objects of reference [51] in the exchange of opinions within Twitter.

The emergence of order in the information that flows through online social media prior to critical moments seems to enrich the social theory of crises from an adaptive social perspective. The (apparent) loss of structure described by social theory (*i.e.*, the conjunctural desectorization of the social space, structural uncertainty, and the processes of deobjectivation) actually signifies a restructuring of order engendered by critical events. In fact, the deep social crisis manifested by the Chilean society has shown an evident loss of structure in part of its organization; however, other parts of the social system seems to reorganize itself into new structures. The complex behavior observed in critical moments such as the ones described in this work, along with others in which society is organized against the established order, included the future national constitution, would be the manifestation of the spontaneous increase of complexity that the systems manifest in its adaptive process. Thus, the complexity of the adaptive system is maintained and even increased during the process. This is a hypothesis that may be probed in a future as well as a deeper understanding behind the observed correlation between the organization of information in online social networks and social crisis events.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: Twitter Public Dataset.

AUTHOR CONTRIBUTIONS

All authors provided critical feedback and helped shape the research, analysis, and manuscript.

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Research Article

Digital Outburst: The Expression of a Social Crisis through Online Social Networks

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There is a growing concern about the effects that the relationship between the activity of society in the physical world and in the digital world could have. In this study, we address this question in a context of social crisis. Our quantitative and qualitative analysis of the data associated with the critical process suggests a deep and nontrivial relationship between both worlds. Perhaps the most important result refers to the leading role of language, its meaning, and symbolism in the development of social transformation processes linked to the complexity of the social system and its adaptive nature.

1. Introduction

Victor Hugo, the great French writer and political activist, lived through troubled social times. He was convinced that his country needed drastic social changes. The abolition of the monarchy and, in its replacement, the arrival of the republic, represented that change in social organization that he, along with many others, considered necessary. His famous phrase “Nothing is more powerful than an idea whose time has come” gave collective ideas a leading role and immense transformative potential. Relegating individuals to a secondary role is useful as vehicles for their propagation and execution.

This scenario represents one of the many moments in which human societies have faced crisis processes. Although the pressures for change, articulated in collective ideas that are manifested in language games, are of different nature and context-dependent. They represent a common mechanism

behind social crises: they operate as pressures so that the system adapts to new social needs or challenges [1, 2]. These social processes unveil evolutionary properties of the system that emerge from adaptive demands without previous purposes, related to the survival of the social system itself [3, 4]. Evidencing a sort of endogenous restlessness of the system, permanently willing to reproduce the differentiation and diversity of social meanings.

From the complex systems theory, the dynamic and evolutionary nature of societies, which produces this differentiation and diversity and which inevitably pushes the social system to processes of adaptations–innovations and therefore of crisis, is framed within the scope of the so-called “complex adaptive systems” (CAS) [5, 6]. These types of systems, composed of multiple components with nontrivial dependency and affectation interactions, manifest a wide range of possible behaviors, which defines them as “complex” [7]. However, its main characteristic is its ability to

incorporate, spontaneously during its evolutionary history, information (i.e., complexity) as a result of their interaction with the environment, in order to function in an environment that demands new capabilities. Thus, in the evolutionary history of a CAS, the past is characterized by a lower level of information or complexity than in a future state [8].

The interesting thing is that the same complexity acquired by the system, by diversifying the roles of its components and improving their combination, begins to exert pressure for the system to incorporate it into its functional order. The above would also be valid for human societies. The complexity acquired by the social system, translated into the creation of new norms, bureaucracy, infrastructure, social values, institutionalism, among other adjustments, has an associated cost that may contribute to the destabilization of the system [9]. Thus, complexity, crisis and evolution are closely related concepts in the history of human organizations, giving crisis a natural, collective, and necessary character for the system's evolution. This vision enriches the important contribution of the social sciences to the understanding of the phenomenon whose thinkers have focused on the identification of certain conditions behind the social crises. According to Marx [10], the cause of social conflict lay in the unequal distribution of private ownership of production goods, the origin of the domination of some over others. Weber [11] agrees that the origin of the conflict is at the level of the economy, but without the character or scope that Marx gives it. Coser [12] introduces the concept of "relative deprivation" as a conditioning factor of social mobilizations and violence. Dahrendorf [13] installs the unequal distribution of authority as the cause of contemporary social conflict. For Kornhauser [14], the problem lies in the conflictive relationship between the elite and the nonelite. For Touraine [15], the phenomenon of conflict is linked to the "technocracy" which, as the new ruling class, ends up imposing its ideas. Foucault [16] believes that the origin of the conflict is in a relationship of domination that is constantly created in social bonds (in the microphysics of power). Habermas [17] sees the origin of social conflict in the absence of consensus in society. While Lyotard [18] characterized postmodernity as part of a process of sociocultural mutation that has led to the collapse of the historical project of modernity, creating conditions of permanent social instability. For del Rey Moratto [19], the conditions for the conflict are provided by the power of language. Within this group, the ideas of Luhmann [20] and Dobry [21] stand out by incorporating certain aspects of complex systems.

The traumatic experience of Victor Hugo, exiled between 1852 and 1870 for defending those transformative ideas in his time, is revived today in many places around the world. For some years now, countries in different continents have been facing deep social crises that demand common transformations, advocating for better living conditions, equality, justice, among others. In fact, between 2018 and 2020, there are around 42 countries that had major social disruptions [22]. Chile, within these countries, can be considered a paradigmatic case. Its history is characterized by various social crises (in the years 1810, 1818, 1833, 1891, 1924, and 1973) that have determined changes and

transformations in the organization of social, political, and economic systems.

Today, as in the past, Chile is going through a profound crisis characterized by one of the largest expressions worldwide regarding the number of events associated with social crisis, the number of people involved, and the duration of the process [23]. According to Roberts [24], the present situation went from a state of stability or a state of routine conjuncture according to Dobry [21], since the end of the military dictatorship in 1990, to a state of crisis or fluid critical conjuncture, with the so-called "penguin revolution" in 2006. The "Chilean miracle," praised in much of the world during the 1990s, began to suffer when a series of adaptation pressures formed a critical mass demanding a new order, or a new social contract according to Rousseau's ideas [25–27]. The language game of the Chilean crisis embraced social valuations such as probity, transparency, gender, feminism, environment, among others, which reflect the internalization of global social valuations and others of their own. They started to put pressure on the order established up to that moment causing a functional differentiation and diversity (with expressions of social fragmentariness) self-organized around diverse interests of social collectives whose identity contours were constructed and perceived according to the meaning they acquired and assigned [4].

1.1. New Information Technologies and Social Crises. Chilean social pressure coincided with the massive irruption of information technologies as a form of social communication. Some works on the relationship between new forms of information/communication and social crises indicate the concern of epistemic public crises that may impact the political spheres. This phenomenon is due to the quantity and speed of information production and the forms of knowledge construction due to digital technologies [28] and, also, the emerging dynamics of digital network recruitment that has been observed in mass protests [29].

Thus, as in other countries, the new information technologies became platforms where dissent occurred regarding the rules of social functioning established in recent decades. Little by little, the Internet, and its online social networking applications, helped the propagation of these ideas by eliminating geographical and temporal barriers. Generating an environment whose "social temperature" began to increase and exploded on October 18, 2019 (18-O). It ended up by breaking part of the sociopolitical structure of the country, the result is still underdevelopment.

18-O was preceded by a series of unfortunate statements from government officials and by an increase in the value of public transportation (subway) in the country's capital. High school students responded to the increase with evasion of the charge [30]. Triggering an escalation of evasion that derived on October 18 in different forms of multisectoral manifestations and social violence unprecedented in the country. The panorama that the country experienced for several days included marches, pot-banging, burning of subway stations, looting, destruction, and a questioned police response.

That social outburst, as a critical salient of the Chilean social crisis, had a milestone on the night of November 15, 2019, when in a transversal agreement of Parliament, as a way to institutionalize the conflict, the so-called “Agreement for Social Peace and New Constitution” (Acuerdo por la Paz Social y la Nueva Constitución), ASPNC, was generated. In it there was an agreement to rewrite the Chilean Constitution through a Constituent Convention mechanism [31–33].

The new social organization, demanded by social events of different types that had been occurring since 2006 and that exploded in October 2019, is materialized, potentially, in this agreement as an emerging property of the collective. Which is the product of the multiple interactions between ideas, thoughts, feelings, and actions of the individuals that make up the country.

This research is inserted in the context described above, particularly, in the study and analysis of the Chilean social outburst, as climax of the social crisis, and in the institutionalization of this conflict in the milestone of ASPNC as a social adaptation to the crisis. The study aims to contribute with a description of the phenomenon of social crises from the perspective of complex systems, in particular, from its adaptive nature. This research assumes the social system as one of complex and adaptive character; therefore, subject to certain fundamental laws that operate within and on them. Although it is not the purpose of this work to deepen in these, but rather to demonstrate its manifestation.

1.2. Hypothesis and Objectives. The research is based on the following hypotheses: (i) part of the complexity of a social system is expressed in the social contract that it generated and that defines its identity dynamically; (ii) this social contract enters into dissent (Crisis) when ideas, thoughts, feelings, and actions of its social agents operate as adaptation pressures in search of a new order (i.e., new social contract); (iii) these adaptation pressures and the possible resulting scenarios (i.e., new social contract) can be observed from the activity of the society in cyberspace, being a reflection of what happens in the material society (activity of society in physical space).

This work focuses on the transformative potential of collective ideas, thoughts, feelings, and actions, and on the capacity of the digital environment to guide these processes through the use of language represented by hot topics (Trending Topics) that circulate in digital circuits as a projection of these ideas, thoughts, feelings, and actions of the components of the social system. To validate these hypotheses, the research has specific objectives: (i) unveil manifestations of the complexity phenomenon from the digital society, before and during the Chilean social outburst; (ii) study the correlation between social events and their expression in online social networks before and during the social outburst; (iii) explore possible causal relationships between material and digital social expressions in times of crisis and, finally; (iv) characterize the events associated to social outbursts as well as the relationships between actors (agents and affected) by these events.

The study is structured as follows: Section 2 describes the quantitative and qualitative methodology used for the analysis of the Chilean social outburst that affected the country during the months of October and November 2019. Section 3 presents the results obtained from the developed analysis. In this section, the results are divided into three parts: (i) changes detected in digital behavior before and during the social outburst; (ii) analysis of social behavior, both material and digital, during the social outburst; and (iii) analysis on causality between the material and digital activity of Chilean society. Section 4 presents a discussion of the results obtained and their interpretation according to the proposed model of social crisis. Section 5 presents the main conclusions drawn from this work.

2. Methodology

2.1. Period Studied. To address the process of transformation and social adaptation of Chilean society, and its expression in online social networks, we analyzed the period from September 1 to November 15, 2019. This period covers the three most critical days of the social outbreak (red), 48 days before (blue) and 26 days after (green), which culminated with the milestone ASPNC (Figure 1). It is important to note that the separation of the outbreak into two parts (red and green) is due only to the particularity of the social behavior manifested in the first three days of the outbreak, but in no case does it mean that the outbreak has ended after those first three days.

2.2. Correlation Analysis between the Material Society and the Digital Society. A quantitative and qualitative analysis of the social events that occurred during the studied period and their correlation with the digital social expression of these events on the online social network Twitter was made.

To determine the social events during the period under study to be analyzed, an automatic extraction from Google, every day and throughout the period (Table 1), of news published by the main Chilean media according to the classification of Digital New Report (2020)1.

The period from October 4 to November 15, 2019 (hatched area Figure 1) used as a basis the list of events of sociopolitical character described in [23], subsequently complemented with the main news/events associated, collected from the main Chilean media according to Digital News Report (2020). In order to analyze only those events with sociopolitical character in the previous period, between September 1 and October 4, 2019, a classification of the news was performed leaving aside those with international character, entertainment, sports, and others (Table 1).

For the period from October 4 to November 15, 2019 (hatched area Figure 1), a categorical content analysis [34] was also performed, which allowed classifying each of the 817 news/events of that period into five categories, which are also subdivided into subcategories (Table 2).

Correlation between events and digital activity. To determine the correlation between the events analyzed and Twitter activity, all the Trending Topics (TT) [35] associated

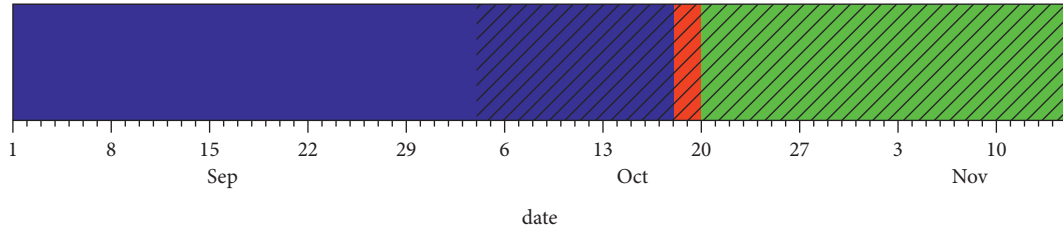


FIGURE 1: Period studied. Blue region corresponds to the period prior to the Chilean social outbreak. Red region corresponds to the first three days of the social outbreak. Green region corresponds to the period after those three days that culminates with the milestone ASPNC. Hatched area corresponds to the period used as a basis for the list of sociopolitical events described in [23].

TABLE 1: Number of News and Trending topics used in the analysis corresponding to the period studied divided into two stages: before the Social Outbreak (48 days) and during the Social Outbreak (29 days).

	Before	During	Total
News/events	2659	1012	3671
News/events sociopolitical character	533	817	1350
Trending topics (unique)	5553	4359	9912

TABLE 2: Description of the analysis categories for the news/events during the Chilean social outbreak.

Category	Definition	Subcategory
Agent	Social sector from where the action described in the news or event is exercised.	Art, culture, and entertainment; citizenship, sports, entrepreneurship, armed forces (AF), forces of order and security (FOS), government, national media, international media, international organizations, private organizations, public organizations, social organizations, others, political party, judicial branch, legislative branch, services.
Affected	What or who receives the action described in the news or event.	The same subcategories as in agent category, plus events, goods, and services.
Territory	Geographical location where the news or event studied takes place.	Country, international, different cities in Chile (e.g.: Valparaíso, santiago, temuco).
Type of relationship	How to characterize the agent-affected relationship, from the affected person's reaction.	Synergistic or conflictive.
Type of event	Characterization of the pattern of the event or news based on the main action that is described.	Constitutional accusation, social support, search for consensus, controversial behavior, control, unprecedented control, internal control FA or FOS, damage to goods and/or services, report human rights violations, detention of FA or FOS members, demand for the cessation of violence, event management, service management, FA or FOS impunity, social mobilization, reparation, police repression, violence.

with Chile for each day of the period studied were extracted from the Trendinalia database (<https://www.trendinalia.com/>), as well as the duration (minutes) of each one (Table 1). Once the TTs were extracted, automatic processing was carried out to determine the presence of the TT in the headline of the news, in its content, or in the agent or person affected by the event. Finally, the degree of correlation between these events and the digital social activity was performed by considering the presence (Twitter match) and the duration of the correlated TT.

Causality analysis between digital and material activity in society. To address the possible causal relationships between society's digital and material activities, we used a procedure that is similar to the one described above (Twitter match). In this case considering the presence of

TT the days before/after the day of the analyzed event. Two types of (potential) causality relationships were obtained when: (i) Twitter conditions a material event (i.e., there is Twitter match between the day of an event with a TT of the previous day), or when, (ii) the material event conditions the reaction on Twitter (i.e., there is Twitter match between the day of an event with a TT of the following day).

Given the number of events during the most critical days of the social outburst, as well as the dissemination of information in various media, this methodology is not entirely accurate. For this reason, the milestone ASPNC and the accusations made against government officials during the social outburst were used to test the relationship between both the worlds digital and material.

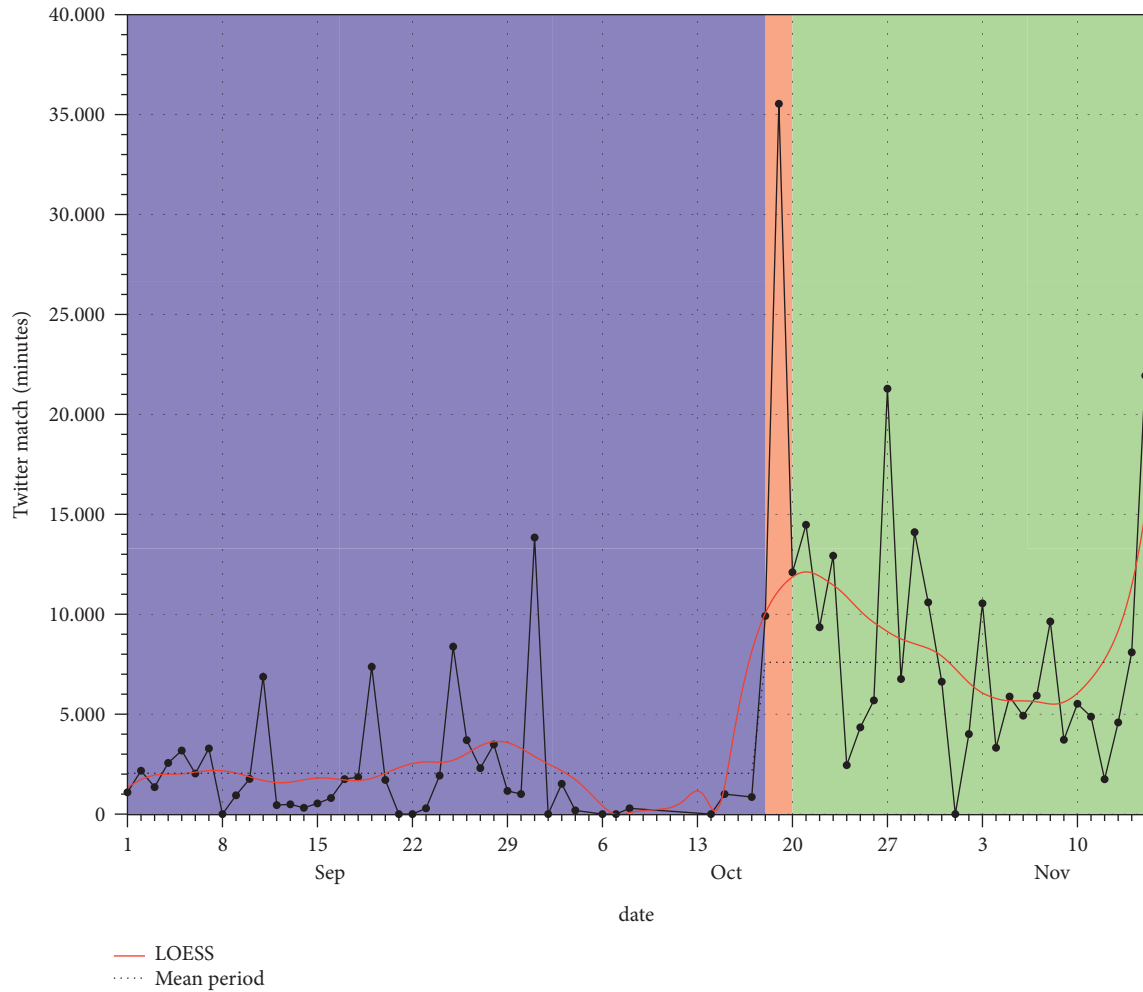


FIGURE 2: Relationship between “social events” that appear in digital media and their appearance on Twitter as Trending Topics. Vertical axis corresponds to the duration of those TTs that were associated with the events described in the digital media.

2.3. Analysis of Social Complexity. Two models were created to quantify the dynamics of the complexity of the Chilean social system during the social outburst: (i) System of Ideas and (ii) System of Actors. The system of ideas reflects the dynamics of relationships between the type of concepts that transited in the digital society during the studied period. The system of actors represents the dynamics of relationships between actors (agents and affected) during the social outburst. Changes in social complexity depend on changes in the structure of relationships between the entities of both systems.

System of Ideas. The graph $I(T, E)$ is defined as an undirected network of ideas composed by T trending topics and E links between them. The relationship e_{ij} between trending topics i and j occurs when both cooccur on the same day. Thus, for day d , I_d will correspond to a clique network where all the TTs of that day are linked to each other because they cooccur on the same day d .

Two I networks were constructed to analyze their structure and determine the complexity of these systems of ideas before and after the social outburst. I_a corresponds to the network accumulated during the preoutburst period

from September 1 to October 17, 2019. If a TT i appears on more than one day during this period, different daily networks will be related. The same procedure was performed for the postburst period from October 18 to November 15, 2019.

The frequency of appearance of a TT i on different days, as well as the frequency of relationships between trending topics i and j on different days, will define attributes for nodes and links, respectively, which will be considered in the analysis. The study of the structure of these networks was complemented with a classification of these TT in different categories.

System of Actors. The graph $A(N, R)$ is defined as a network of actors composed by N agents/affected and R relationships between them. The relationships between actors i and j is directed, that is, from agent (i) to affected (j). The frequency of relationships between actors i and j in different days of the studied period will define the attributes for the nodes and links which will be considered in the analyses. The study of the structure of these networks was complemented with a classification of these actors into different categories (see Table 2).

3. Results

The results of this research are divided into three parts. The first one refers to the results of the analysis that allows us to show the differences in the behavior of the digital society before and after the social outburst. The second one refers to the analysis of social behavior, both material and digital, during the social outburst. Finally, there is a section referring to causal relationships between digital and material activity of society.

3.1. Digital Behavior before and during the Social Explosion. Figure 2 shows the correlation between material and digital societies using the concept Twitter match. In this study, a Twitter match is defined when a material social event has its manifestation on Twitter. The figure shows that during the period before the social outburst (blue region), very few events of a sociopolitical nature had a correlation with Twitter's social activity. These changes completely after the first 3 days of the social outburst. During this period, Twitter becomes a much more sociopolitical platform where the majority of the "material" events associated with the outburst have a manifestation in society's digital activity.

Figure 3 shows other changes in the behavior of digital society before and during the outburst. The lower plot shows the amount of daily TTs before and during the social outburst. Before the social outburst, there was an average of close to 250 daily TTs for Chile. However, during the outburst, this number was very variable and, on average, with less daily TTs. On the other hand, the TTs of a sociopolitical nature increased considerably during the outburst in a clear sign of connection between the digital society and what was happening in the streets of the country (Figure 3, middle plot). There are no significant differences between the two periods in the average duration (minutes) of the TTs in each day.

The stronger connection between material and digital societies during the burst was manifested first by a stronger correlation between events associated with the social outburst and digital activity (Figure 2) and by the sociopolitical character that the digitized society acquires (Figure 3). Figure 4 suggests an even deeper change in digital behavior during the burst.

Before the social explosion (Figure 4, left), 49% of the TTs referred to Entertainment (*E*) and Sports (*G*). The International topic was the third most represented category ($I=16\%$), followed by Political (*P*), which, together with Social (*S*), accounted for only 20% of the hot topics on the digital social network. However, during the social outburst (Figure 4, right), social and political contributed with 47% of the TTs, while entertainment and sports, together, reached only 21%, whereas international fell to a 9% of representation, showing a clear change in the topics that began to be discussed digitally once the digital explosion began.

This change can also be seen in another way. If we consider the different categories of TTs as the space of possibilities in which the digital social system can manifest

itself, we can understand this change as a new form of organization of the digital society. As mentioned, before the social outburst, entertainment and sports dominated the social network landscape, but not only in terms of number of TTs but also considering the time these remained as such.

Figure 5 shows that after the social outburst started, the thematic diversity is greater when considering the number and duration of TTs. This translates into a higher entropy (*S*) of the system during the social outburst.

Finally, regarding the relationship between the topics that dominated Twitter's digital society, Figure 6 shows clear differences before and during the social outburst. The figure highlights the above described where before the outburst (left network), the main nodes correspond to entertainment and sports (node size proportional to the number of associated TT), while after the beginning of the outburst, social and political take prominence. However, the networks also show something else. While before the outbreak, only 1% of the TT relationships were between social and political, after the outbreak began, these relationships increased to 12%, that is, after the social revolt began, both types of hot topics appear together in digital society. On the other hand, before the social outburst, political and social topics appear weakly associated with other type of topics with low relevance (category Others) such as dates, places, international trending topics, while after the beginning of the social outburst, 33% of the social and political hot topics appear linked to the category Others. Denoting the transversal character that these categories acquire during the social outburst.

3.2. Digital Behavior during the Social Explosion. Digital behavior during the first days of the social explosion. The period of 3 days from the beginning of the outburst requires a particular analysis. This period is characterized by an anomalous behavior, when comparing it to the presocial outburst period, and to the period following these first 3 days of revolt. Figure 7 shows the probability distribution of TT duration before (blue), after (green), and during (red) the three peak days of the social outburst.

Before and after these 3 days, the probability distribution shows a similar behavior with a 2-hour mode, i.e., before and after the burst, it is most likely to find hot topics that are maintained for 2 hours. However, during the first 3 days of the outbreak, the most probable modal duration is less than 1 hour. This indicates that during this period there was a frequent renewal, a high diffusion of hot topics where none managed to establish itself as the dominant topic, which is consistent with the social activity of those days where information flowed in a massive, disorderly, and imprecise way. The particular behavior of those days is evident when comparing the probability distribution of periods with the same duration (3 days) in prior months (August and September 2019) to the social outburst (Figure 7, inset).

One possible way to conceptually understand the above described is by means of a stochastic growth and decay model of the Lotka–Volterra type. This model has been used and discussed for innovation adoption analysis [36, 37]. In

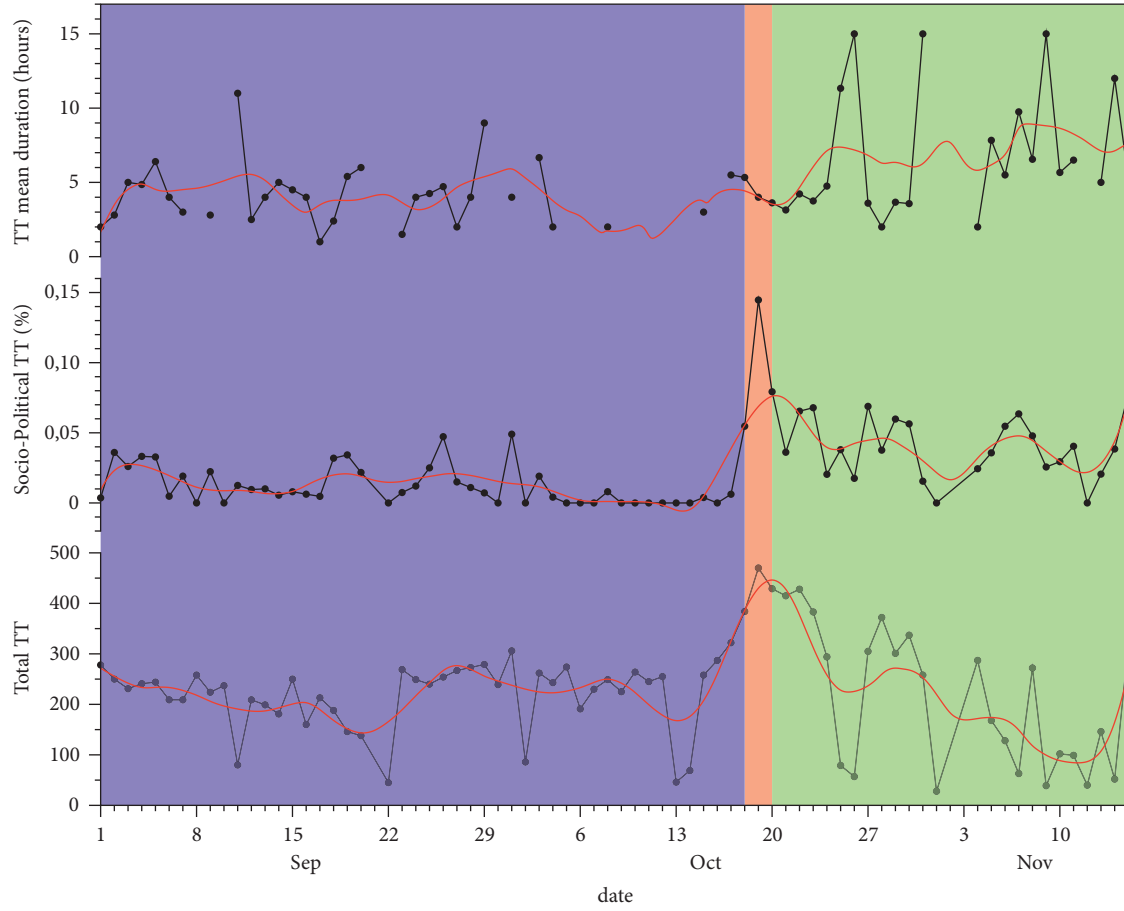


FIGURE 3: Bottom: amount of total TTs before, during (red band) and after the burst. Middle: number of TT with “social relationship” (qualitative analysis). Top: average duration of TTs before, during (red band) and after the outbreak.

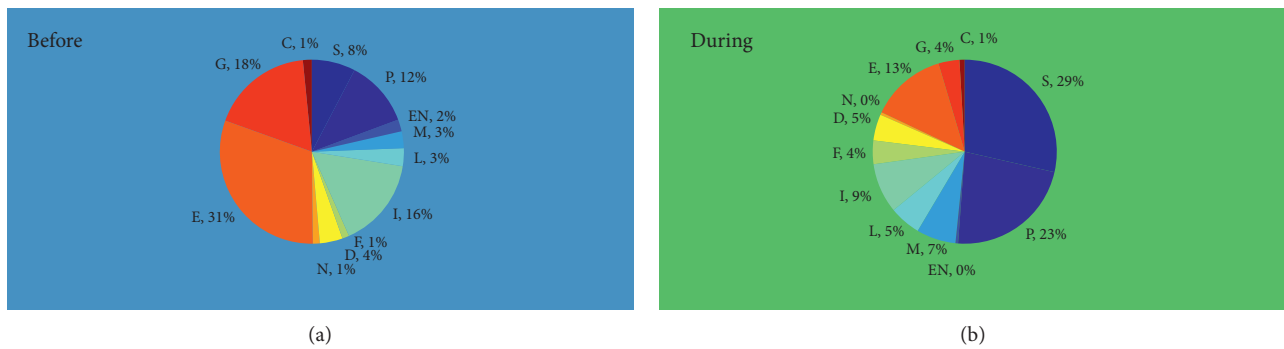


FIGURE 4: Distribution of TT categories before (left) and during (right) the social outbreak. D = date, P = political, S = social, M = media, E = entertainment, I = international, G = sport, EN = environment, L = place, C = commerce, F = police, army, others, N = natural event.

this particular case, we will use it to understand the adoption of trending topics in the digital community.

We insist that this model does not seek to understand in detail the dynamics and the different aspects of it. However, we believe it is a good way to understand without much paraphernalia the relevant aspects for this discussion:

$$d_t x = (g + e)x - q x^2. \quad (1)$$

Here g is the speed of TT creation, e is a stochastic variable that accounts for the random process in the creation of TT (we will consider it Gaussian, uncorrelated, and of variance $2D$), this mechanism will be important in disruption times. On the other hand, q is a decaying process in the production of TT. It can be proved [38] that the stationary distribution of the process in (1) will be

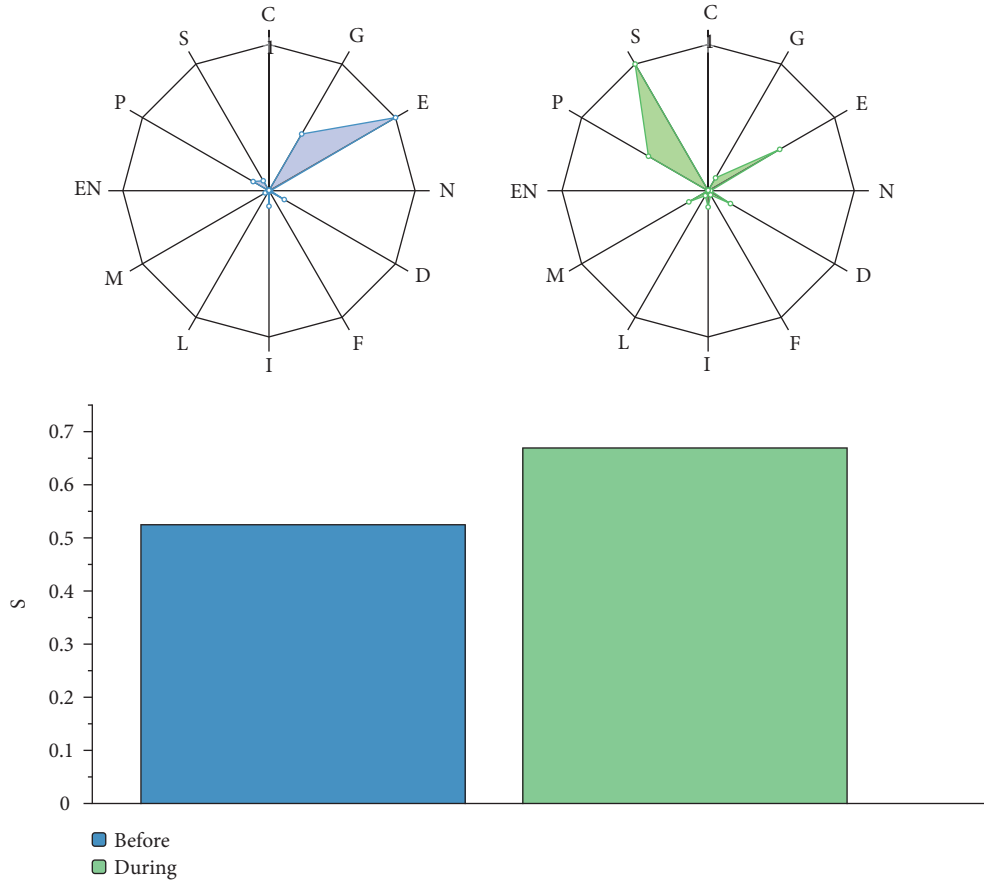


FIGURE 5: Use of the communication categories space before and during the social outbreak. Entropy (S).

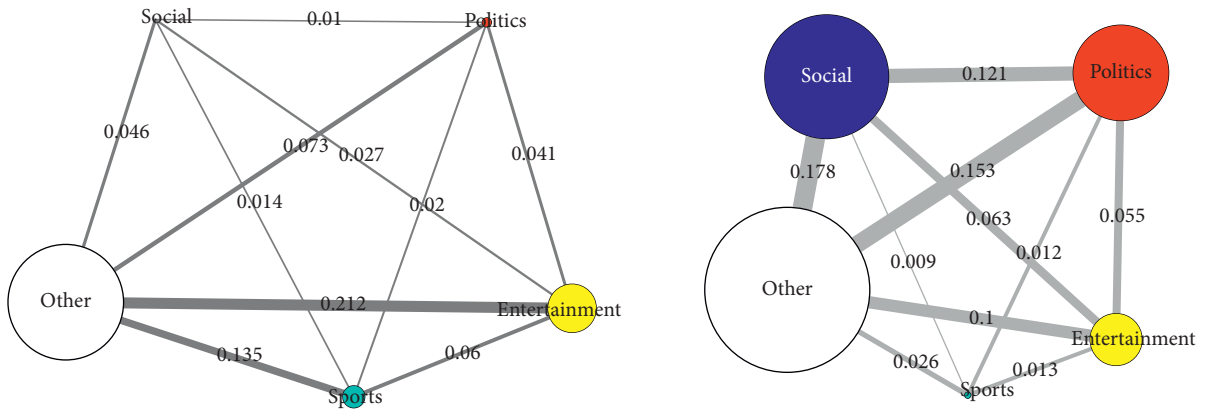


FIGURE 6: Network of ideas I(T, E) before and after the social outbreak. The value of links that represents the frequency of relationship are normalized. The size of the nodes represents the number of TTs belonging to those categories.

$$p(x) = \frac{b^a}{\Gamma(a)} x^{a-1} e^{-x}, \text{ with } a = \frac{g}{D} \text{ and } b = \frac{q}{D}. \quad (2)$$

We can see that changes in the agitation of the discussion (increasing in D), together with an increase in the decay of topic adoption, resulting from the much more active flow of information, in agitated moments, can account for the characteristics shown by the empirical data (see Figures 7 and 8). We emphasize that the discussion of this model is

beyond the scope of the present work, but we show the type of dynamic analysis that can be used to understand the changing characteristics of the TT duration distribution.

Relations between actors during the social outbreak. During the Chilean social outbreak, a series of actors, both agents and affected (Table 2), played a leading role in the actions of the material society. Figure 9 shows the synergistic relationships between the actors involved in the social outbreak.

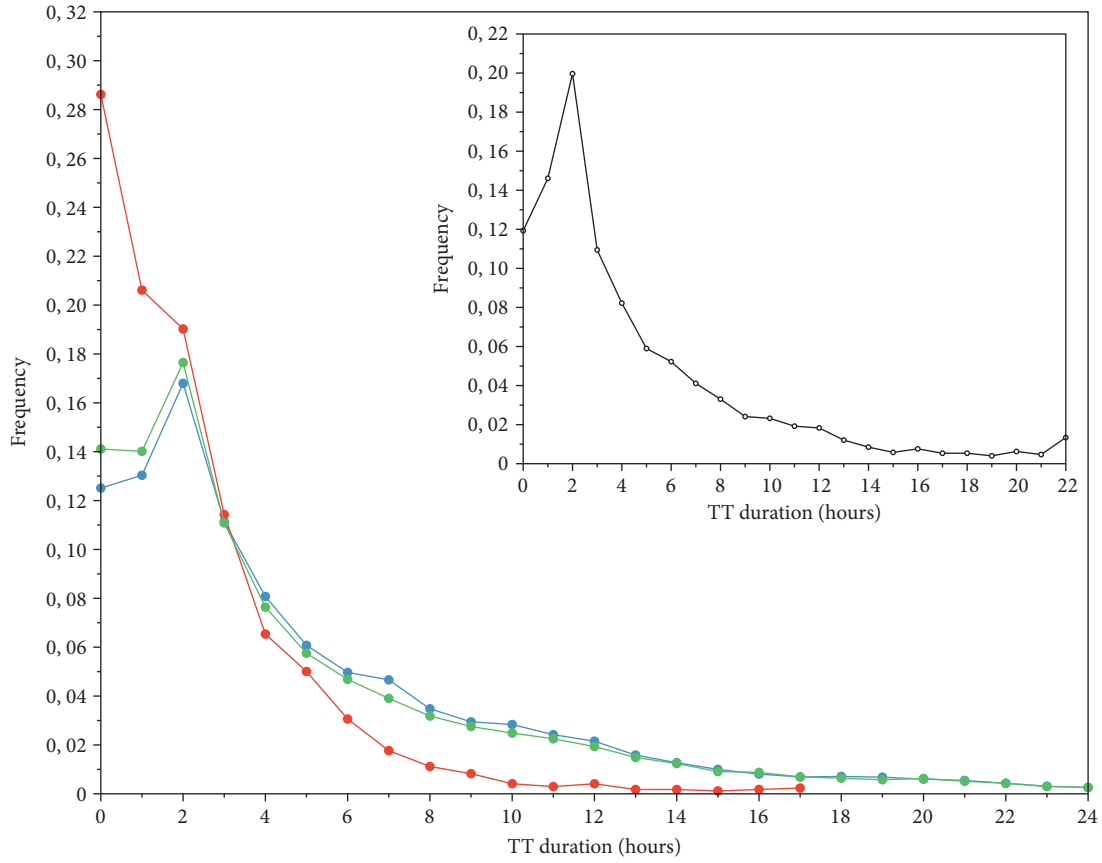


FIGURE 7: Probability distribution of the duration of TT. Blue: before, Red: 3 first days of social outbreak, Green: after. Inset: Probability distribution of the duration of TT in periods of social normality of 3 days, similar in the duration of the first 3 days of the Chilean social outbreak.

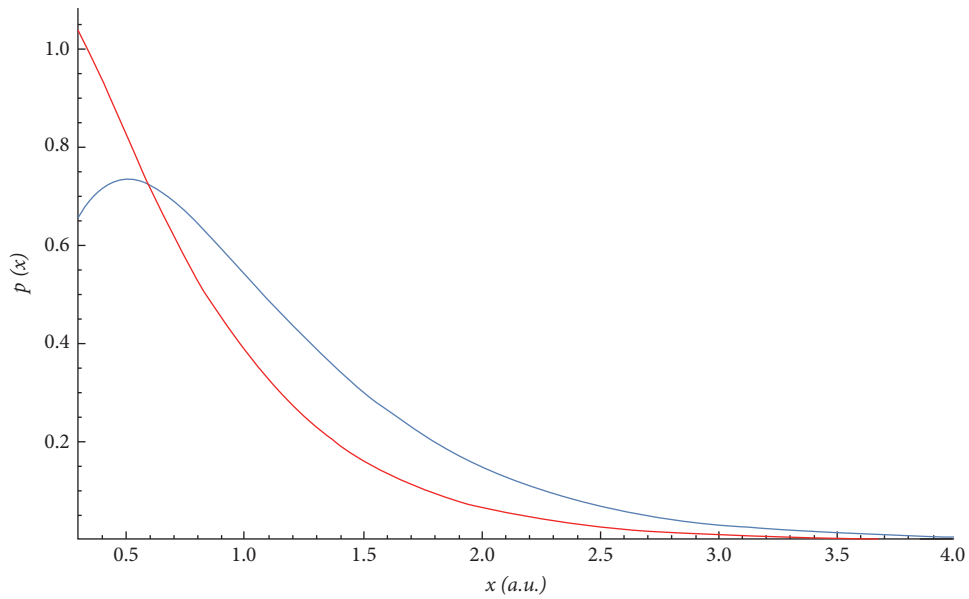


FIGURE 8: Probability distribution of the duration of TT, using the model proposed by equation (2). Blue: $g = 2, e = 3, D = 1.5$ Red: $g = 2, e = 2, D = 1$.

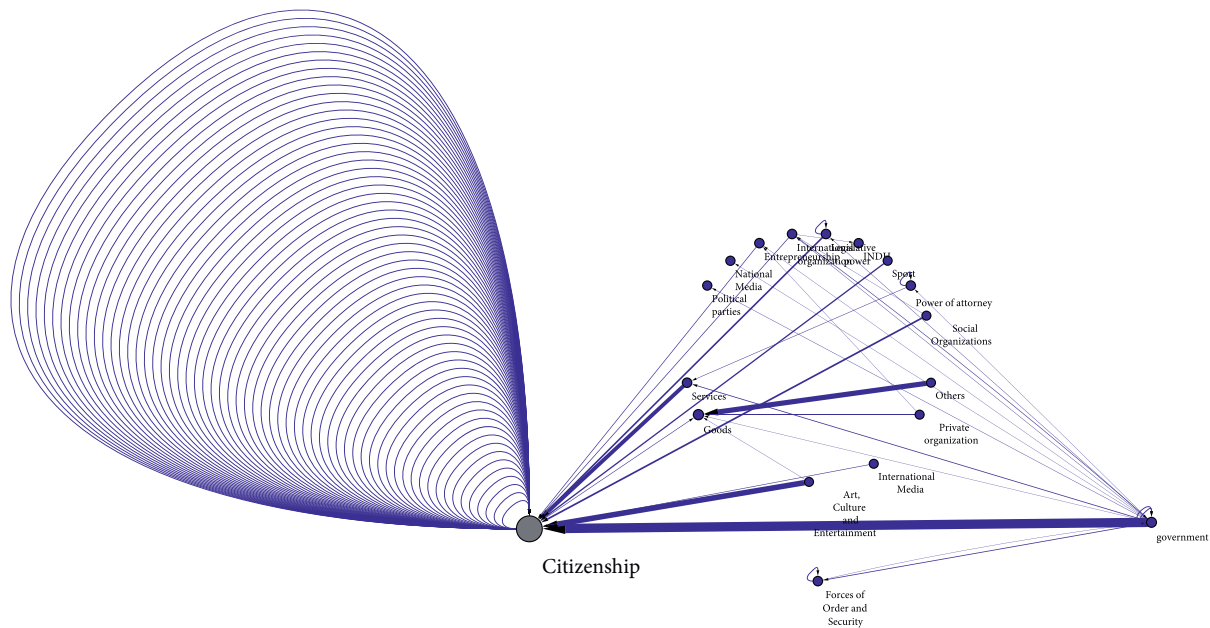


FIGURE 9: Synergistic relationships between actors during the social outbreak.

The network shows a series of synergistic actions from the government to the citizens. The vast majority are short-term events related to the search for consensus in face of social pressure exerted by the latter. Also noteworthy are the social support events (synergistic relationships) between the world of Arts and Culture with citizens. On the other hand, citizens appear as a very active agent in social mobilization events with synergistic, cooperative, and self-supporting relationships (self-links). Finally, the relationship between the agent “Others” and material “Goods” appears frequently, clearly as reparatory actions in the face of the violence of that period.

The conflictive network (Figure 10) shows the other side of the social outburst. At first glance, the density of the links in this network stands out in comparison to the synergistic network, highlighting the conflictive nature of the period. In this sense, the conflictive relationship between the agent “Armed Forces/Forces of Order and Security” and the citizenry stands out. It also highlights the conflictive relationship between government political parties and the citizens during this period evidencing the breakdown of relations between citizens and traditional politics as a sign of the country’s sociopolitical transformation.

The analysis of the dynamics of the relationships described above provides another type of information. Figure 11 shows the entry on the scene of different actors during the social outbreak as well as the generation of relationships between them. We can observe that during the first days of the outbreak (red zone) practically the entire universe of actors participating in this process is configured. However, this analysis highlights the virtually linear increase in the number of relationships between these actors. Although it is true that during the first days of the outbreak almost all the protagonists enter the scene, during this process the network

of relationships between them becomes more complex, generating an intricate network of synergic and conflictive relationships between actors.

3.3. Relationship between Material Activity and Digital Activity. One of the most relevant questions that arise from the analysis of the collected data is which are the relationships between material and digital activity of Chilean society. Our results suggest that Twitter activity at the beginning of the outbreak is reactive. A total of 65% of the events in the days prior to the outbreak had a Twitter match with the TT of the following day. The causality analysis in the days after the beginning of the outburst is extremely imprecise, showing a fluid and dizzying relationship between the material and digital society, making it very difficult to detect causal relationships. However, it is interesting to note that hot topics related to the creation of a new constitution, began to be discussed on Twitter the day after the outbreak started and four days before the first material event referring to the topic. Such digital pressure continued to grow until November 15 with the milestone ASPNC (Figure 12).

Something similar occurs with the pressure exerted by the digital society to constitutionally accuse high-ranking government officials (Figure 13). As in the case of the petition for a new constitution, the digital society began to exert pressure two days before the first material event associated with such accusations.

4. Discussion

In this section, we try to connect the results obtained with the social crisis model (Figure 14) as the result of a process of social adaptation proposed in this study. We understand the (complex) social system as one made up of individuals with

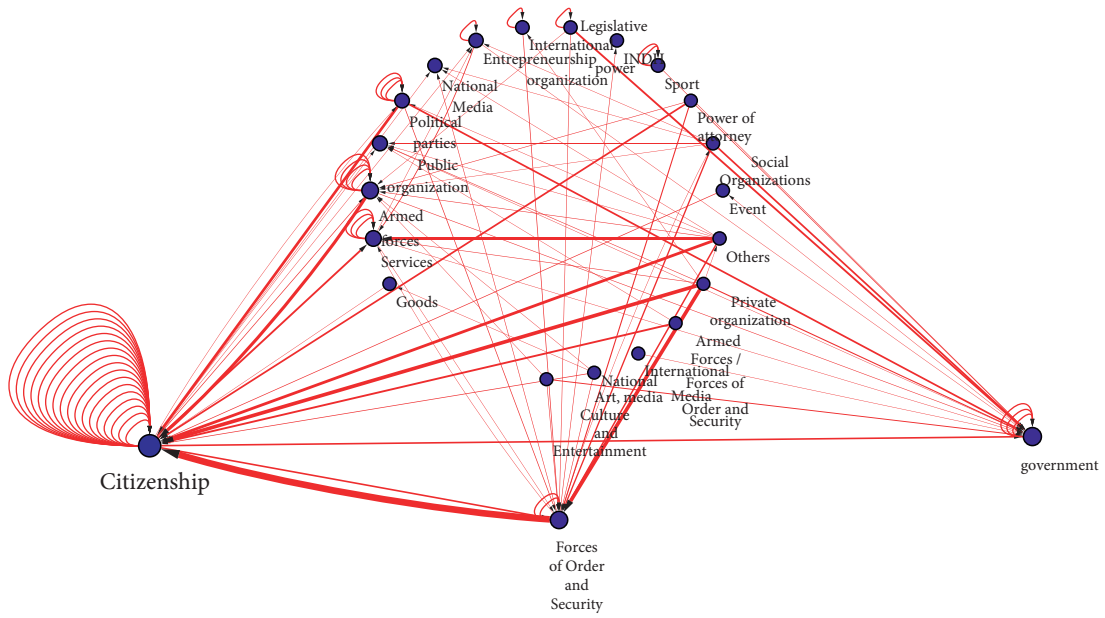


FIGURE 10: Conflictive relationships between actors during the social outbreak.

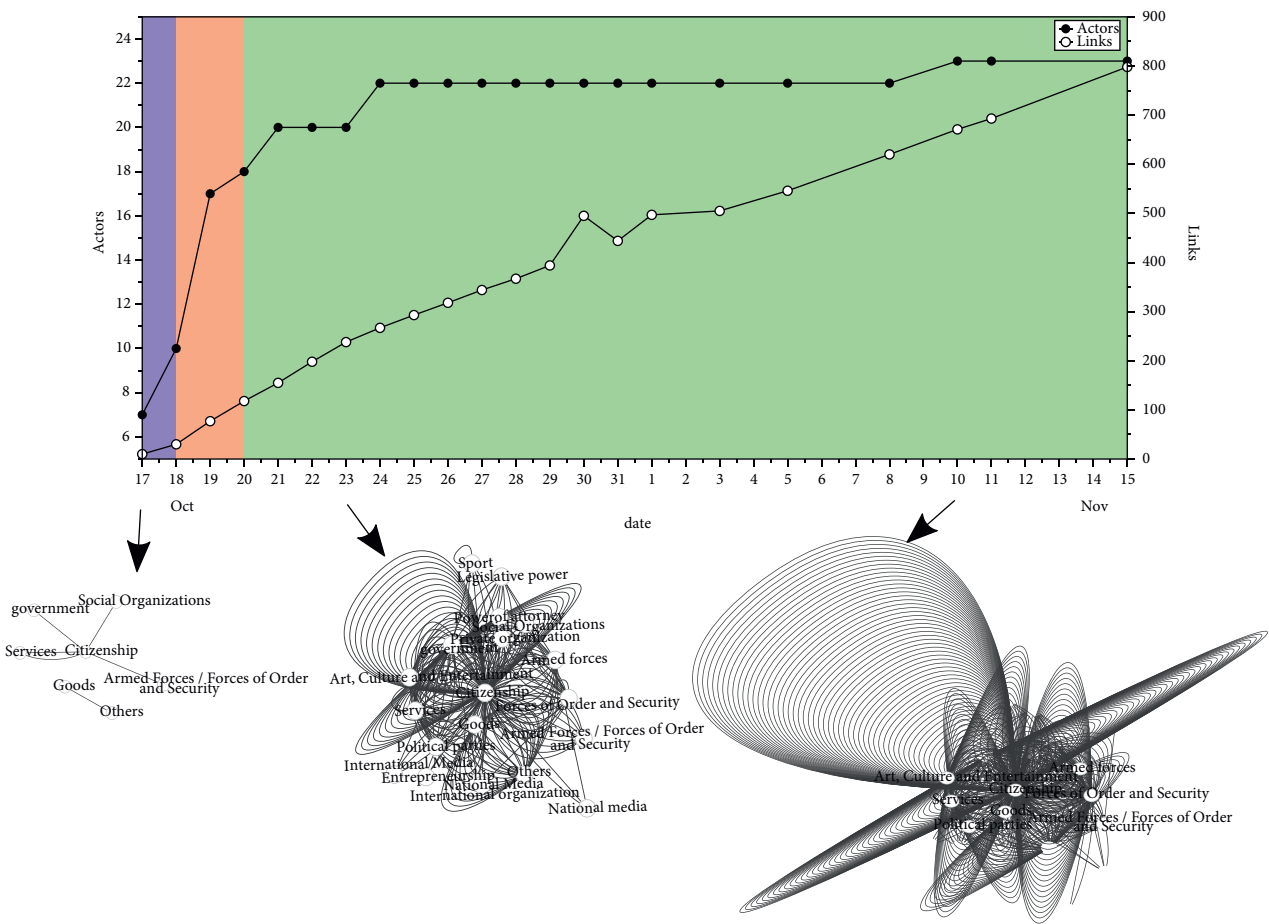


FIGURE 11: Change in complexity of system of actors $A(N,R)$ during the social outbreak.

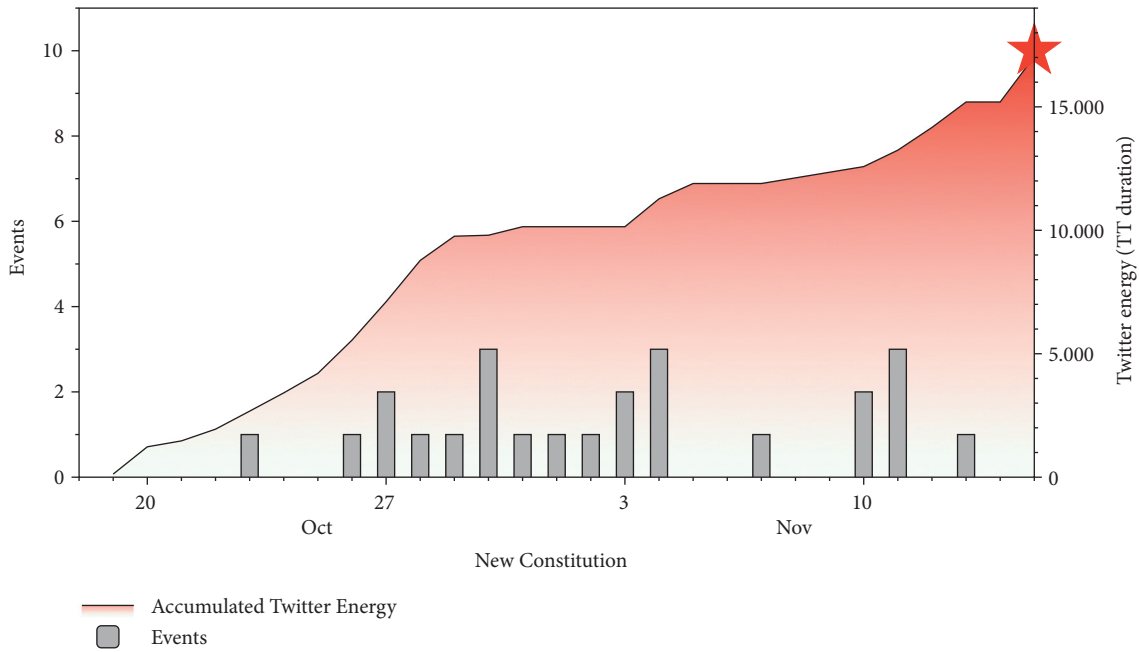


FIGURE 12: Accumulated Twitter energy (TT duration) regarding TTs related to a new Constitution for Chile. Gray bars indicate the number of events of the material society referring to a new constitution. The red star represents the milestone ASPNC.

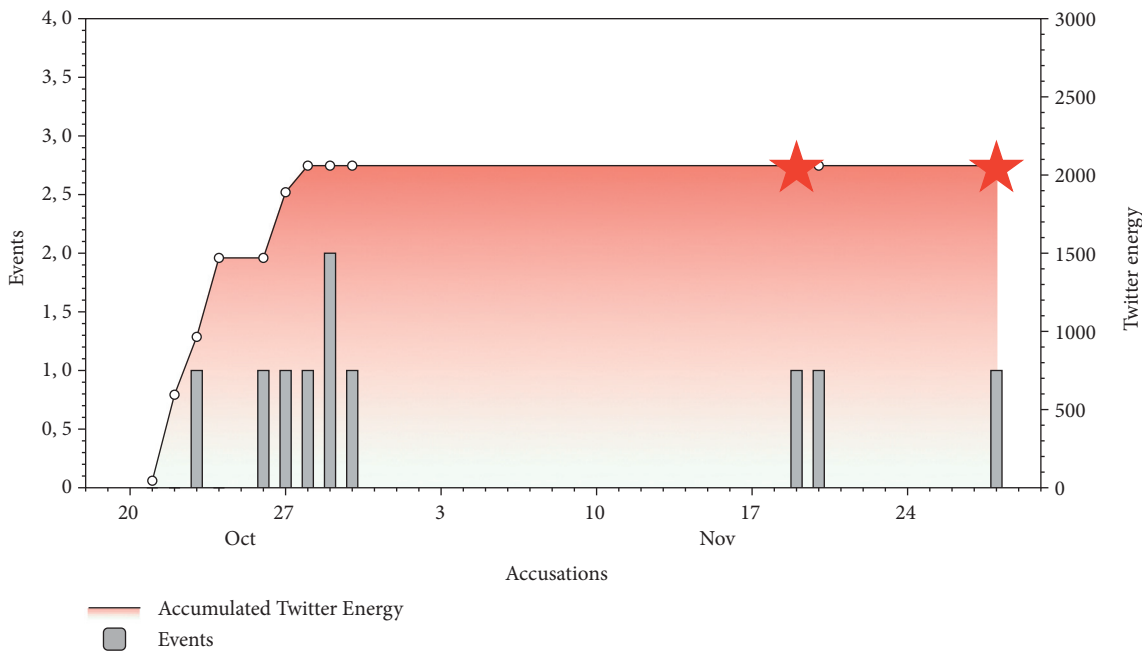


FIGURE 13: Accumulated Twitter energy (TT duration) regarding TTs related to constitutional accusations. Gray bars indicate the number of material society events related to these accusations. The red stars represent events that mark the execution of these accusations.

ideas, thoughts, feelings, and actions that characterize the social group they form and reflected in the constructed social contract. During noncrisis periods (i. e., routine conjuncture [21]), societies are far from a “state of consensus,” in fact, social systems are permanently inhabited by conflicts, struggles, disagreements, cleavage, etc. However, in a state of routine conjuncture, the forms adopted to regulate conflicts operate with some efficiency so that they do not lead to

violence or major social ruptures. It is important to note that the relationship we make between social contract and the state of routine conjuncture is just a simplification for the model.

When adaptive pressures overwhelm regulatory mechanisms, new ideas, thoughts, feelings, and actions, incorporated by the spontaneous increase of complexity of the system, together with other ideas, thoughts, feelings, and

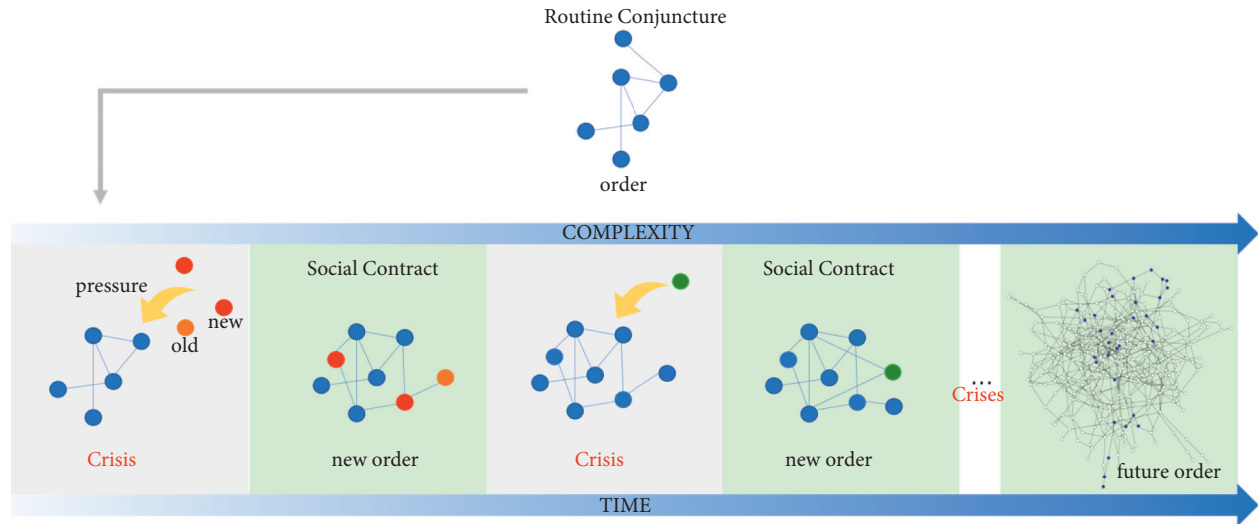


FIGURE 14: Crisis model. A social system can be described from the organization of ideas, thoughts, feelings, and actions of the agents that compose it. From this organization, an order emerges, or social consensus, that defines the way it operates. This order is permanently subjected to adaptation pressures (crisis) that may or may not result in structural changes. This is a continuous process in the evolutionary history of societies.

actions already existing, but now released by those same adaptive pressures, seek a new organizational arrangement. At this moment, the system enters another state, the fluid critical conjuncture [21], or “Crisis,” characterized by the structural plasticity of the system.

The process that begins with a state of routine conjuncture, than a subsequent adaptive pressure that can trigger a structural rearrangement, is continuous in the evolutionary history of the social system. Thus, crises (social) should be understood as natural events, unavoidable and totally necessary for the survival of the system, enriching its models of response to environmental pressures. From this perspective, the phenomenon is part of a deterministic process, although it is governed by the complexity of the system, which makes it impossible to know exactly its result.

In light of the results of this research, we were able to observe what was described in this model. Before the social outburst, the routine situation was characterized by a social behavior, whose reflection in the digital world, accounted for a society interested in topics related to entertainment and sports. On October 18, 2019, a series of events, with “nonspecial” characteristics (controversial behaviors, unfortunate government statements, increase in the price of transport, among others), caused a chain reaction that completely altered the behavior of Chilean society, both in its material and digital manifestations. The “nonspecial” characteristics of the earlier events to the outbreak coincide with [39] regarding the fact that the precursors of massive events are not different from those of minor events when the rules of complexity operate on the system.

The social reaction unleashed that day was characterized during the first days by a thematic explosion and active flow of information that fits with the stochastic growth and decay model of the Lotka–Volterra type (see Sec. Results 3.2). This behavior allowed the emergence of a

new order or organization of ideas and where a series of actors of the outburst began to form a complex network of relationships (Figure 11). It was possible to evidence a process of creative rupture [40, 41] in the behavior of the digital society where social and political issues took prominence over the previously characteristic hot topics that practically disappeared (see Sec. Results 3.1). Despite the fact that the typical behavior of the digital society regarding the probability of distribution of the duration of the hot topics, returned to the way it was before (see Sec. Results 3.2).

The functioning of the digital society did not change in its form, although it did change in the topics it installs. In fact, the outburst made possible the (re)entry of the idea of a new constitution, strongly discussed in 2016 [1], being the digital society, in light of our results, fundamental in repositioning this issue allowing the milestone ASPNC (Figure 10). On November 15, 2019, the Chilean material society found in this agreement a proposal for a “solution” to generate a new social consensus, a new order. This solution was mostly validated by society on October 25, 2020 [42].

We understand this agreement as the result of a self-movement of society toward an organized complexity in the form of a new social contract. Through an emerging process of self-organization, Chilean society captures part of the ideas and abstract language that pressures the social consensus constructed prior to the outbreak. In fact, the environmental issue, of current relevance due to climate change consequences [43, 44], is shared by 38% of the candidates elected to draft the new constitution according to their campaign proposals [45], being the most transversal issue. Other topics that are protagonists of the Chilean crisis such as the recognition of the country as multinational, the defense of water, social rights, decentralization, gender equity, and citizen participation were also incorporated as

force ideas in the programs of the constituents in charge of drafting the new constitution.

5. Conclusions

In this work, we propose a different approach to the phenomenon of social system crises. We understand that these processes can be explained by the adaptive nature of the social system and the associated increase in complexity. However, given the complexity of the social system, this approach requires a quantitative and qualitative analysis of the data associated with the process.

The dynamic nature of the social system generates emergent structures and patterns that in some cases may mean a restructuring of social components, generating a new order. We say that this new order, associated with the incorporation of a growing social complexity, can be translated into a new social contract after a period of profound transformation where previously existing relationships are broken, and new interactions are born. A phenomenon of creative rupture is totally necessary for the survival of the social system. This is what we reveal in the case of the climax of the Chilean social crisis.

On the other hand, the power of language behind the crisis appears in this work. The traditional analysis of online social networks has been focused mainly on the relational structure of its users. However, in this work, we focus on the structure of abstract language relationships behind the crisis. In this sense, it seems that the system of ideas (TIs) hides deep information about the transformation of the social system. It is more than the classic analysis of the number of tweets or the identification of accounts that lead the conversations. In fact, the flow of ideas in cyberspace not only highlights the social transformation but also accounts for the dynamics in the complexity of the social system as well as its ability to guide processes of social transformation.

Our results also seem to validate the model proposed for the crisis processes. The adaptive nature of the social system allows it to explore new organizational structures. In this sense, the rupture of the order prior to the social outbreak, and its replacement by a new emerging one, seems to be materialized in the milestone ASPNC. This social “solution,” as an exploration of the space of possibilities of the social system, is nothing more than that, an exploration that will also have to face adaptation pressures. In fact, since the formation of the Constituent Assembly, it has had to overcome a series of external and internal obstacles. This is a clear sign that the crisis processes constantly affect the system at all scales. The response of this emerging social solution to the pressures of adaptation will tell if its product (i. e., the new constitution) allows the country to exit the critical transformation process it is going through, for an indeterminate time.

Finally, what we can infer from our analysis is a profound relationship between digital and material societies. Although each one has its own logic, our results suggest a nontrivial relationship between the two where, in some cases, one operates as a conditioner on the other. However, and more important than that is the fact that the digital

behavior of society seems to contain relevant information about the processes of social transformation associated with crises. Not only because of the meaning of the symbolic language that circulates on online social networks, but also how it is dynamically articulated and expressed during the process.

A series of questions remain open with this work, for example, we would like to know if what we observe for the Chilean case is also happening in other countries in crisis. Another question is what is the role of the symbolic behind the language of crises. We will try to solve these and other questions in future works.

Data Availability

Publicly available data sets were analyzed in this study. This data can be found at Twitter Public Dataset.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this study or with the funding received for this research.

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