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Towards a simple dynamical model of citizens' perception

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Abstract

Purpose – The purpose of this paper is to propose a minimal dynamic two-dimensional map for the relation between citizens' perception of quality of life (y) and their perception of the city Mayor management abilities (F).

Design/methodology/approach – The authors use data from the *Ciudades cómo vamos*? project and test a simple hypothesis: there is a linear positive correlation between y and F. Following the authors propose a two-dimensional map based on ideas from a statistical regression model and a non-linear dynamical map on the [0; 1] interval.

Findings – The authors give evidence that suggests that y and F are not linearly correlated. The authors show that the two-dimensional map, mentioned above, is able to reproduce non-trivial and unsynchronized relations between the variables, as well as the whole range of correlation coefficients.

Research limitations/implications – There is a very limited amount of data to work with, therefore it was not possible to explore other possible relations thoroughly. Regarding the dynamical map, the authors are aware that there are still many venues for its study.

Originality/value – To the authors' knowledge, this is the first reported attempt at modeling the dynamics between two variables obtained via survey on which perception is a key component of the questions.

Keywords Dynamic maps, Perception of city life, Perception of government, Perception of quality of life

Paper type Research paper

1. Introduction

Independent studies like the "*Ciudades cómo vamos*?" project of *Fundación Corona*[1] are becoming ubiquitous around the globe (see e.g. the *Red Latinoamericana por Ciudades y Territorios Justos, Democráticos y Sustentables*[2]). These are non-government endeavors that make a periodic follow up of changes in the quality of city life and the execution of the development plans of local administrations – among other measurements.

The "*Ciudades cómo vamos*?" project, in particular, is ongoing since 1988 and evaluates the recoil or advance of the quality of life (QL) on a particular city; this is carried out via a set of indicators, and by the use of a yearly poll of citizens' perception. This program is currently evaluating ten cities in Colombia (Barranquilla, Bogotá, Bucaramanga, Cali, Cartagena, Ibagué, Manizales, Medellín, Pereira, and Valledupar). Of all the results that the project has collected we are interested in two particular results from the citizens' perception polls: the perception of quality of city life, and the perception of government management. Since government actions (like investing in services, health, education, etc.) are, in principle, taken in order to address a dysfunction within the city or to improve it, one could argue that the mentioned perceptions must be correlated to a high degree; that is, if the perception of city quality is high, then the

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perception of government management should be high (or vice versa) or that if one detects a trend on city quality perception (raising or declining) then one must also detect the same trend on the perception of government management. However, this is hardly the case, as will be shown in Section 2.

The first part our study (Section 2) is to describe the data from the ten cities from the "*Ciudades cómo vamos*?" project and show that there is no general correlation that one can consistently find between the perception of the city management and the perception of the QL in the city. We limit the study to four (Barranquilla, Bogotá, Cali, and Cartagena) of the ten cities in order to have time series that include more than four years of surveys.

Section 3 is concerned with an attempt to model the relationship between the perception of the city government and the perception of the QL in a particular city. We take as a starting point the statistical model proposed by Pudney (2007). Based on this statistical model we explore a series of two-dimensional maps that relate the perception of the QL ($y_t = h(\{y_{t-\mathrm{i}}\}, F_{t-1})$ with the perception of the city government ($F_t = \mathrm{g}(\{F_{t-i}\}, y_{t-1})$), where h and g represent different functions. Therefore, we are proposing to model perception of the QL as a function of the perception of city government management and vice versa. As is well known (see e.g. Villalobos *et al.*, 2010) the maps outlined above can have non-trivial and chaotic behavior.

This work can help in the understanding of complex dynamics like the one discussed above. Simple models that are capable of describing a wide range of behaviors (like fixed point, periodic, or strange attractors) are a useful tool when understanding complex systems. Models like the ones on this paper can be used as insightful tools that can help policy makers understand the different kind of behaviors that policies may have on the population. Understanding the potential that dynamical systems have to move toward chaotic regimens is a relevant insight when dealing with complex situations.

2. "*Ciudades cómo vamos*?" A state of the art

In this section we will do a brief description of the "*Ciudades cómo vamos*?" project and the particulars that are relevant to this work. We will describe the construction of an index of the perception of the QL and another for the perception of city government management (MM). Also, we will limit the data sets of our study based on the availability of data for each of the cities that participate on the project. We will show that for four cities the linear correlation between QL and MM is not trivial.

The project "*Ciudades cómo vamos*?" is currently under way in ten cities (see Table I for a complete list). The goal of this project is to evaluate the QL of the citizens regarding safety, the city general situation, education, health, mobility, neighborhood and housing,

Table I. Cities that are part of the "*Ciudades cómo vamos?*" surveys and the years from which data are available

City	Years	City	Years
Barranquilla	2008-2013 (6)	Ibagué	2010-2013 (3)
Bogotá	1998-2013 (11)	Manizales	2012-2013 (2)
Bucaramanga	2010-2013 (3)	Medellín	2012-2013 (2)
Cartagena	2008-2013 (6)	Pereira	2011-2013 (3)
Cali	2008-2013 (6)	Valledupar	2011-2013 (3)

Notes: Total number of years with complete data are given between parenthesis. *Italized* cities are the ones studied in this paper public services, public spaces, recreational and cultural offer, coexistence and mutual liability, and finally the management of the city. Unfortunately this survey was not applied to different cities at the same years, therefore we have to content with, at least, a ten years gap between Bogotá's survey and other cities. The range of surveys for different cities can be seen in Table I. This fact creates a difficulty for the analysis and data correlations among all cities. We have to work with this restriction and limit our study to four cities: Barranquilla, Bogotá, Cartagena, and Cali (emphasized on Table I).

The surveys applied in the different cities that are part of the "*Ciudades cómo vamos*?" study are made up of close to 48 questions divided among seven categories. We are interested in questions that inquire about the perceived QL in the city and the perceived efficiency of the Mayor's management.

In this paper we will use the following categories derived from the surveys[3][4]:

(1) citizens' perception of the QL; and

(2) citizens' perception of the MM.

Variable QL is taken directly from the question: "Are you satisfied with your city as a place to live?" We built MM as an average percentage of the following questions (these questions inquire about the perception, they are not the official figures): "Fiscal Performance Index," "Overall performance index," "Timely responses to petitions, complaints and claims," "Percentage public servants," "Poverty line," and "Indigence line."

An exception to our data are the survey from the city of Bogotá because the question "Are you satisfied with your city as a place to live?" is not present. Therefore, we use the questions: "How is your overall satisfaction with the sewer service?," "How is your overall satisfaction with the electrical energy service?," "How satisfied are you in general with Bogotá's road infrastructure?" and "How safe do you feel in your neighborhood?" to make an average percentage. All these questions have three possible answers: satisfied, not satisfied, and indifferent. Results are given as percentages of these possible answers. We are aware that care should be taken when working with do not know responses (indifferent in our case) (Manisera and Zuccolotto, 2014). The treatment of do not know responses is still an open issue, although there are good techniques on how to handle them (see e.g. Schafer and Graham, 2002). In this paper we will treat the indifferent response as equivalent to the not satisfied answer.

In Table I we show the range of years for which the cities of the "*Ciudades cómo vamos*?" study have data that is relevant to this paper. We have emphasized the cities that have gathered data from questions that relate to the perception of QL and the perception of government for, at least, four years. Let us note that Bogotá has missing (or incomplete) data for 1999, 2001, 2002, 2004, and 2013.

From the collected data we propose to build two indexes for each city: the citizens' perception of QL; and the citizens' perception of the MM. The indexes are built as percentages (from 0 to 1) and both obey the following formula: number of people that answered in a positive way (answered satisfied) divided by the total of people that took the survey.

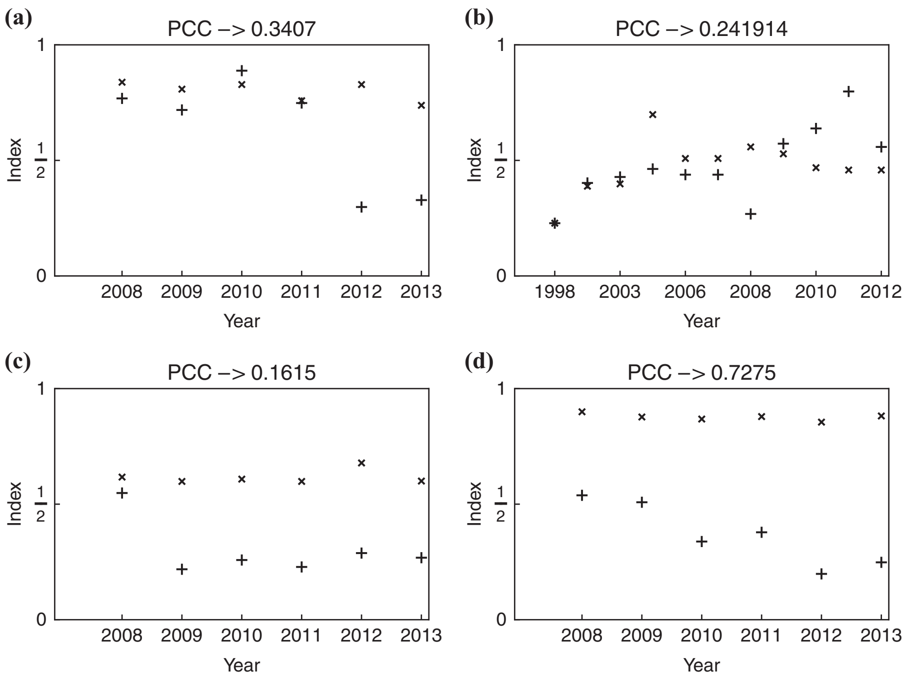
As we discussed in "Section 1" it is somewhat intuitive to argue that there should be some kind of correlation between these indexes; after all one must expect that good governments have a positive impact on the QL of its citizens. Using the indexes described in the previous paragraph we have explored if there is some consistency between them. In particular we have calculated Pearson's correlation coefficient (PCC) (Pearson, 1895) between both indexes for each city.

The PPC is a measure of the linear dependency between two sets of variables; it is a number between −1 and +1 where a value of 0 indicates no correlation, +1 a total positive linear correlation, which means that both series are synchronized, and −1 a total negative linear correlation, which means that if one series raises the other one falls by similar amounts. Here we understand a total correlation if we can express one index (y) as a linear function of the other index (x) in the form $y = mx+b$ for some pair (m, b).

Figure 1 shows both indexes (QL plotted as x, and MM as +) and the PCC between them (limited to four significant figures). As can be seen from the picture, there is no consistent value of the correlation coefficient between both series. Also, there is no obvious synchronization between them. All coefficients are positive and small, except for the data from Cali. We note that Bogotá (the city that has more data to examine) has a small coefficient.

It is possible that the correlation between these variables could behave differently and in a more consistent way. For example, one could propose that introducing a delay on one of the series could give more consistent results. However, in order to explore this possibility much more data are needed for each city than the currently available and, also, we could not ignore missing data as has been done. It is for these reasons that we have limited ourselves to calculate the PCC directly and not with a different approach.

Another possibility is to test for autocorrelation of the series. We have performed a hypothesis test for randomness on each series with the null hypothesis that the autocorrelations are all zero, and the alternative that at least one of the autocorrelation coefficients is different from zero. With this test we calculate a p-value that, if small,



Notes: (a) Barranquilla; (b) Bogotá; (c) Cartagena; and (d) Cali

Figure 1. Plots of QL (x) and MM (+) with Pearson's correlation coefficient between both indexes

suggests that randomness is unlikely. We show the *p*-value for each series from Figure 1 on Table II. As can be observed, the data are likely to be random. Once again, this requires further study with longer time series.

We have shown that a simple assumption: that the citizens' perception of the MM should be correlated to their perception of the QL in their city is not true. We used data from the "*Ciudades cómo vamos*?" project from Fundación Corona in order to explore the correlation between those variables.

The results from this section can be interpreted in at least two ways: the relationship between QL and MM is not linear, or the relation has a very important stochastic component. We assume the former and propose a non-linear minimal model in the following section.

3. Some models for the dynamics of perception

In this section, we build a simple dynamical model that aims to capture the rich dynamics observed between the citizens' perception of QL and their perception of government management. As was showed on the previous section, these variables are not linearly correlated. We found positive correlations for all data sets, but some were close to 0 and others close to +1. There are many possible explanations for this observation, one being that there is not enough data to support a trend or identify some global behavior. We put forward the hypothesis that the relation between these variables is not linear; our purpose is to present a simple model that may help explain the dynamics involved between these two variables.

There is very few work done on the dynamics of perception, we found only one scientific work related to it (Pudney, 2007). The previous statement does not imply that there is little work done on perception, on the contrary the literature on the topic is abundant (see, e.g. Méndez *et al.*, 2014; Norwich, 2014). However, we were not able to find published work that tries to model perception as a variable. We propose to use Pudney (2007) as our staring point; there the authors propose a statistical regression model where they argue that the perception of well-being, $y_{i,t}$ of an individual i, at time t, can be expressed as:

$$\Delta y_{i,t} = \lambda\left(W_{i,t} - y_{i,t-1}\right) + \vec{\mu} \cdot \Delta \vec{z}_{i,t} + \xi_{i,t},$$

we call this Equation (1), where we write $\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$, and $W_{i,t}$ is the well-being of individual i at time t, $\vec{z}_{i,t}$ is a vector of observable quantities, $\xi_{i,t}$ represents a stochastic variable, and both $0 \leqslant \lambda \leqslant 1$ and $\vec{\mu}$ are parameters to be found using regression techniques.

Table II.
Autocorrelation test (AT) *p*-value for the eight time series shown in Figure 1

City	AT	City	AT
Barranquilla QL	0.12	Barranquilla MM	0.32
Bogotá QL	0.51	Bogotá MM	0.32
Cartagena QL	0.49	Cartagena MM	0.88
Cali QL	0.89	Cali MM	0.48

Notes: The *p*-value is obtained from a hypothesis test for randomness on each series. The null hypothesis is that the autocorrelations of the series are all equal to 0. Small *p*-values indicate that the data are autocorrelated. None of the calculated values are small enough to indicate autocorrelation

Based on Equation (1) we propose the following non-stochastic dynamical model for a citizens' perception of some quantity y_t related to another perceived quantity F_t at time t:

$$y_t = (1-\lambda)y_{t-1} + \lambda\psi F_t + \mu\Delta F_t,$$

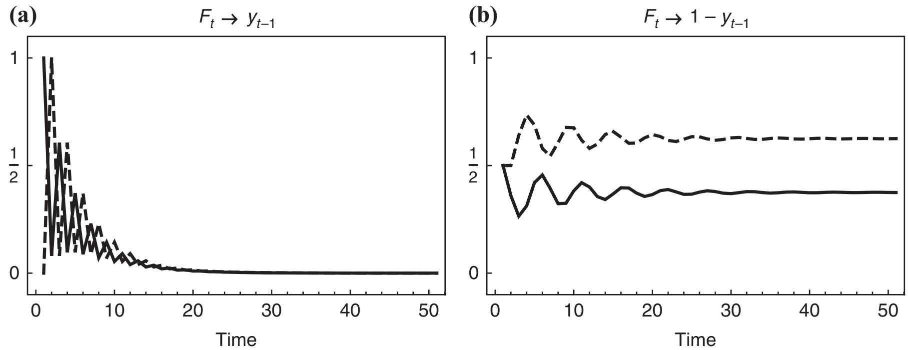
We call this Equation (2), where $\lambda \in [0,1]$ and $\psi,\mu \in [1,1]$. We restrict both y_t and F_t to the [0,1] interval. Intuitively one can interpret $(1-\lambda)$ as some sort of inertia or resistance to change; if we set $\psi = \mu = 0$ we are left with a model of exponential decay where $(1-\lambda)$ is the rate of decay. In this paper we make no attempt at interpreting the ψ and μ parameters beyond bounding them to the mentioned intervals.

The model in Equation (2) is quite simple and can be interpreted as a proposal where the perception y_t is proportional to yesterday's perception ($y_{t=1}$) and both the actual perception value of F_t and its change. Following the observations made in Section 2 we propose y_t to be perceived QL and F_t to be the perception of the MM.

We must give some mathematical form for F_t. A first proposal that comes to mind is for it to be a growing or decreasing function. A growing function, like $F_{t+1} = \alpha F_{\mathrm{t}}$ or $F_{t+1} = \alpha + F_t$ for $\alpha > 0$, can be interpreted as a situation where the MM is always better perceived. Regardless of whether this assumption can be true or not, the fact remains that Equation (2) will grow in the same manner as F_t. The same happens if we use a decreasing function like $F_t = \alpha F_{\mathrm{t}-1}$; this particular form goes to 0, which may be a more realistic model of the perception of public management, but also forces $y \to 0$.

A second and more realistic proposal is to model F_t as an oscillatory function (like $\sin(\omega t)$, or a square pulse, etc.). But given the nature of Equation (2) we would find that y_t always synchronizes with F_t; this implies that there is a high positive correlation between both variables in contradiction with the observed behavior.

A third proposal is to make F_t dependent on y_t; several options are available but we will keep a simple form. The simplest dependence on y would be to write $F_t = y_t$ which has a simple interpretation: management perception is the same as life quality perception. Another option is $F_t = y_{t-1}$, this would tell us that management is equal to last year's perceived QL. The dynamics displayed by this proposal is shown in Figure 2(a); there we can observe that after a transient oscillatory behavior the dynamics between both indexes converge. We have used $\{\lambda = 0.8, \psi = 0.6, \mu = -0.6\}$ and $y_0 = 1$, $F_0 = 0$.



Notes: (a) For the linear map $F_t = y_{t-1}$; and (b) for $F_t = 1 - y_{t-1}$. In both cases we use Equation (2) for y_t. See the text for parameter values

Figure 2. Dynamics of the citizens' perception of the city's QL (solid line) and the citizens' perception of the Mayor's management (dashed line)

A fourth proposal is $F_t = 1 - y_{t-1}$; in this case we would be implying that the perception of management is the complement of the perception of the QL, i.e., that the citizens would have an excellent opinion of management if the QL is very low and vice versa. We give an instance of the behavior of this functional form in Figure 2(b); there we can observe that after a transient oscillatory behavior the dynamics between both indexes converge; we have used $\{\lambda = 0.7, \psi = 0.6, \mu = -0.8\}$ and $y_0 = 1$, $F_0 = 0.5$. As can be seen from the figures, there is no difference (in terms of how the dynamics correlate) between both indexes. This observation gives us an argument to look for more complex models in order to find non-trivial dynamics for both variables.

In the following subsection we will analyze the dynamics of both variables when they are related via a non-linear map. We will use the tent map (Collet and Eckmann, 2009) since it has a simple interpretation on this context.

3.1 Analysis of tent map

A tent map is a one-dimensional map given by the following piece-wise function:

$$x_{t+1} = \begin{cases} 2x_t & \text{if } 0 \leqslant x < \frac{1}{2} \\ 2(1-x_t) & \text{if } \frac{1}{2} \leqslant x \leqslant 1 \end{cases},$$

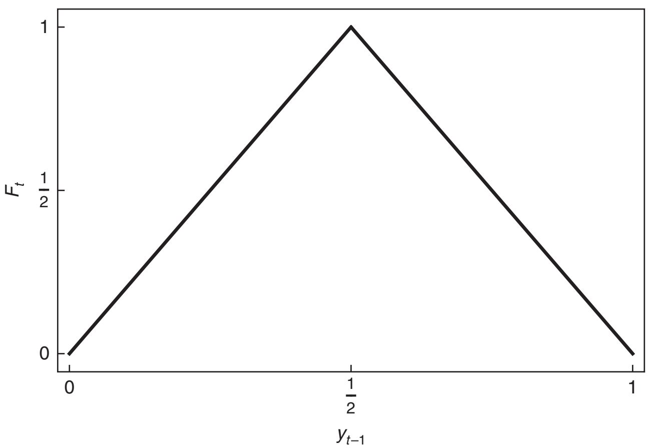
This is a non-linear map that has chaotic dynamics (Collet and Eckmann, 2009).

We propose to use this map together with Equation (2) to build a two-dimensional map as follows:

$$F_t = \begin{cases} 2y_{t-1} & \text{if } 0 \leqslant y_{t-1} < \frac{1}{2} \\ 2(1-y_{t-1}) & \text{if } \frac{1}{2} \leqslant y_{t-1} \leqslant 1 \end{cases},$$

we call this Equation (3).

Figure 3 shows the tent map F_t described by Equation (3). We interpret the tent map in our model as follows: if the perception of QL (y_t) is either very low or very high (this is



Notes: This figure shows the behavior of F_t according to the value of y_{t-1}

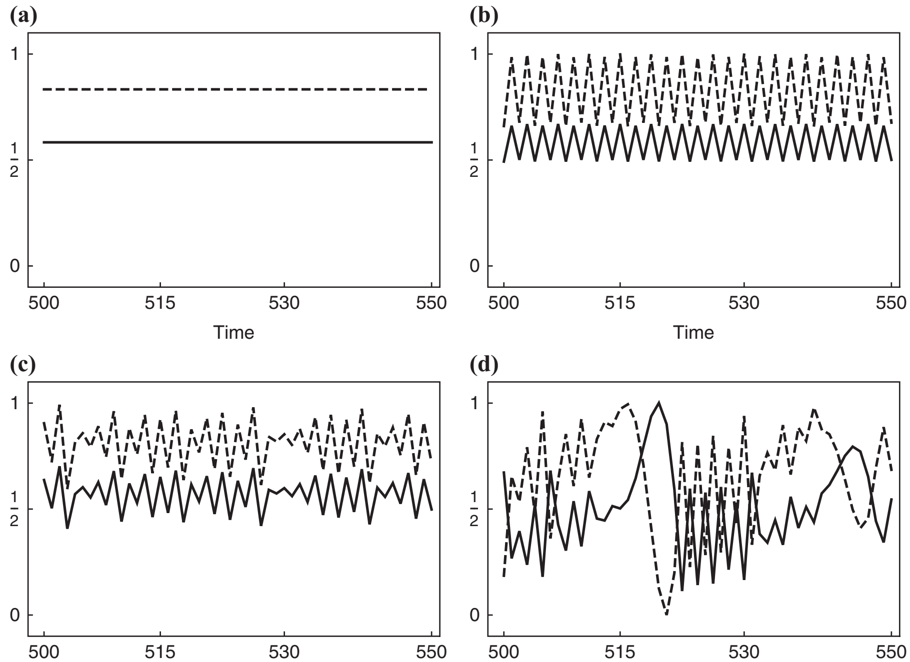
Figure 3.
Tent map from Equation (3)

either close to 0 or to 1) then, the perception of the MM (F_{t+1}) will be very low. However, if $y_t \sim 1/2$ then we have $F_{t+1} \sim 1$.

We now turn our attention to the possible dynamics that this map offers. First, let us do a cursory exploration of the possible time series that can be observed with this proposal. In Figure 4(a)-(d) we show four possible realizations of the map for different parameter values. All series are presented from time step 500 through 550. In other words, we are plotting y_t and F_t for $t = \{500, 501, \ldots, 549, 550\}$. We do this in order to be sure that transient behavior is not part of the plot, and that we are in fact studying the asymptotic dynamics of the system's attractor (Villalobos *et al.*, 2010).

Figure 4(a) shows a fixed point steady state, in this case the dynamics is constant and does not change; clearly the PCC between these two series would be equal to one. This is not a very interesting case, however, it shows that our model is capable of reproducing steady state dynamics of the form $(y_t, F_t) = (y_{t-1}, F_{t-1})$.

Figure 4(b) shows a period-two steady state for both variables. Here we see oscillatory behavior where the odd time steps take one value, and even ones a different one. Also note that both series are synchronized, for this series the PPC is also equal to one. As with the fixed point case, oscillatory behaviors can be modeled with much simpler maps of the form $(y_t, F_t) = (y_{t-2}, F_{t-2})$.



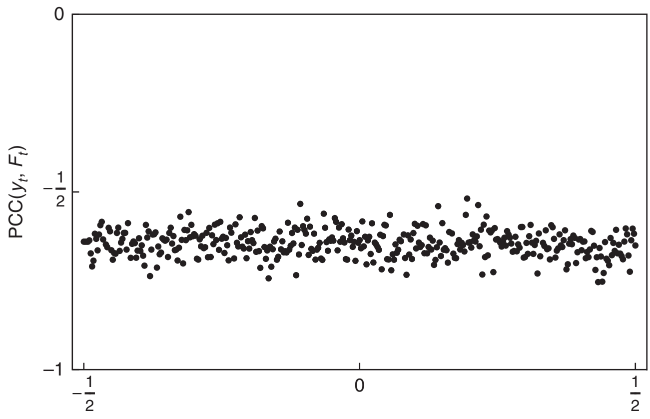
Notes: We show the dynamics without transient behavior. All plots used initial conditions $y_0 = F_0 = 1/2$. (a) Fixed point dynamics, obtained with $\{\lambda = 0.2, \psi = 0.7, \mu = -0.4\}$; (b) period-two oscillations, obtained with $\{\lambda = 0.2, \psi = 0.7, \mu = 0.4\}$; (c) synchronized chaotic dynamics, obtained with $\{\lambda = 0.2, \psi = 0.7, \mu = 0.6\}$; (d) not synchronized chaotic dynamics, obtained with $\{\lambda = 0.2, \psi = 0.8, \mu = -0.8\}$

Figure 4.
Four possible realizations of the model described by Equations (2) and (3)

Figure 4(c) shows synchronized chaotic behavior. We call it synchronized because it is clear that there is a high (close to one) correlation coefficient between both series. We call it chaotic in the dynamical sense (Strogatz, 2014) – although we do not show that there is high sensitivity to initial conditions or positive Lyapunov exponents. High sensitivity to initial conditions and positive Lyapunov exponents are to be expected given the chaotic nature of the tent map used in Equation (3). Chaotic behavior is interesting on its own, but is not the aim of this paper to explore and characterize it.

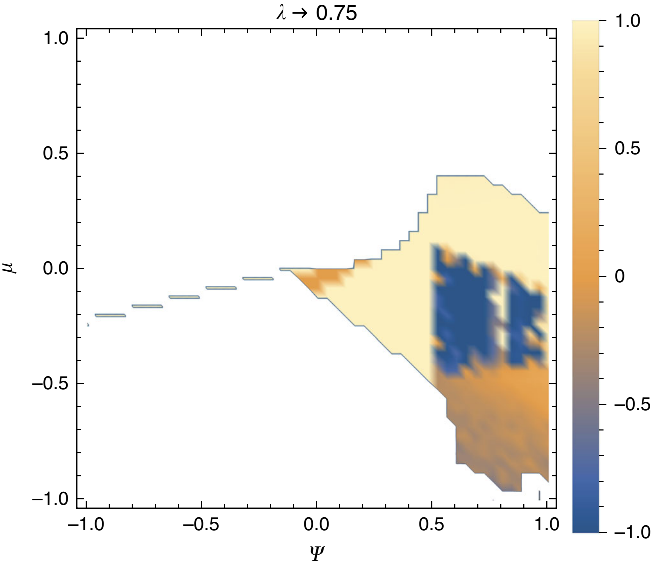
Figure 4(d) shows unsynchronized chaotic behavior. We call it unsynchronized because it is clear that the correlation coefficient between these series is not one. Given that we have high sensibility to initial conditions (the dynamics is expected to be chaotic) we must find that the correlation coefficient is also be sensitive to initial conditions. Meaning that if we change the initial conditions of the map (y_0, F_0) we would observe a different correlation coefficient between the series. This is shown in Figure 5 where we have plotted the resulting PCC between both series on the vertical axis and the difference between initial conditions $\delta = y_0 - F_0$. As can be seen from the picture, for a single set of parameter values (in this case $\{\lambda = 0.2, \psi = 0.8, \mu = -0.8\}$) we get a wide range of possible correlation coefficients. We have calculated the PPC with steps 500 through 550 of the series resulting from a simulation with initial conditions: $(y_0, F_0) = \left(\frac{1}{2}, \frac{1}{2} + \delta\right)$.

Finally, we turn our attention to the behavior of the PCC as a function of the model's parameters $\{\lambda, \psi, \mu\}$. Given that we have a three parameter model it is not easy to visualize its behavior across all possible combinations. We propose to use a density plot for variables $\{\psi, \mu\}$, i.e., a Cartesian plot where, for a fixed value of λ, $\psi \in [-1,1]$ is placed on the horizontal axis and $\mu \in [-1,1]$ on the vertical. Point (ψ, μ) is colored according to the value of the PCC between y_t and F_t. We show one density plots constructed with this procedure on Figure 6. The following color convention is used to represent the PCC: a blue point (dark gray on a gray scale) represents a PCC ~ -1, orange is for values near 0, and light orange (light gray) represent a PCC close to 1. White regions are combinations of parameters that are not valid in our model (they give either negative values for y_t or F_t, or $y_t > 1$ or $F_t > 1$).



Notes: This Figure was obtained with $\{\lambda = 0.2, \psi = 0.8, \mu = -0.8\}$ and $y_0 = 1/2$, $F_0 = 1/2 + \delta$

Figure 5. Pearson's Correlation Coefficient (PCC) as a function of the difference between initial conditions $\boldsymbol{\delta = y_0 - F_0}$



Notes: Blue (dark gray) is for values close to –1, orange for 0, and light orange (light gray) for + 1. White regions indicate combination of parameters for which the series take values outside the [0; 1] interval

Figure 6. Pearson's Correlation Coefficient (PCC) between y_t and F_t on a density plot, as a function of (ψ, μ) for fixed λ

It can be seen in Figure 6 that the model described in Equations (2) and (3) can reproduce all possible values for the PCC between y_t and F_t, from −1 to +1. This fact, together with the evidence for chaotic behavior is a good argument in favor of our model as an adequate, and simple, candidate to capture the dynamics between the proposed variables.

We have showed that a simple non-linear dynamical two-dimensional map is capable of reproducing all possible linear correlation values between its variables. We interpreted this map as the relation between citizens' perception of QL (y_t) and their perception of the city's MM abilities (F_t) along with a possible interpretation of the model. We also did a cursory examination of the possible dynamics that the map is able to reproduce.

4. Conclusions

In this paper we have proposed a simple minimalist model for two survey variables. The initial motivation to undertake this work is the data gathered from different Colombian cities by the "*Ciudades cómo vamos*?" project. Surveys on different cities asked questions that, at a first approximation, should be consistently correlated: the perception of the QL in the city and the perception of the MM ability. After all, if the Mayor is good at managing her resources, then the QL in the city should be good. We found that this is not the general case for four of the cities of the study. We found that these two variables are, indeed, positively correlated but not highly correlated on some cases. We also tested for autocorrelation on each of the series with negative results.

Given a diversity of correlation values we proposed a dynamical two-dimensional map based on a statistical regression model for the perception of the QL in the city as a function of the MM ability and explored some simple relations. We found that the simplest model that was able to generate non-trivial dynamics was one where the perception of the MM followed a non-linear functional form (the tent map). We arrived at this conclusion after exploring simpler relations like linear or oscillatory ones.

We explored the possible steady state dynamics that the proposed model was capable of reproducing, we found that for certain sets of parameters our proposal was able to reproduce fixed point dynamics, oscillatory behavior, as well as chaotic behavior with both variables synchronized or not. We also showed that for the case of unsynchronized chaos, the PCC varied in a non-trivial way with respect to changes in initial conditions. This behavior was expected, since chaotic behavior is, by definition, high sensitivity to initial conditions; however, the dispersion of values observed was not. This point merits further research, it would be interesting to characterize the variance of the PPC as a function of the difference in initial conditions; as well as the possible distributions of the coefficient.

We closed the study of the model by showing an instance where, for a fixed value of λ, all possible values of the correlation coefficient (from -1 to $+1$) could be obtained. From this result we can infer that it is highly possible that both variables (perception of the QL in the city and the perception of the MM ability) are actually correlated, but in a non-trivial way.

Further work related to our proposal should include more data in order to explore in a more thorough way the autocorrelations of the series or the relations between them in order to solidify or refute our findings. Furthermore, different non-linear models must be explored, since we have limited ourselves to show that using one non-linear model introduces rich dynamics. The family of models presented here could be used to test assumptions or behaviors that policy makers implement with regards to a perceived measurement of their management skills. With a robust non-linear model the possibility of intervening public policy with technics from chaos control (Strogatz, 2014) may be a promising venue. All this is highly speculative at this point.

Notes

1. www.fundacioncorona.org.co/templates/plantilla_cinco.php?loc = 5
2. http://redciudades.net/blog/
3. We have used the reports found in www.bogotacomovamos.org/acerca-de/red-de-ciudades/ and http://redciudades.net/blog/tag/red-colombiana-de-ciudades-como-vamos/ as data sources.
4. Authors' translations.

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