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1 Introduction

1.1 General Introduction

The aim of this paper is to either prove or disprove the research paper with title **"Scale-Free Networks Provide a Unifying Framework for the Emergence of Cooperation"** written by F.C. Santos and J. M. Pacheco and published in Physical Review Letters nr 95 (later on referred to as "The Paper"). Regardless of the outcome this work is going to be useful because the above mentioned authors did not provide the code that was used to conduct the necessary simulations. Therefore goal is not only to disprove the above mentioned paper but also to provide readers with clear and easy to follow code.

1.2 Description of The Paper

The Paper was published in "Physical Review Letters" on 26th August 2005 and according to Google Scholar has been since cited over 1600 times. It clearly shows the magnitude of said paper and its groundbreaking character. This paper is presenting the results of simulations conducted by the authors and its implications for evolutionary game theory. The crucial thing to understand is that the authors of The Paper changed the approach to modelling such games by applying Scale Free Networks of Contacts (later on referred to as "SF NOC's"). Its innovativeness lies in the never used before degree distribution of said graph. Before used graphs had a degree distribution with a single peak. It means that every "player" could interact only with a fixed number of other "players". SF NOC's is said to perform better at modelling the actual, existing societies and networks. It complies with the rules of growth and preferential attachment (rich gets richer). If we analyse some actual networks - for example Twitter network, we observe that those with bigger count of "followers" are more likely to gain new ones than accounts with low count of "followers". One of the goals of The Paper was to compare results of simulations on different kinds of graphs. According to The Paper, players that occupy vertices of SF NOC are much more likely to cooperate than of any other graph. Those results came up both in Snowdrift game (later on referred to as SG) and Prisoners Dilemma game (later on referred to as PD).

1.3 A brief description of Snowdrift game and Prisoners Dilemma game

Prisoners Dilemma:

The Prisoners Dillema game is a widely known problem in both game theory and decision analysis. It shows that there exists situations in which the outcome is not optimal, even though players act in their own best interest.

	<i>C</i>	<i>D</i>
<i>C</i>	R, R	T, S
<i>D</i>	S, T	P, P

Where the parametrisation is as follows:

$$T = b > 1$$

$$R = 1$$

$$P = 0$$

$$S = 0$$

$$1 < b \leq 2$$

We clearly see that those parameters show an order as follows: //

$$T > R > P = S$$

Snowdrift Game:

The Snowdrift game represents a metaphore for cooperative interactions between players. Contrary to PD, the Snowdrift game stimulates the cooperative behaviour amongst players. It doesn't make the defection strategy totally not applicable, but payoffs of this game favourizes cooperative behaviours more than the PD.

	<i>C</i>	<i>D</i>
<i>C</i>	R, R	T, S
<i>D</i>	S, T	P, P

Where the parametrisation is as follows:

$$T = \beta > 1$$

$$R = \beta - \frac{1}{2}$$

$$S = 1 - \beta$$

$$P = 0$$

$$T > R > P > S$$

2 Basic things

2.1 Compiling L^AT_EX files

The `.tex` file is just a plain text file. It contains the L^AT_EX formatting codes together with the content of a paper. To get a `.pdf` file you have to compile the `.tex` file using a sequence `pdflatex, biblatex, pdflatex, pdflatex`. This sequence is a default in most editors designed for use with L^AT_EX.

2.2 Basic formatting for a text

Paragraphs are coded by an empty line. That is if you want to start a new paragraph it is enough to leave an empty line and start typing like that:

This is the first paragraph.

This is the next paragraph.

Everything about the paragraph is formatted for you including all indents and spacings. Again, you don't have to take care of it manually.

Basic text formatting, e.g. bold face and italic, is achieved with the following commands: `\textbf{}`, `\textit{}`, `\underline{}`, producing **text**, *text*, text. I suggest not overusing those commands!

Alignment is done through environments `center`, `flushleft` and `\flushright` giving the following examples.

This is centered.

This is aligned to the left.

This is aligned to the right.

In other environments it is possible to use `\centering` to center content of that environment (like in `figure` or `table` environments).

2.3 Fonts and fonts' sizes

You do not change fonts and fonts' sizes! Technically it can be done but I will reject this.

3 Mathematics

This is testing footnotes¹.

3.1 Basic mathematics

There are two types of mathematics inside a \LaTeX document. The first one is the in-line mathematics and the displayed mathematics. The first one looks like this: $F(x) = \int_{-\infty}^x f(\omega) d\omega$ with the code looking like this: `\(F(x) = \int_{-\infty}^x f(\omega) d\omega \)`. The displayed mathematics looks like that

$$F(x) = \int_{-\infty}^x f(\omega) d\omega$$

with the code

```
\[
F(x) = \int_{-\infty}^x f(\omega) d\omega
\]
```

As you can see the same code is formatted differently depending on the type of mathematics.

3.2 Referencing mathematics and other things

To reference mathematics (only displayed formulas) you use the `equation` environment with a `\label{}` within. The reference is done through the `\ref{}` command. The example is

$$F(x) = \int_{-\infty}^x f(\omega) d\omega. \tag{1}$$

To reference the equation you use the `\ref{}` command giving (1). The `\label{}` / `\ref{}` pair works for anything that can be referenced.

¹This is a footnote. We can put some math here $x^2 - f(x) = g(x^2)$ which is not encouraged but sometimes necessary. The other thing we can do is to put here an URL <https://tex.stackexchange.com/questions/249415/set-font-size-for-footnotes>.

3.3 Some more mathematical formulas

Here are slightly more complex formulas. Let A be a matrix

$$A = \left(\begin{bmatrix} 1 & \alpha^2 \\ 2 & \sqrt{\pi} - \log(x - \sin(y)) \end{bmatrix}^2 - \begin{bmatrix} 1 & f(x) \\ 2 & g(y) \end{bmatrix} \cdot \begin{bmatrix} x \\ y \end{bmatrix} \right),$$

where

$$f(x) = \begin{cases} \frac{1}{x} & \text{for } x < -\frac{1}{2}, \\ \frac{1}{1+x^2} & \text{for } x \geq -\frac{1}{2} \end{cases}$$

and

$$g(y) = \sin \left(\frac{\mathbf{E}(X)}{\cos(y) + \log(y)} \right), \quad \text{where } X \sim N(0, \sigma).$$

It is very easy to typeset a normal form game. Below is an example of such a game.

	L	M	H
L	16, 9	3, 13	0, 3
M	21, 1	10, 4	-1, 0
H	9, 0	5, -4	-5, -15

4 Figures and tables

Both figures and tables use the same ideas. To insert a table you use the `table` environment. This is an example of a simple table.

Table 1: This is an example of a table.

Name	property 1	property 2	property 3
Michael	23	34	–
John	34	–	28
Mr. Niceguy	123	231	312

Table 1 is a very simple table and much more is possible.

To insert a figure you need to have a figure. In the catalog there are two figures and the following is an example of the `figure` environment.

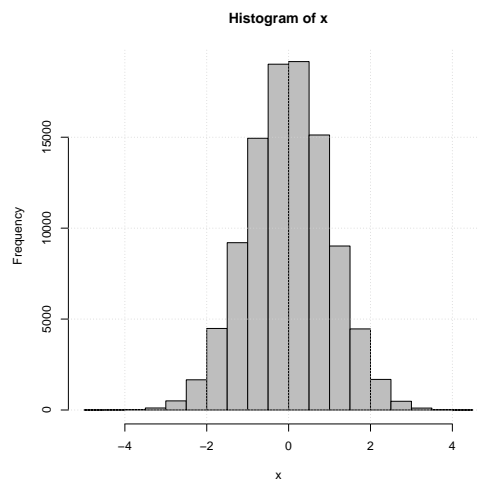
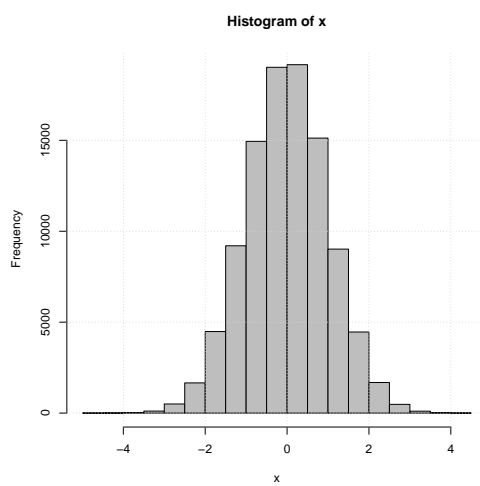
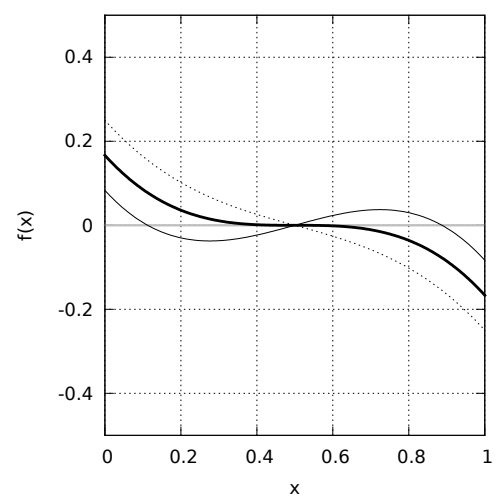


Figure 1: This is just an example. *Source:* own calculations.

Figure 2 is a slightly more complex than just a simple figure but it is useful to have such template. It is possible to reference subfigures as 2a and 2b.



(a) This is a caption for the first figure. This caption is wrapped at the right width and the height is being compensated.



(b) This is another caption.

Figure 2: This is the main caption and it is below the figures. *Source:* own calculations

5 Bibliography

The content for the bibliography is in a different file named `refs.bib`. You can change the name but then you have to change the information in this file from `\bibliography{refs}` to `\bibliography{new-name}` where `new-name` is the name of your file. The file `refs.bib` contains some examples for books and papers.

The process of citation is simple. The command `\cite{garland2010}` gives this ? and puts all information into the bibliography section at the end. Everything is sorted and formatted for you so that you don't have to worry about this. An example of a paper with many authors is ? or ?.

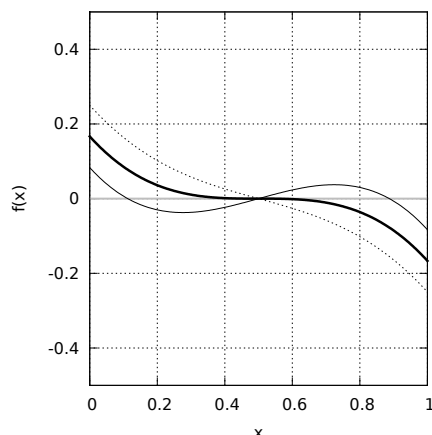


Figure 3: This is how one can wrap a text around a figure. *Source:* own calculations

Table 2: Binary variables used in the VAR model

t	year	elections	crises	tax cuts
1	1961	0	0	0
2	1962	0	0	0
3	1963	0	0	0
4	1964	1	0	0
5	1965	0	0	1
6	1966	0	0	0
7	1967	0	0	0
8	1968	1	0	0
9	1969	0	0	0
10	1970	0	0	0
11	1971	0	0	0
12	1972	1	0	0

Continued on next page

Table 2 – *Continued from previous page*

t	year	elections	crises	tax cuts
13	1973	0	0	0
14	1974	0	1	0
15	1975	0	1	0
16	1976	1	0	0
17	1977	0	0	0
18	1978	0	0	0
19	1979	0	0	0
20	1980	1	0	0
21	1981	0	0	0
22	1982	0	1	1
23	1983	0	0	0
24	1984	1	0	0
25	1985	0	0	0
26	1986	0	0	1
27	1987	0	0	0
28	1988	1	0	0
29	1989	0	0	0
30	1990	0	0	0
31	1991	0	1	0
32	1992	1	0	0
33	1993	0	0	0
34	1994	0	0	0
35	1995	0	0	0
36	1996	1	0	0
37	1997	0	0	0
38	1998	0	0	0
39	1999	0	0	0
40	2000	1	0	0

Continued on next page

Table 2 – *Continued from previous page*

t	year	elections	crises	tax cuts
41	2001	0	1	1
42	2002	0	0	1
43	2003	0	0	1
44	2004	1	0	0
45	2005	0	0	0
46	2006	0	0	0
47	2007	0	0	0
48	2008	1	1	0
49	2009	0	1	1
50	2010	0	0	1
51	2011	0	0	0
52	2012	1	0	0
53	2013	0	0	0
54	2014	0	0	0
55	2015	0	0	0

A Appendix: Some important stuff

This appendix contains all the necessary important stuff, blah, blah, blah ...

Table 3: Tutaj jest tytu tablicy

Nazwa atrybutu	Wartoci	Opis
chk_acct	-	stan rodków na rachunku biecym (jakociowa)
	A11	... <0 Marek Niemieckich
	A12	0 <... <200 Marek Niemieckich
	A13	... >200 Marek Niemieckich
	A14	brak rachunku biecego
duration	-	czas trwania kredytu w miesicach (numeryczna)
history	-	przeszo kredytowa (jakociowa)
	A30	brak kredytów w historii/wszystkie kredyty poprawnie spacone
	A31	wszystkie kredyty poprawnie spacone (zaciagnite w tym banku)
	A32	kredyty poprawnie spacone po dzie dzisiejszy
	A33	opónienia w poprzednich spatach kredytu
	A34	konto krytyczne/zaciagnite kredyty w innych bankach
purpose	-	cel (jakociowa)
	A40	nowy samochód
	A41	uzywany samochód
	A42	meble
	A43	telewizor
	A44	urzdzenia gospodarstwa domowego
	A45	remont
	A46	edukacja
	A47	wakacje
	A48	przekwalifikowanie
	A49	biznes
	A410	inne

kontynuowane na nastpnej stronie

Table 3 – kontynuacja z poprzedniej strony

Nazwa atrybutu	Wartoci	Opis
amount	-	kwota kredytu (numeryczna)
say_acct	-	saldo na rachunku oszczędnościowym/warto posiadanych obligacji (jakociowa)
	A61	... <100 Marek Niemieckich
	A62	100 <= ... <500 Marek Niemieckich
	A63	500 <= ... <1000 Marek Niemieckich
	A64	... >= 1000 Marek Niemieckich
	A65	nieznane/ brak oszczędności
employment	-	czas zatrudnienia w obecnej pracy (jakociowa)
	A71	brak zatrudnienia
	A72	... <1 rok
	A73	1 <= ... <4 lata
	A74	4 <= ... <7 lat
	A75	... >= 7 lat
install_rate	-	wielko raty jako procent rozporzdzalnego przychodu (liczbowa)
pstatus	-	pe i stan cywilny (jakociowa)
	A91	mczyzna; rozwodnik/w separacji
	A92	kobieta; rozwiedziona/ w separacji/ matka
	A93	mczyzna ; wolny
	A94	mczyzna ; onaty/ wdowiec
	A95	kobieta ; wolna
other_debtor	-	inni duncy/ porczyciele (jakociowa)
	A101	brak
	A102	współkredytobiorca
	A103	porczyciel
property	-	wasno/ mienie (jakociowa)

kontynuowane na następnej stronie

Table 3 – kontynuacja z poprzedniej strony

Nazwa atrybutu	Wartoci	Opis
	A121	nieruchomo
	A122	(jeli nie A121) umowa oszczdnociowa/ ubezpieczenie na ycie
	A123	(jeli nie A121/A122) samochód lub inne
	A124	nieznane
timer_resid	-	czas zamieszkania w aktualnym miejscu zamieszkania (liczbowa)
age	-	wiek w latach (liczbowa)
other_install	-	inne zobowizania ratalne (jakociowa)
	A141	bank
	A142	sklepy
	A143	brak
housing	-	warunki mieszkaniowe (jakociowa)
	A151	wynajem
	A152	wasno
	A153	zamieszkanie bez ponoszenia kosztów
other_credits	-	liczba aktualnych kredytów w tym banku (liczbowa)
job	-	praca (jakociowa)
	A171	bezrobotny/niewykwalifikowany; cudzoziemiec
	A172	niewykwalifikowany; rezydent
	A173	wykwalifikowany pracownik/urzdnik
	A174	menader/ samozatrudniony/ wysocewykwalifikowany/ wyszy urzdnik
num_depend	-	liczba osób na utrzymaniu (liczbowa)
telephone	-	telefon (jakociowa)
	A191	brak
	A192	tak, zarejestrowany pod nazwiskiem klienta
foreign	-	pracownik zagraniczny (jakociowa)

kontynuowane na nastpnej stronie

Table 3 – *kontynuacja z poprzedniej strony*

Nazwa atrybutu	Wartoci	Opis
response	A201	tak
	A202	nie
	-	decyzja kredytowa
	1	tak
	2	nie

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Streszczenie

Tutaj zamieszczaj Pastwo streszczenie pracy. Streszczenie powinno by dugoci okoo pó strony.