Testing the possibility to manage cooperation in CO_2 crisis through mechanisms to face the dependence of the initial condition of trust using a simulation model

Evaluando la posibilidad de gestionar la cooperación en la crisis del CO_2 a través de mecanismos para enfrentar la dependencia de las condiciones iniciales de confianza usando un modelo de simulación

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RESUMEN

Los mecanismos de cooperación, basados en confianza, presentan dependencia de sus condiciones iniciales. Se ha probado que es posible promover y mantener la cooperación a través de la combinación de mecanismos usando un modelo de simulación sobre la crisis del CO_2. Los resultados sugieren que la cooperación puede ser promovida y sustentada con la combinación de estos mecanismos. Los experimentos de simulación ofrecen soporte a la hipótesis de que es posible administrar la cooperación en dilemas sociales de gran escala incluso si las condiciones iniciales de confianza no son suficientes para esperar altos niveles de acción colectiva.

PALABRAS CLAVE: Gestión de la cooperación, Dilemas sociales a gran escala, Mecanismos, Confianza, Dependencia de las condiciones iniciales.

ABSTRACT

The mechanism of cooperation based on trust presents dependence to its initial conditions. We tested the possibility to promote and sustain cooperation through a combination of mechanisms using a simulation model in the CO_2 crisis. Our results suggest cooperation can be promoted and sustained with our combination of mechanisms. The simulation experiments offer support to our hypothesis about the possibility to manage cooperation in large-scale social dilemmas even if the trust's initial conditions are not enough to expect high levels of collective action.

KEYWORDS: Management of cooperation, Large-scale social dilemmas, Mechanisms, Trust, Dependence to initial conditions.

1. INTRODUCTION

Cooperation is an alternative feasible to face small-scale social dilemmas (Ostrom *et al.*, 2005); (Ostrom, 2002); (Ostrom *et al.*, 2000). In laboratory (Ostrom *et al.*, 1994). And field (Ostrom *et al.*, 2005). Settings, cooperation is promoted and sustained using a mechanism based on trust (Ostrom *et al.*, 2000). A dynamic version of the mechanism based on trust is presented on Figure 1. In this mechanism, trust promotes reciprocity. Later, reputation is affected by reciprocity. More reciprocity produces more in reputation and increases cooperation. Finally, reputation improves trust. In terms of dynamics, the initial conditions for trust affects the performance of cooperation because this core variables (trust, reputation, and cooperation) are joined in a reinforcing feedback loop that reinforce any initial condition. The literature reports this condition in models which present this feedback loop (Castillo *et al.*, 2005).

For example, we can assume the problem of making saving in energy consumption as a social dilemma. In this case, we can see the conflict between individual rationality represented by temptation to free ride and the group rationality.

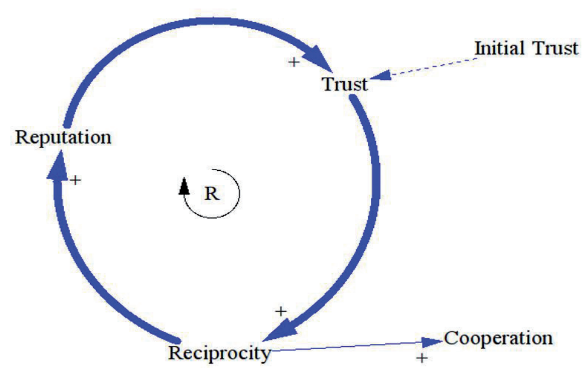

Figure 1. *Dynamic mechanism of cooperation based in trust. This is our dynamic interpretation based in (Ostrom, 2000) and (Castillo, et al, 2005)*

More electricity is saved if the group develops trust. This mechanism, presented in Figure 2, shows us the dependence of the initial conditions which define the performance of trust in this situation as presented in Figure 3.

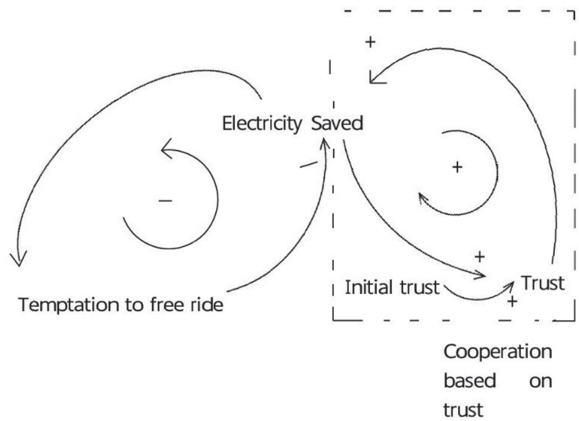

Figure 2. *Mechanism of cooperation based on trust for electricity savings*

This mechanism is represented using the following differential equations:

$$\frac{dTrust}{dt} = it - ot \quad (1)$$

$$\frac{dTempfride}{dt} = increfr - decrefr \quad (2)$$

$$\frac{dEnergysaved}{dt} = generation - consumption - contribution \quad (3)$$

This mechanism of cooperation based on trust exhibits dependence to initial conditions (Castillo, et al., 2005). As is presented in Figure 3.

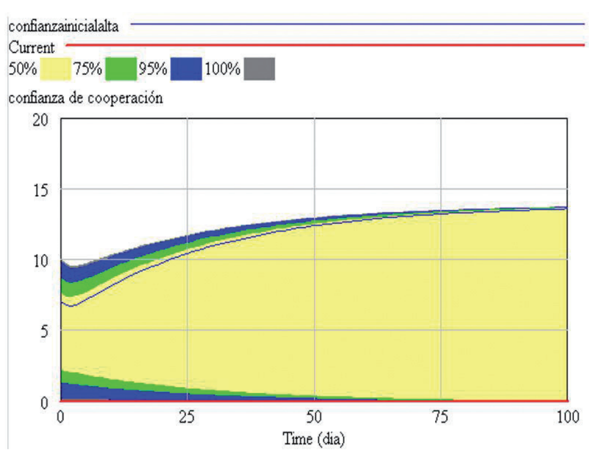

Figure 3. *Dependence to initial conditions for trust. This sensitivity analysis presents confidence zones for mechanism of cooperation based in Trust in a model for cooperation in energy provision for households*

Figure 3 presents how initial conditions drive behavior of trust. We performed a sensitivity analysis for initial conditions of trust. This analysis consisted in 200 simulations using initial trust between 0 and 10 based in the uniform probability distribution. Figure 3 shows how initial conditions for trust affect the behavior of trust because this mechanism is conformed by a reinforce feedback loop. To be effective, cooperation requires a minimum value for initial trust.

This is a problem for managers because they are not able to assure the effectiveness of this cooperation mechanism if it is applied for facing social dilemmas. If trust is depending of its initial conditions, this mechanism could be insufficient to promote, assure and sustain cooperation for all possible initial conditions. Additionally, there is not an agreement about the possibility to apply cooperation based on trust in large-scale social situations (McGinnis *et al.*, 2008). Or not (Biel *et al.,* 1999). The mechanism of cooperation based on trust was developed to meet and work for the conditions of small-scale social dilemmas. However, we have found cooperation based on trust combined with other cooperation mechanisms could explain how people solve large scale social dilemas such as the Colombian electricity crisis and the Californean electricity crisis (incluir citaciones). This alternative way is a possible option which can be used by institutional designers to solve large scale social dilemmas like Climate Change. In this paper we propose an alternative for using cooperation based on trust as a core of a construct, a configuration as a unity of mechanisms crafted to achieve a social goal, which solve the dificulties its difficulties through additional mechanisms so we claim is possible to manage cooperation in large-scale social dilemmas using additional mechanisms combined with cooperation based on trust to face the dependence to initial conditions. To test this claim, we developed a simulation model to the CO_2 crisis. We use a particular structure of combined mechanisms to test if cooperation can be promoted and sustained even with zero as initial condition to trust.

1.1 CO_2 Crisis

Most documented explanation about Climate Change claims that the greenhouse effect has high influence on temperature (Intergovernmental Panel on Climate Change-IPCC. 2007). The atmosphere keeps some heat according to the effect of green house gases like CO_2, that has been increased as a consequence of industrial activity mainly (Intergovernmental Panel on Climate Change-IPCC. 2007). As global shared resource, climate is vulnerable to social dilemmas because individuals and nations can benefit in the short run from greenhouses emissions, while all of us pay the price (Ostrom *et al.,*2002); (Buck, 1998). To reduce the concentration of greenhouse gases (GHGs), emissions must fall below the rate at which GHGs are removed from the atmosphere. However, people do not understand the dynamics of the climate change (Sterman, 2002). Figure 4 shows data for CO_2 measured at Manua Loa, Hawaii (Tans, 2010). This behavior is explained as a consequence of the accumulation of CO_2 in the atmosphere and this occurs because emissions are higher than the ability of the system to capture CO_2.

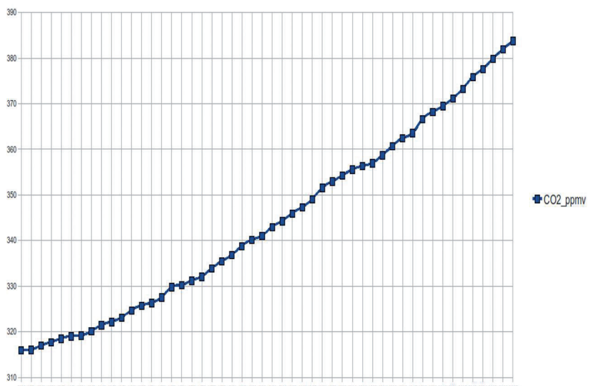

Figure 4. *CO_2 Data measured at Manua Loa, Hawaii (Tans, 2010)*

This paper presents an analisys based on the design and test of a construct to assure effective cooperation for facing CO_2 crisis. We develop a simulation model which integrates a representation of accumulation of CO_2 in the atmosphere and how the construct could reduce the accumulation of CO_2.

2. METHOD

The steps we followed to develop the construct and model the case were:

- To develop a dynamic hypothesis that explains how mechanisms can promote and sustain cooperation.
- To model the CO_2 crisis as a large-scale social dilemma.
- To simulate experiments to test the effectiveness of mechanisms to promote and sustain cooperation.

We use System Dynamics guidelines (Sterman, 2000); (Forrster, 1961) to develop our construct as a dynamic hypothesis, to apply it for modeling the concentration of CO_2 in the atmosphere and the effect of the mechanisms for promoting cooperation, assuming the situation as a social dilemma. We developed the model using Vensim 5.7 for Windows emulated in Ubuntu 10.04 through Wine emulator.

There are other methods which could be useful for studying the problem. Agent based models, and experimental economics. Agent based modeling is not useful if we want to explain how a mechanism actually solve a social dilemma. Experimental economics is not applicable because the characteristics of large-scale social dilemmas. In large-scale social dilemmas people are distributed around the entire entire planet. They do not have the opportunity to meet face to face around the resource and this is essential in order to perform a simulation experiment. Consequently, System dynamics allow us to perform simulation experiments to test the mechanisms. We can represent the rules people use to decide how much emissions they want to do. As a result, we can use the model to evaluate the effect of all actions of people around the atmosphere as a share resource. Finally we can represent all the delays in the information about the state of the shared resource.

3. RESULTS

Initially, we present the construct that define our claim about how cooperation mechanisms can promote cooperation in large scale social dilemmas. Then, we explain a model that represents the CO_2 crisis. Later we present simulation experiments that support our dynamic hypothesis.

3.1 Construct

We assume a construct as a structure that combined mechanisms to promote a social objective (Elster, 1989); (Maskin, 2008). Our construct integrates three mechanisms: cooperation based on trust, cooperation as norm, and cooperation as perception of damage. Figure 5 presents the mechanism of cooperation based on trust. This mechanism is defined by a reinforcing feedback loop as explained before. This means every change in a variable present in this kind of feedback loop is reinforced. This feedback loop presents dependence to initial conditions and path dependence. An increase in the value of trust about resource management promotes cooperation in resource management therefore achieving a sustainable use of the resource. This feedback loop is based on (Ostrom, 2000).

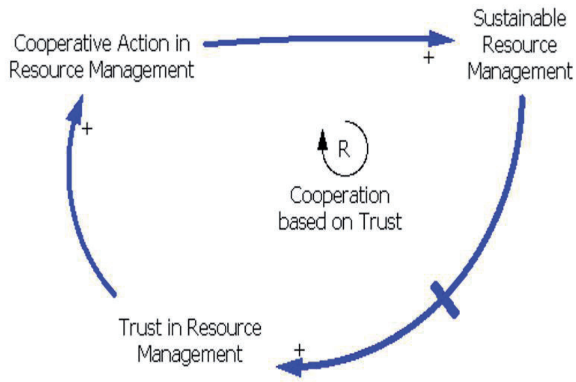

Figure 5. *Mechanism of cooperation based on trust as a component of the proposed construct*

Figure 6 presents the mechanism of cooperation based on trust integrated with the mechanism of cooperation as norm. This part of the construct suggests that people can learn to cooperate in long term because they cooperate in the short term. An increase in cooperative actions promotes learning about resource management that improves the resource's sustainability. This learning allows us to assume cooperation as a norm. This mechanism is inspired in (Biel *et al*., 1999).

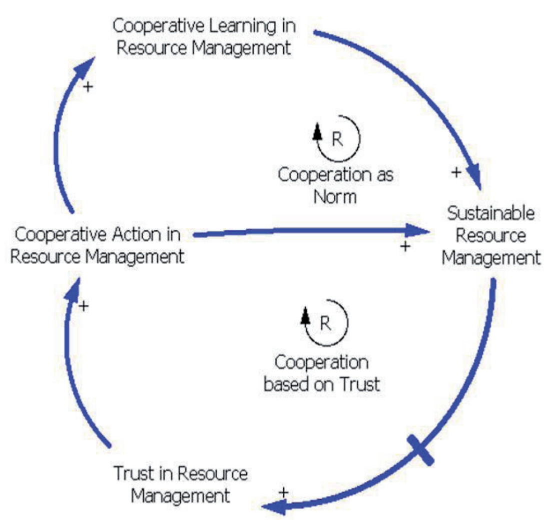

Figure 6. *Mechanism of cooperation as norm with cooperation based on trust*

Figure 7 presents the mechanism of cooperation as perception of damage incorporated to the construct. A reduction of the sustainable resource management promotes an expectancy of scarcity that increases the resource sustainable management. This mechanism consists of a balance feedback loop. This means a change in a variable of the feedback loop is compensated. This mechanism is inspired in (Schelling, 1958).

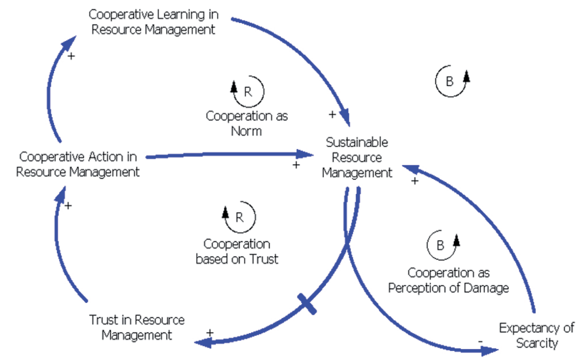

Figure 7. *Mechanism of cooperation by perception of damage*

Figure 8 presents the construct as a united configuration of mechanisms to promote and sustain cooperation in large scale social dilemmas. This construct is based in general structure proposed by (Parra, 2010). All mechanisms allow community members to face the temptation to free ride. Free riding is represented with a feedback loop of balance. An increase in the availability of the resource produces free riding that feeds back decreasing the resource sustainable management. Our construct suggests a configuration of mechanisms able to face social dilemmas by effective cooperation. Next, we present the model developed to test the ability of these mechanisms to promote cooperation in the CO_2 crisis.

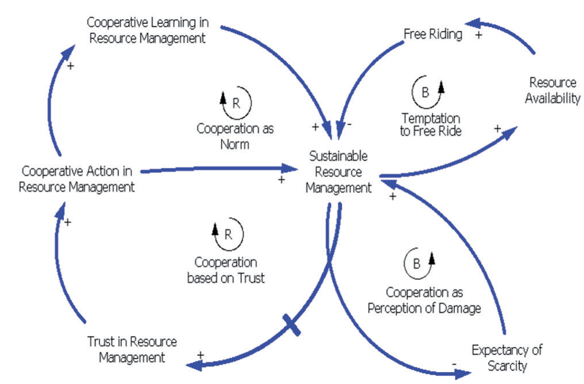

Figure 8. *Free riding and mechanisms of cooperation*

We proposed our Dynamic Hypothesis as an expression of the mechanism for cooperation for large scale resource social dilemmas. In Figure 9 we claim that only people will recognize a threat of damage about climate and the emissions on GHGs if they find a strong relationship between the emissions of GHGs and the effects of global warming as the extreme events. Only this recognition will produce enough pressure to reduce the emissions.

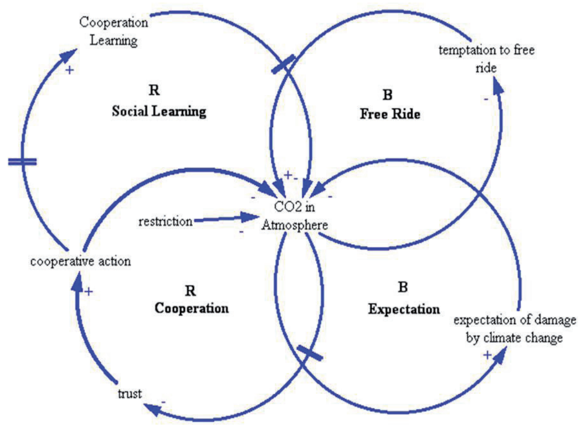

Figure 9. *Dynamic Hypothesis about how cooperation could contribute to reduce CO_2 concentration in atmosphere*

3.2 The Simulation Model

We developed a simulation model to test the proposed mechanism. The model is a system of differential equations. The general structure of the model is presented in Figure 10. This structure is formed by each mechanism.

We present each particular structure for the specific mechanism. Figure 11 presents the stocks and flows diagram for recognition of danger. The recognition of danger is accumulated by the awareness of an increase in the concentration of CO_2. This recognition suffers depreciation because its defined lifetime . More lifetime better to sustain cooperation with this mechanism.

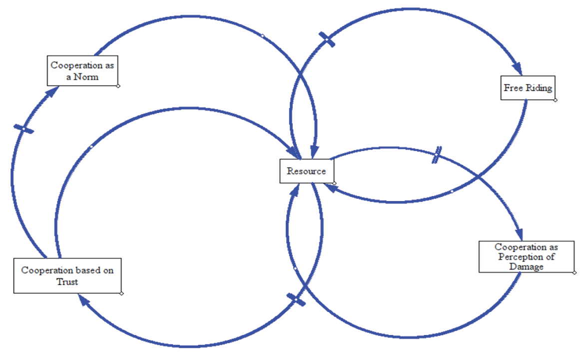

Figure 10. *General structure for the model*

Figure 12 presents the structure for temptation to free ride. If the concentration of CO_2 is reduced then this accumulates temptation to free ride. This accumulation is depleted by a lifetime. More lifetime increases the emission of CO_2 because of the temptation to free ride.

Figure 13 presents the structure to trust. Cooperation is measured by the improvements in the reduction of CO_2 concentration. This perception is accumulated in the differential equation to trust. Trust is depleted according to a lifetime. More lifetime sustains trust for a longer period of time.

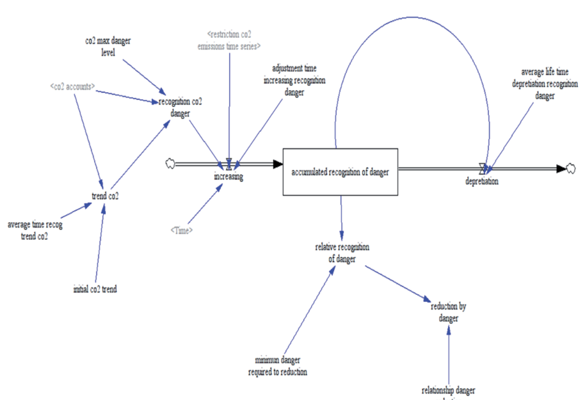

Figure 11. *Model's structure for perception of danger*

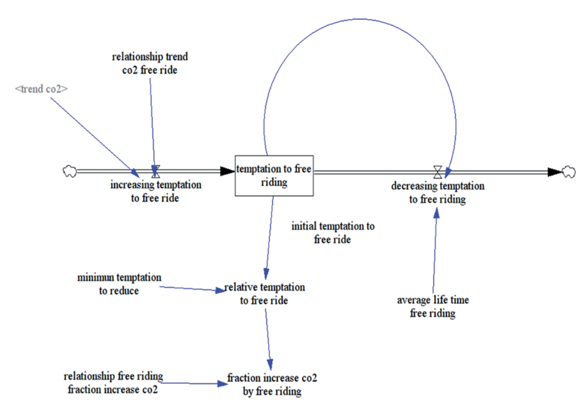

Figure 12. *Model's structure for temptation of free riding*

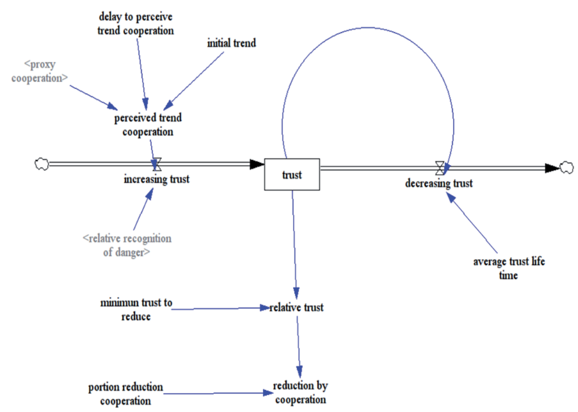

Figure 13. *Model's structure for trust*

Figure 14 presents the structure for CO_2 concentration. We suppose emissions are accumulated in the atmosphere. Due to nature's process, CO_2 is capture C according to a lifetime.

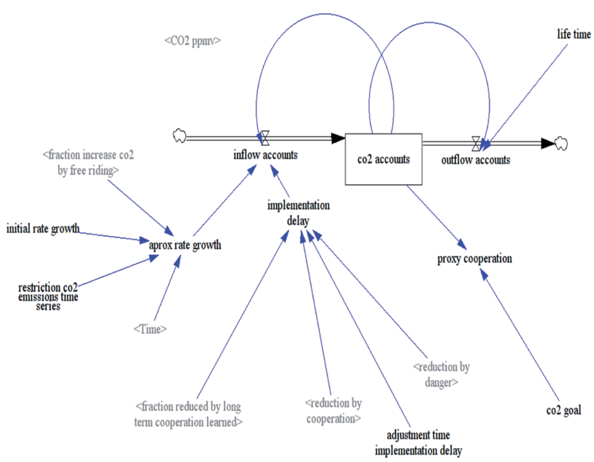

Figure 14. *Model's structure for 2 basic dynamics*

More lifetime supposes more climate change effects. These are the differential equations which define the model.

$$\frac{dco2accounts}{dt} = inaccounts - outaccounts \quad (4)$$

$$\frac{dTrust}{dt} = increasetrust - decreasetrust \quad (5)$$

$$\frac{daccumulat\ edre\ cognition\ of\ danger}{dt} = increase - depretiation \quad (6)$$

$$\frac{dtemptation\ to\ free\ ride}{dt} = increasetempfree - decreasetempfree \quad (7)$$

$$\frac{dpositivepascooperation}{dt} = ncreaselearning - decreaselearning \quad (8)$$

3.3 Simulation Experiments

We set the value for social objective in 315 p.p.m.v. for 2 in the atmosphere. We assume the concentration of CO_2 for 2010 as an initial value for the simulation. We test if the mechanisms of the construct are able to promote and sustain cooperation in order to achieve the social objective proposed. The simulation results support our dynamic hypothesis.

Some important variables used in this scenario with their initial values are presented in Table 1.

Table 1. *Some important variables used in this scenario with their initial values*

Variable	Initial value (t=0)
Delay to perceive trend cooperation	5 years
Average trust life time	5 years
CO_2 average lifetime in the atmosphere	7 years
Average life time depretiation recognition danger	5 years
Adjustment time increasing recognition danger	2 years
Average life time free riding:	10 years
Life time positive experience	10 years

Figure 15 presents the results for the simulation experiment defined by the initial conditions. As we can see, CO_2 can be controlled with the combination of mechanisms used.

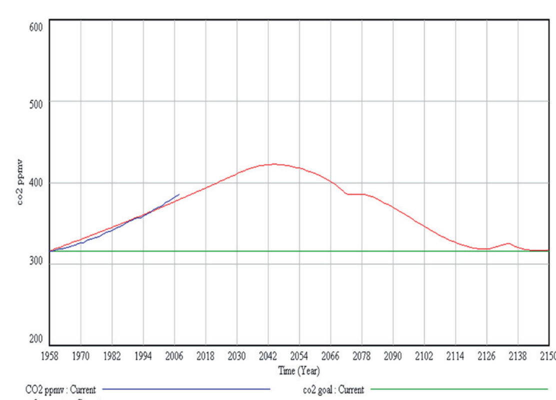

Figure 15. *Simulated behavior for CO_2 under a treatment based of mechanisms for promoting cooperation in red. In blue CO_2 data by (Tans, 2010)*

Each mechanism has its zone of predominance. Figure 16 shows the zone of predominance for cooperation as perception of damage. This controls the exponential growth for CO_2. This mechanism allows to promote cooperation even if the initial condition for trust is zero. This assures enough initial trust to feed the cooperation based on trust.

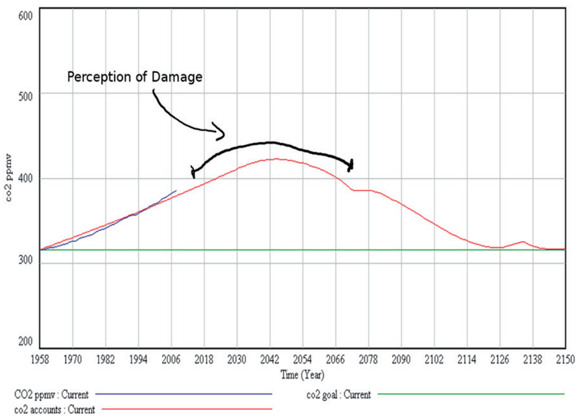

Figure 16. *Simulated behavior for CO_2 under a treatment based of mechanisms for promoting cooperation and the predominance for cooperation as perception of damage in red. In blue CO_2 data by(Tans, 2010)*

Figure 17 presents the zone of predominance for cooperation based on trust. This kind of cooperation, that will be learned as a norm, will allow to achieve the goal of 315 p.p.m.v. for CO_2 in the atmosphere as social objective.

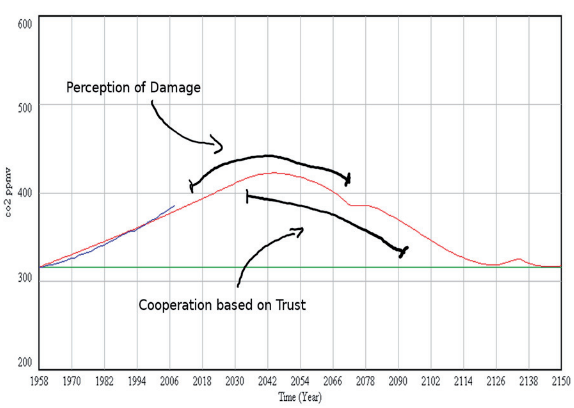

Figure 17. *Simulated behavior for CO_2 under a treatment based of mechanisms for promoting cooperation and the predominance for cooperation based on trust in red. In blue CO_2 data by (Tans, 2010)*

Figure 18 presents how cooperation as norm controls CO_2 in the long run.

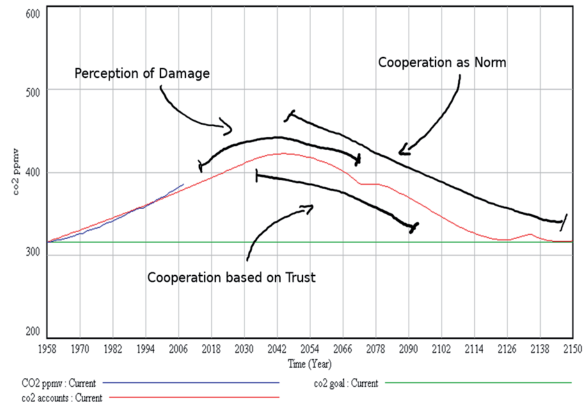

Figure 18. *Simulated behavior for CO_2 under a treatment based of mechanisms for promoting cooperation and the predominance for cooperation as norm in red. In blue CO_2 data by (Tans, 2010)*

3.4 Sensitivity Analysis

We performed sensitivity analysis to test if small changes in the average life time for cooperation as perception of damage can produces more than proportional changes in cooperation. We made 200 simulations for 5 to 33 years for life time in cooperation as perception of damage. Figure 19 presents the dynamic confidence bounds for the sensitivity analysis for CO_2. Higher the value for life time in cooperation as perception of damage, better reduction for CO_2.

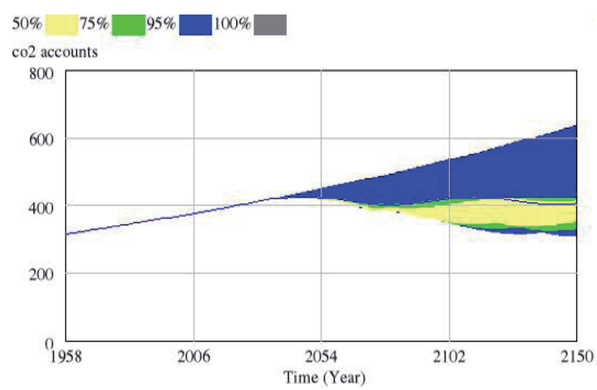

Figure 19. *Sensitivity analysis for cooperation as perception of damage*

4. DISCUSSION

We presented a construct as a dynamic hypothesis that explains how mechanisms are combined to promote cooperation in the CO_2 crisis assumed as a large-scale social dilemma. The dynamic version of the Ostrom's mechanism of cooperation based on trust (Ostrom, 2000) for large-scale social dilemmas that we suggested worked under the conditions of this kind of social dilemmas. We explained how the dependence for trust's initial conditions in the mechanism of cooperation based on trust proposed by (Ostrom, 2010) is controlled with our construct. We applied System Dynamics guidelines to develop the model and test the construct (Parra, 2010).

(Castillo *et al.*, 2005). Offered a behavioral model that explains cooperation in data from a field experiment in a small-scale situation. That model used only the mechanism of cooperation based on trust. Our model combines as unit three mechanisms to assure an effective and sustainable cooperation even in non existing initial conditions for trust in a large scale situation like the CO_2 crisis.

Our work suggests how cooperation can be effective to face social dilemmas like CO_2 crisis. This supposes a new alternative to face this crisis. This alternative could be tested and combined with other designs to face CO_2 crisis like green certificates (Morthorst, 2000) and emissions permits (Jensen *et al.*, 2000).

Cooperation is a possible option even in large-scale social situations. Previous contributions suggested the possibility to extend the mechanism based on trust for applying in large-scale situations (McGinnis, *et al.*, 2008) but not using a combination of mechanisms.

In the case of CO_2 crisis we recognize limitations for our construct to be considered. Dynamic complexity, understood as the effect of delays in information about the state of the shared resource and the effect of others cooperation is critical in the success of cooperation. This problem could be linked with the work about difficulties for people to make high quality decisions in situations of high inertia and delays (Sterman *et al.*, 2007); (Diehl *et al.*, 1995); (Sterman, *1989*). Our results suggest a new application of dynamic complexity studies for large-scale social dilemmas like CO_2 crisis.

5. CONCLUSION

We presented how cooperation can be promoted and sustained even with zero initial trust. Our construct offered an explanation about how mechanisms for cooperating are able assure effective cooperation in a large scale situation.

6. REFERENCES

OSTROM, E; WALKER, J. *Trust and reciprocity: Interdisciplinary lessons from experimental research*. Russell Sage Foundation Publications. 2005.

OSTROM, Elinor. *et al*. *The drama of the commons.* National Research Council. 2002.

OSTROM, E. A behavioral approach to the rational choice theory of collective action. *In Polycentric games and institutions: readings from the Workshop in Political Theory and Policy Analysis*, (pp. 472). University of Michigan Press. 2000.

OSTROM, Elinor., *et al*. *Rules, games, and common-pool resources*. University of Michigan Press. 1994.

OSTROM, E. *et al*. What do people bring into the game? Experiments in the field about cooperation in the commons. *Agricultural Systems*, 82(3), 307–326. 2004.

CASTILLO, D; SAYSEL, A. Simulation of common pool resource field experiments: a behavioral model of collective action. *Ecological Economics*, 55(3), 420–436. 2005.

McGINNIS, M; OSTROM, E. Will Lessons from Small-Scale Social Dilemmas Scale Up? New issues and paradigms in research on social dilemmas. Berlin: Springer. 189–211. 2008.

BIEL, A. *et al*. Norm perception and cooperation in large scale social dilemmas. *Resolving social dilemmas: Dynamic, structural, and intergroup aspects*. Psychology Press. 245–252. 1999.

Intergovernmental Panel on Climate Change-IPCC. Climate Change 2007: Synthesis Report. Ipcc, UN. 2007.
BUCK, S. *The global commons: an introduction.* Island Press. 1998.

STERMAN, J; SWEENEY, L. Cloudy skies: assessing public understanding of global warming. *System Dynamics Review*, 18(2), 207–240. 2002.

TANS, P. Data carbon dioxide measured at Manua Loa Observatory, Hawaii. Earth System Research Laboratory. [web en línea]. < www.esrl.noaa.gov/gmd/ccgg/trends >. [Consulta: 10-7-2013] 2010.

STERMAN, J. *Business dynamics: Systems thinking and modeling for a complex world*. Irwin/McGraw-Hill. 2000.

FORRESTER, J. *Industrial Dynamics*. MIT press Cambridge, MA. 1961.

ELSTER, J. *Nuts and bolts for the social sciences*. Cambridge University Press. 1989.

MASKIN, E. Mechanism design: How to implement social goals. *American Economic Review*, 98(3), 567–576. 2008.

SCHELLING, T. The strategy of conflict. Prospectus for a reorientation of game theory. *Journal of Conflict Resolution*, 2(3), 203. 1958.

PARRA, J. A. *Constructo para la evaluación de la cooperación en dilemas sociales de gran escala*. PhD thesis, Universidad Nacional de Colombia. Doctorado en Ingeniería Área Sistemas. 2010.

MORTHORST, P. The development of a green certificate market. *Energy policy*, 28(15), 1085–1094. 2000.

JENSEN, J; RASMUSSEN, T. Allocation of co2 emissions permits: A general equilibrium analysis of policy instruments* *1. Journal of Environmental Economics and Management*, 40(2), 111–136. 2000.

STERMAN, J; SWEENEY, L. Understanding public complacency about climate change: Adults mental models of climate change violate conservation of matter. *Climatic Change*, 80(3), 213–238. 2007.

DIEHL, E; STERMAN, J. Effects of feedback complexity on dynamic decision making. *Organizational Behavior and Human Decision Processes*, 62(2), 198–215. 1995.

STERMAN, J. Misperceptions of feedback in dynamic decision making. *Organizational behavior and Human Decision Processes*, 43(3), 301–335. 1989.

DIEHL, Ernst; STERMAN, John. Effects of feedback complexity on dynamic decision making. *Organizational Behavior and Human Decision Processes*, 62(2), 198–215. 1995.

STERMAN, John. Misperceptions of feedback in dynamic decision making. *Organizational behavior and Human Decision Processes*, 43(3), 301–335. 1989.

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9. APPENDIX

Simulation model equations.

accumulated recognition of danger= INTEG (
increasing-depretiation,
init accumulated recognition of danger)
~ Dmnl
~ |

adjustment time implementation delay=
20
~ Year
~ |

adjustment time increasing recognition danger=
2
~ Year
~ |

aprox rate growth=
IF THEN ELSE(restriction co2 emissions time series(Time)>0 ,0, initial rate growth*\
fraction increase co2 by free riding)
~ Dmnl/Year [0,1,0.0005]
~ 0.1465
|

average life time depretiation recognition danger=
5
~ Year [1,40]
~ |

average life time free riding=
10
~ Year [1,60]
~ |

average time recog trend co2=
10
~ Year
~ |

average trust life time=
5
~ Year
~ |

co2 accounts= INTEG (
inflow accounts-outflow accounts,
CO2 ppmv)
~ co2 ppmv
~ |

co2 emissions per capita time series(

```
	[(0,0) - (0,10)],(1980,4.16),(1981,4.04),(1982,3.95),(1983,3.91),(1984,4.03),(1985,4.05\
		),(1986,4.08),(1987,4.11),(1988,4.17),(1989,4.16),(1990,4.11),(1991,4.03),(1992,3.96\
		),(1993,3.94),(1994,3.92),(1995,3.92),(1996,3.96),(1997,3.98),(1998,3.92),(1999,3.93\
		),(2000,3.96),(2001,3.95),(2002,3.99),(2003,4.14),(2004,4.31),(2005,4.42),(2006,4.48\
		))
	~	Metric Tons of Carbon Dioxide/(people*Year)
	~		|

co2 goal= INITIAL(
	315.98)
	~	co2 ppmv
	~	315.98 year 1958
	|

co2 max danger level=
	400
	~	co2 ppmv [0,2000,1]
	~		|

CO2 ppmv
	~	co2 ppmv
	~		|

decreasing cooperation learning=
	positive experiences of cooperation/life time positive experiences
	~	Dmnl/Year
	~		|

decreasing temptation to free riding=
	temptation to free riding/average life time free riding
	~	Dmnl/Year
	~		|

decreasing trust=
	trust/average trust life time
	~	Dmnl/Year
	~		|

delay to perceive trend cooperation=
	5
	~	Year
	~		|

depretiation=
	accumulated recognition of danger/average life time depretiation recognition danger
	~	Dmnl/Year
	~		|

fraction increase co2 by free riding=
	relationship free riding fraction increase co2(relative temptation to free ride)
	~	Dmnl
	~		|
fraction reduced by long term cooperation learned=
```

relation positive experiences and reduction(relative long term cooperation)
~ Dmnl
~ |

growth rate co2 time series(
[(1959,0) - (2100,3)],(1959,0.95),(1960,0.51),(1961,0.95),(1962,0.69),(1963,0.73),(1964\
,0.29),(1965,0.98),(1966,1.23),(1967,0.75),(1968,1.02),(1969,1.34),(1970,1.02),(1971\
,0.82),(1972,1.76),(1973,1.18),(1974,0.78),(1975,1.1),(1976,0.91),(1977,2.09),(1978\
,1.31),(1979,1.68),(1980,1.8),(1981,1.43),(1982,0.72),(1983,2.16),(1984,1.37),(1985\
,1.24),(1986,1.51),(1987,2.33),(1988,2.09),(1989,1.27),(1990,1.31),(1991,1.02),(1992\
,0.43),(1993,1.35),(1994,1.9),(1995,1.98),(1996,1.19),(1997,1.96),(1998,2.93),(1999\
,0.94),(2000,1.74),(2001,1.59),(2002,2.56),(2003,2.29),(2004,1.56),(2005,2.55),(2006\
,1.69),(2007,2.17),(2008,1.66),(2009,1.66),(2010,1.66),(2011,1.66))
~ co2 ppmv/Year
~ |

implementation delay=
DELAY N((reduction by danger+reduction by cooperation+(1-fraction reduced by long term cooperation learned\
)), adjustment time implementation delay , 0,3)
~ Dmnl
~ |

increasing=
(recognition co2 danger+restriction co2 emissions time series(Time))/adjustment time increasing recognition danger
~ Dmnl/Year
~ |

increasing cooperation learning=
MAX(perceived trend cooperation , 0)*relative recognition of danger
~ Dmnl/Year
~ IF THEN ELSE(relationship trend cooperation learning(perceived trend \
cooperation):AND:relationship relative recognition of danger cooperation \
learning
>1, 1 ,
0)
|

increasing temptation to free ride=
relationship trend co2 free ride(trend co2)
~ Dmnl/Year
~ IF THEN ELSE(trend co2>0, 0 ,1)
|

increasing trust=
IF THEN ELSE(perceived trend cooperation>0 :AND:relative recognition of danger>1 , 1\
, 0)
~ Dmnl/Year
~ :AND:restriction co2 emissions time series(Time)>0
|

inflow accounts=

```
	co2 accounts*(aprox rate growth-(aprox rate growth*implementation delay))
	~	co2 ppmv/Year
	~		|

init accumulated recognition of danger=
	0
	~	Dmnl
	~		|

init trust=
	0
	~	Dmnl
	~		|

initial co2 in at= INITIAL(
	CO2 ppmv)
	~	co2 ppmv
	~		|

initial co2 trend=
	0.01
	~	1/Year
	~		|

initial positive experiences of cooperation=
	0
	~	Dmnl
	~		|

initial rate growth=
	0.1465
	~	Dmnl/Year [0.1465,1,1e-005]
	~		|

initial temptation to free ride=
	0
	~	Dmnl
	~		|

initial trend=
	0.01
	~	1/Year
	~		|

life time=
	7
	~	Year [0,500,1]
	~		|

life time positive experiences=
	10
	~	Year
	~		|
```

```
minimun danger required to reduction=
        1
        ~       Dmnl [0.1,20,0.01]
        ~               |

minimun learning required to promote reduction by cooperation=
        1
        ~       Dmnl [0.001,40,0.0001]
        ~               |

minimun temptation to reduce=
        0.1
        ~       Dmnl [0.1,5,0.01]
        ~               |

minimun trend cooperation to increase cooperation learning=
        0.8
        ~       1/Year
        ~               |

minimun trust to reduce=
        1
        ~       Dmnl [0.1,6]
        ~               |

outflow accounts=
        co2 accounts/life time
        ~       co2 ppmv/Year
        ~               |

perceived trend cooperation=
        TREND( proxy cooperation , delay to perceive trend cooperation , initial trend)
        ~       1/Year
        ~               |

portion reduction cooperation(
        [(0,0)-(6,0.1)],(0,0),(1,0),(2.78899,0.00964912),(4.0367,0.0390351),(4.73394,0.0710526\
                ),(5,0.1))
        ~       Dmnl
        ~               |

positive experiences of cooperation= INTEG (
        increasing cooperation learning-decreasing cooperation learning,
                initial positive experiences of cooperation)
        ~       Dmnl
        ~               |

proxy cooperation=
        co2 goal/co2 accounts
        ~       Dmnl
        ~               |
```

```
recognition co2 danger=
	IF THEN ELSE( trend co2>0 :AND:co2 accounts>co2 max danger level, 1 , 0 )
	~	Dmnl
	~		|

reduction by cooperation=
	portion reduction cooperation(relative trust)
	~	Dmnl
	~		|

reduction by danger=
	relationship danger reduction(relative recognition of danger)
	~	Dmnl
	~		|

relation positive experiences and reduction(
	[(0,0.8)-(2,1)],(0,1),(0.654434,1.02193),(0.844037,0.922807),(0.978593,0.867544),(1.19878\
		,0.831579),(1.52905,0.801754),(2,0.8))
	~	Dmnl
	~		|

relationship danger reduction(
	[(0,0)-(2,0.05)],(0,0),(1,0),(1.43119,0.00745614),(1.82263,0.0219298),(2,0.05))
	~	Dmnl
	~		|

relationship free riding fraction increase co2(
	[(0,1)-(3,1.1)],(0,1),(1,1),(1,1.03728),(1.05505,1.06272),(1.3211,1.08377),(1.81651,\
		1.09342),(3,1.1))
	~	Dmnl
	~		|

relationship relative recognition of danger cooperation learning=
	IF THEN ELSE(relative recognition of danger>1, 1, 0 )
	~	Dmnl
	~		|

relationship trend co2 free ride(
	[(-2,0)-(0,1)],(-2,1),(-0.715596,0.982456),(-0.428135,0.947368),(-0.238532,0.833333)\
		,(-0.12844,0.587719),(0,0))
	~	Dmnl/Year
	~		|

relationship trend cooperation learning(
	[(-1,0)-(1,1)],(-1,0),(-0.9,0),(-0.8,0),(-0.0397554,0),(0.00917431,0.192982),(0.0165138\
		,0.267544),(0.0568807,0.644737),(0.0642202,0.802632),(0.302752,0.969298),(1,1))
	~	Dmnl
	~		|

relative long term cooperation=
	positive experiences of cooperation/minimun learning required to promote reduction by cooperation
	~	Dmnl
	~		|
```

```
relative recognition of danger=
        accumulated recognition of danger/minimun danger required to reduction
        ~       Dmnl
        ~               |

relative temptation to free ride=
        temptation to free riding/minimun temptation to reduce
        ~       Dmnl
        ~               |

relative trust=
        trust/minimun trust to reduce
        ~       Dmnl
        ~               |

restriction co2 emissions time series(
        [(1950,0)-(2100,1)],(1950,0),(2008,0),(2009,0),(2010,0),(2011,0),(2020,0),(2100,0))
        ~       Dmnl
        ~               |

temptation to free riding= INTEG (
        increasing temptation to free ride-decreasing temptation to free riding,
                initial temptation to free ride)
        ~       Dmnl
        ~               |

trend co2=
        TREND(co2 accounts, average time recog trend co2 , initial co2 trend)
        ~       1/Year
        ~               |

trust= INTEG (
        increasing trust-decreasing trust,
                init trust)
        ~       Dmnl
        ~               |

********************************************************
        .Control
********************************************************~
                Simulation Control Parameters
        |

FINAL TIME  = 2150
        ~       Year
        ~       The final time for the simulation.
        |

INITIAL TIME  = 1958
        ~       Year
        ~       The initial time for the simulation.
        |
```

```
SAVEPER  = 1
	~	Year [0,?]
	~	The frequency with which output is stored.
	|

TIME STEP  = 0.0625
	~	Year [0,?]
	~	The time step for the simulation.
	|

\\\---/// Sketch information - do not modify anything except names
V300  Do not put anything below this section - it will be ignored
*restriction
$192-192-192,0,Times New Roman|12||0-0-0|0-0-0|0-0-255|-1--1--1|-1--1--1|96,96,75,0
10,1,Time,325,397,26,11,8,2,1,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,2,co2 accounts,649,265,60,29,3,131,0,0,0,0,0,0
12,3,48,332,238,10,8,0,3,0,0,-1,0,0,0
1,4,6,2,4,0,0,22,0,0,0,-1--1--1,,1|(530,241)|
1,5,6,3,100,0,0,22,0,0,0,-1--1--1,,1|(400,241)|
11,6,48,465,241,6,8,34,3,0,0,1,0,0,0
10,7,inflow accounts,465,260,49,11,40,3,0,0,-1,0,0,0
12,8,48,925,247,10,8,0,3,0,0,-1,0,0,0
1,9,11,8,4,0,0,22,0,0,0,-1--1--1,,1|(856,247)|
1,10,11,2,100,0,0,22,0,0,0,-1--1--1,,1|(747,247)|
11,11,48,792,247,6,8,34,3,0,0,1,0,0,0
10,12,outflow accounts,792,266,53,11,40,3,0,0,-1,0,0,0
1,13,2,12,1,0,0,0,0,64,0,-1--1--1,,1|(709,111)|
10,14,life time,945,124,25,11,8,3,0,0,0,0,0,0
1,15,14,12,0,0,0,0,0,64,0,-1--1--1,,1|(873,190)|
10,16,aprox rate growth,340,362,56,11,8,3,0,0,0,0,0,0
1,17,16,7,0,0,0,0,0,64,0,-1--1--1,,1|(396,315)|
1,18,2,7,1,0,0,0,0,64,0,-1--1--1,,1|(526,107)|
10,19,CO2 ppmv,353,131,46,11,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,20,19,2,0,0,0,0,0,64,1,-1--1--1,,1|(476,186)|
10,21,co2 goal,929,548,28,11,8,3,0,0,0,0,0,0
10,22,proxy cooperation,791,377,58,11,8,3,0,0,0,0,0,0
1,23,2,22,0,0,0,0,0,64,0,-1--1--1,,1|(725,325)|
1,24,21,22,0,0,0,0,0,64,0,-1--1--1,,1|(864,467)|
10,25,restriction co2 emissions time series,128,420,46,19,8,3,0,0,0,0,0,0
1,26,25,16,0,0,0,0,0,64,0,-1--1--1,,1|(229,392)|
10,27,Time,286,457,26,11,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,28,27,16,0,0,0,0,0,64,0,-1--1--1,,1|(309,415)|
10,29,initial rate growth,119,343,54,11,8,3,0,0,0,0,0,0
1,30,29,16,0,0,0,0,0,64,0,-1--1--1,,1|(221,351)|
10,31,reduction by cooperation,571,549,45,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,32,31,34,0,0,0,0,0,64,0,-1--1--1,,1|(545,444)|
10,33,reduction by danger,739,508,45,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,34,implementation delay,516,326,48,19,8,3,0,0,0,0,0,0
10,35,adjustment time implementation delay,703,585,67,19,8,3,0,0,0,0,0,0
1,36,33,34,0,0,0,0,0,64,0,-1--1--1,,1|(632,421)|
1,37,35,34,0,0,0,0,0,64,0,-1--1--1,,1|(613,461)|
1,38,34,7,0,0,0,0,0,64,0,-1--1--1,,1|(491,294)|
10,39,fraction increase co2 by free riding,190,269,71,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
```

1,40,39,16,0,0,0,0,0,64,0,-1--1--1,,1|(265,315)|
10,41,fraction reduced by long term cooperation learned,345,553,84,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,42,41,34,0,0,0,0,0,64,0,-1--1--1,,1|(425,445)|
12,43,0,1611,290,337,195,3,188,0,0,1,0,0,0
cooperation_co2_model_vs
\\\---/// Sketch information - do not modify anything except names
V300 Do not put anything below this section - it will be ignored
*trust
$192-192-192,0,Times New Roman|12||0-0-0|0-0-0|0-0-255|-1--1--1|-1--1--1|96,96,75,0
10,1,trust,568,351,40,20,3,3,0,0,0,0,0,0
12,2,48,208,338,10,8,0,3,0,0,-1,0,0,0
1,3,5,1,4,0,0,22,0,0,0,-1--1--1,,1|(453,338)|
1,4,5,2,100,0,0,22,0,0,0,-1--1--1,,1|(292,338)|
11,5,48,373,338,6,8,34,3,0,0,1,0,0,0
10,6,increasing trust,373,357,47,11,40,3,0,0,-1,0,0,0
12,7,48,963,343,10,8,0,3,0,0,-1,0,0,0
1,8,10,7,4,0,0,22,0,0,0,-1--1--1,,1|(869,343)|
1,9,10,1,100,0,0,22,0,0,0,-1--1--1,,1|(691,343)|
11,10,48,780,343,6,8,34,3,0,0,1,0,0,0
10,11,decreasing trust,780,362,49,11,40,3,0,0,-1,0,0,0
1,12,1,11,1,0,0,0,0,64,0,-1--1--1,,1|(660,169)|
10,13,average trust life time,880,468,52,19,8,3,0,0,0,0,0,0
1,14,13,11,0,0,0,0,0,64,0,-1--1--1,,1|(831,416)|
10,15,proxy cooperation,205,222,43,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,16,perceived trend cooperation,361,289,50,19,8,3,0,0,0,0,0,0
1,17,15,16,0,0,0,0,0,64,0,-1--1--1,,1|(275,252)|
1,18,16,6,0,0,0,0,0,64,0,-1--1--1,,1|(366,320)|
10,19,delay to perceive trend cooperation,343,163,57,19,8,3,0,0,0,0,0,0
1,20,19,16,0,0,0,0,0,64,0,-1--1--1,,1|(350,219)|
10,21,initial trend,481,187,35,11,8,3,0,0,0,0,0,0
1,22,21,16,0,0,0,0,0,64,0,-1--1--1,,1|(431,229)|
10,23,init trust,485,249,26,11,8,3,1,0,0,0,0,0
10,24,relative trust,575,517,39,11,8,3,0,0,0,0,0,0
1,25,1,24,0,0,0,0,0,64,0,-1--1--1,,1|(570,431)|
1,26,23,1,0,0,0,0,0,64,1,-1--1--1,,1|(517,290)|
10,27,portion reduction cooperation,328,624,55,19,8,3,0,0,0,0,0,0
10,28,reduction by cooperation,580,623,40,19,8,3,0,0,0,0,0,0
1,29,27,28,0,0,0,0,0,64,0,-1--1--1,,1|(454,623)|
1,30,24,28,0,0,0,0,0,64,0,-1--1--1,,1|(576,559)|
10,31,restriction co2 emissions time series,44,395,70,19,8,2,1,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,32,Time,393,467,26,11,8,2,1,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
12,33,6161240,1552,1046,343,194,3,188,0,0,1,0,0,0
cooperation_co2_model_vs
10,34,minimun trust to reduce,344,519,50,19,8,3,0,0,0,0,0,0
1,35,34,24,0,0,0,0,0,64,0,-1--1--1,,1|(458,518)|
10,36,relative recognition of danger,330,439,65,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,37,36,6,0,0,0,0,0,64,0,-1--1--1,,1|(349,400)|
\\\---/// Sketch information - do not modify anything except names
V300 Do not put anything below this section - it will be ignored
*expectation of unavailability
$192-192-192,0,Times New Roman|12||0-0-0|0-0-0|0-0-255|-1--1--1|-1--1--1|96,96,75,0
10,1,co2 accounts,327,51,51,11,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128

10,2,trend co2,398,214,31,11,8,3,0,0,0,0,0,0
10,3,recognition co2 danger,563,82,49,19,8,3,0,0,0,0,0,0
1,4,1,2,0,0,0,0,0,64,0,-1--1--1,,1|(359,126)|
10,5,average time recog trend co2,244,265,60,19,8,3,0,0,0,0,0,0
1,6,5,2,0,0,0,0,0,64,0,-1--1--1,,1|(327,237)|
10,7,initial co2 trend,376,353,48,11,8,3,0,0,0,0,0,0
1,8,7,2,0,0,0,0,0,64,0,-1--1--1,,1|(385,290)|
10,9,co2 max danger level,405,-9,52,19,8,3,0,0,0,0,0,0
1,10,2,3,0,0,0,0,0,64,0,-1--1--1,,1|(469,156)|
1,11,9,3,0,0,0,0,0,64,0,-1--1--1,,1|(477,33)|
1,12,1,3,0,0,0,0,0,64,0,-1--1--1,,1|(439,65)|
10,13,restriction co2 emissions time series,669,-18,70,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,14,Time,566,266,26,11,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,15,accumulated recognition of danger,912,178,126,35,3,131,0,0,0,0,0,0
12,16,48,541,166,10,8,0,3,0,0,-1,0,0,0
1,17,19,15,4,0,0,22,0,0,0,-1--1--1,,1|(730,166)|
1,18,19,16,100,0,0,22,0,0,0,-1--1--1,,1|(606,166)|
11,19,48,668,166,6,8,34,3,0,0,1,0,0,0
10,20,increasing,668,185,32,11,40,3,0,0,-1,0,0,0
12,21,48,1415,173,10,8,0,3,0,0,-1,0,0,0
1,22,24,21,4,0,0,22,0,0,0,-1--1--1,,1|(1316,173)|
1,23,24,15,100,0,0,22,0,0,0,-1--1--1,,1|(1126,173)|
11,24,48,1221,173,6,8,34,3,0,0,1,0,0,0
10,25,depretiation,1221,192,38,11,40,3,0,0,-1,0,0,0
10,26,average life time depretiation recognition danger,1359,47,74,28,8,3,0,0,0,0,0,0
1,27,26,25,0,0,0,0,0,64,0,-1--1--1,,1|(1286,122)|
1,28,15,25,1,0,0,0,0,64,0,-1--1--1,,1|(1039,-50)|
1,29,3,20,0,0,0,0,0,64,0,-1--1--1,,1|(614,132)|
1,30,13,20,0,0,0,0,0,64,0,-1--1--1,,1|(668,80)|
1,31,14,20,0,0,0,0,0,64,0,-1--1--1,,1|(610,229)|
10,32,adjustment time increasing recognition danger,812,41,68,28,8,3,0,0,0,0,0,0
1,33,32,20,0,0,0,0,0,64,0,-1--1--1,,1|(736,116)|
10,34,relative recognition of danger,916,299,60,19,8,3,0,0,0,0,0,0
10,35,init accumulated recognition of danger,1054,51,67,19,8,3,1,0,0,0,0,0
1,36,35,15,0,0,0,0,0,64,1,-1--1--1,,1|(997,101)|
1,37,15,34,0,0,0,0,0,64,0,-1--1--1,,1|(913,239)|
10,38,reduction by danger,1148,387,40,19,8,3,0,0,0,0,0,0
10,39,relationship danger reduction,1148,512,60,19,8,3,0,0,0,0,0,0
1,40,39,38,0,0,0,0,0,64,0,-1--1--1,,1|(1148,456)|
1,41,34,38,0,0,0,0,0,64,0,-1--1--1,,1|(1030,342)|
12,42,0,1270,908,333,191,3,188,0,0,1,0,0,0
cooperation_co2_model_vs
10,43,minimun danger required to reduction,775,467,67,19,8,3,0,0,0,0,0,0
1,44,43,34,0,0,0,0,0,64,0,-1--1--1,,1|(840,388)|
\\\---/// Sketch information - do not modify anything except names
V300 Do not put anything below this section - it will be ignored
*free riding
$192-192-192,0,Times New Roman|12||0-0-0|0-0-0|0-0-255|-1--1--1|-1--1--1|96,96,75,0
10,1,temptation to free riding,570,140,58,27,3,131,0,0,0,0,0,0
12,2,48,269,134,10,8,0,3,0,0,-1,0,0,0
1,3,5,1,4,0,0,22,0,0,0,-1--1--1,,1|(456,134)|
1,4,5,2,100,0,0,22,0,0,0,-1--1--1,,1|(334,134)|
11,5,48,395,134,6,8,34,3,0,0,1,0,0,0

10,6,increasing temptation to free ride,395,161,67,19,40,3,0,0,-1,0,0,0
12,7,48,1005,135,10,8,0,3,0,0,-1,0,0,0
1,8,10,7,4,0,0,22,0,0,0,-1--1--1,,1|(906,135)|
1,9,10,1,100,0,0,22,0,0,0,-1--1--1,,1|(716,135)|
11,10,48,811,135,6,8,34,3,0,0,1,0,0,0
10,11,decreasing temptation to free riding,811,162,69,19,40,3,0,0,-1,0,0,0
1,12,1,11,1,0,0,0,0,64,0,-1--1--1,,1|(688,-66)|
10,13,average life time free riding,804,312,52,19,8,3,0,0,0,0,0,0
1,14,13,11,0,0,0,0,0,64,0,-1--1--1,,1|(806,243)|
10,15,initial temptation to free ride,656,215,60,19,8,3,0,0,0,0,0,0
10,16,trend co2,227,26,40,11,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,17,16,6,0,0,0,0,0,64,0,-1--1--1,,1|(300,85)|
10,18,relationship trend co2 free ride,387,-7,55,19,8,3,0,0,0,0,0,0
10,19,fraction increase co2 by free riding,567,414,66,19,8,3,0,0,0,0,0,0
10,20,relationship free riding fraction increase co2,333,412,70,19,8,3,0,0,0,0,0,0
1,21,20,19,0,0,0,0,0,64,0,-1--1--1,,1|(445,412)|
1,22,1,25,0,0,0,0,0,64,0,-1--1--1,,1|(563,214)|
1,23,15,1,0,0,0,0,0,64,1,-1--1--1,,1|(622,185)|
12,24,1900874,1490,654,330,167,3,188,0,0,1,0,0,0
cooperation_co2_model_vs
10,25,relative temptation to free ride,556,295,58,19,8,3,0,0,0,0,0,0
10,26,minimun temptation to reduce,341,282,61,19,8,3,0,0,0,0,0,0
1,27,26,25,0,0,0,0,0,64,0,-1--1--1,,1|(442,287)|
1,28,25,19,0,0,0,0,0,64,0,-1--1--1,,1|(560,347)|
1,29,18,6,0,0,0,0,0,64,0,-1--1--1,,1|(390,70)|
\\\---/// Sketch information - do not modify anything except names
V300 Do not put anything below this section - it will be ignored
*long term cooperation learning
$192-192-192,0,Times New Roman|12||0-0-0|0-0-0|0-0-255|-1--1--1|-1--1--1|96,96,75,0
10,1,positive experiences of cooperation,772,312,94,50,3,131,0,0,0,0,0,0
12,2,48,208,299,10,8,0,3,0,0,-1,0,0,0
1,3,5,1,4,0,0,22,0,0,0,-1--1--1,,1|(566,299)|
1,4,5,2,100,0,0,22,0,0,0,-1--1--1,,1|(330,299)|
11,5,48,448,299,6,8,34,3,0,0,1,0,0,0
10,6,increasing cooperation learning,448,326,65,19,40,3,0,0,-1,0,0,0
12,7,48,1348,302,10,8,0,3,0,0,-1,0,0,0
1,8,10,7,4,0,0,22,0,0,0,-1--1--1,,1|(1223,302)|
1,9,10,1,100,0,0,22,0,0,0,-1--1--1,,1|(981,302)|
11,10,48,1102,302,6,8,34,3,0,0,1,0,0,0
10,11,decreasing cooperation learning,1102,329,65,19,40,3,0,0,-1,0,0,0
1,12,1,11,1,0,0,0,0,64,0,-1--1--1,,1|(933,20)|
10,13,life time positive experiences,1332,192,51,19,8,3,0,0,0,0,0,0
1,14,13,11,0,0,0,0,0,64,0,-1--1--1,,1|(1223,256)|
10,15,perceived trend cooperation,229,60,55,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,16,15,6,0,0,0,0,0,64,0,-1--1--1,,1|(333,187)|
10,17,initial positive experiences of cooperation,156,360,46,28,8,3,1,0,0,0,0,0
1,18,17,1,0,0,0,0,0,64,1,-1--1--1,,1|(433,338)|
10,19,minimun learning required to promote reduction by cooperation,543,517,89,28,8,3,0,0,0,0,0,0
10,20,relative long term cooperation,787,513,55,19,8,3,0,0,0,0,0,0
1,21,1,20,0,0,0,0,0,64,0,-1--1--1,,1|(779,421)|
1,22,19,20,0,0,0,0,0,64,0,-1--1--1,,1|(675,514)|
10,23,fraction reduced by long term cooperation learned,786,684,80,19,8,3,0,0,0,0,0,0
10,24,relation positive experiences and reduction,516,680,52,28,8,3,0,0,0,0,0,0

1,25,24,23,0,0,0,0,0,64,0,-1--1--1,,1|(630,680)|
1,26,20,23,0,0,0,0,0,64,0,-1--1--1,,1|(786,591)|
12,27,3539222,1415,1049,368,189,3,188,0,0,1,0,0,0
cooperation_co2_model_vs
10,28,accumulated recognition of danger,422,82,72,19,8,2,1,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,29,relative recognition of danger,444,76,65,19,8,2,0,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
10,30,relationship relative recognition of danger cooperation learning,617,50,67,28,8,3,1,0,0,0,0,0
1,31,29,6,0,0,0,0,0,64,0,-1--1--1,,1|(445,194)|
10,32,minimun trend cooperation to increase cooperation learning,152,449,84,28,8,3,1,0,0,0,0,0
10,33,relationship trend cooperation learning,149,204,65,19,8,3,1,0,0,0,0,0
10,34,relative recognition of danger,600,208,65,19,8,2,1,3,-1,0,0,0,128-128-128,0-0-0,|12||128-128-128
1,35,34,30,0,1,0,0,0,64,0,-1--1--1,,1|(606,140)|