How Much Abuse Can Markets Take?
On the Structural Effects Corporate Income Redistribution

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Abstract. The paper presents an evolutionary game with four policy variables for the analysis of the long-term structural effects of excessive corporate income redistribution. Different values of the policy variables represent different income policy regimes that affect the equilibrium properties of the game. The paper applies the model to investigate the different ways in which excessive corporate income redistribution alters industry structure and the efficiency of some income policy reforms that aim to correct the negative effects of the excesses.

Keywords: Evolutionary games, corporate income redistribution, income policies.

1 Introduction

Recently a new country joined the group of countries with excessive corporate income redistribution and some weak economic and social institutions: Hungary. Hungary's case is unique because after the fall of communism it successfully transformed its soviet type planned economy into a market economy, and developed and relatively smoothly ran almost all of the important economic institutions of modern capitalism. In addition, in 2004 Hungary joined the European Union, which ensured the conformity of Hungarian corporate taxation, industry regulation, government aids/subsidies, and other practices with European standards. However, in 2010 Hungary began to move away from European style democracy and capitalism. Among other things the Hungarian government introduced very high level, special, sectorial taxes in the banking, telecommunication, insurance and power generation industries, announced low, administrative price ceilings for privately owned public utilities, created numerous state owned enterprises in the transportation, telecommunication, public works and media industries, developed a system in which only a few, well connected companies can successfully apply for and participate in large government projects, often funded by the European Union, and weakened the legal and judiciary system so private contracts can now be overwritten by government agencies[1]. When the European Union raises concerns about the different forms of excessive and ad hoc corporate income redistribution practices, the Hungarian authorities' answer is always the same: these are temporary measures, aimed to reduce the budget deficit, and will be phased out in a timely manner.

Is it really true that measures that result in substantial corporate income redistribution, similar to the ones the Hungarian government recently introduced, have no long-term effects on the economy as long as one phases them out after a while? Or, are there durable, long-term effects of excessive corporate income redistribution, from which the markets cannot bounce back easily, that may inhibit the markets' ability to function in an efficient manner for a long period of time even after the excesses have been eliminated? In the following paper I am going to discuss one of the several economic problems excessive redistribution of corporate income generates: I am going to investigate how redistributing corporate income may affect industry structure of the in the long run and investigate the impact of certain income policy reforms that may be designed to correct the negative effects of massive income redistribution.

[1] An excellent summary and analysis of some recent economic and political developments in Hungary can be found in Kornai (2015).

The model I use in the analysis is an evolutionary game[2] with four players representing four different types of enterprises. I define four policy variables that determine the nature of income distribution among the four enterprise types. Different values of the policy variables represent different corporate income redistribution alternatives. Using this framework I analyze how certain policies impact the dynamic and equilibrium properties of the game given certain initial conditions.

Based upon the dynamic properties of the game under different policy regimes the paper's most important conclusions are as follows:

- Even a significant tax reform and a reduction of subsidies may not necessarily phase out non-viable, inefficient enterprises that emerged during the period with excessive and corrupt income redistribution. In fact, under some conditions excessive income redistribution may result in the long term disappearance of viable, market-oriented firms;
- After a distorted industry structure developed seemingly adequate income policies aiming to correct these excesses could lead to an industry structure that is, considering economic efficiency, far worse than the original distorted industry structure;
- Changing the distribution of income among enterprises alone cannot put the economy onto an irreversible path that leads to the necessary restructuring. However, it can generate a reform friendly environment, in which some institutional reforms could be introduced successfully;
- Under some circumstances even drastic income policy reforms will not result in quick structural change. Structural change in the right direction may come slowly, much later than the reforms conclude.

2 The game

2.1 The Players

In the following game there are be four different players that represent four different types of firms. One characteristic by which enterprises are grouped is their viability: I distinguish between viable and non-viable firms[3]. The second characteristic is the amount of relational capital firms accumulated[4]. Considering relational capital there are two different types of enterprises: the ones with, and the ones without significant relational capital. Relational capital is created by investments in the firm's relations with politicians, bureaucrats, government organizations, business partners, creditors, buyers, etc.

One can define, as Table 1 shows, four enterprise types by applying the criteria described above. Throughout this paper I assume that only these four enterprise types exist and the initial population proportions of these firms are strictly positive, i.e. at the beginning of the game all players are present.

Table 1. The definition of the four enterprise types

	Firm with significant relational capital (R)	Firm without significant relational capital (NR)
Viable firm (V)	**VR**	**VNR**
Non-viable firm (NV)	**NVR**	**NVNR**

2.2 The Payoffs

Consider the parametric payoff table in Table 2. Assume that payoffs represent normalized profits when two firms trade. For example, according to Table 2, after a typical transaction between a VNR and a VR enterprise the VNR firm's payoff will be $4c/a$. The four parameters, a, b, c, and d are the policy variables that calibrate relative profits and therefore regulate the allocation of income among firms. Parameters a and

[2] The idea that structural change in a transitional economy can be described as an evolutionary game originates from Gaddy and Ickes (2000).

[3] A viable firm produces positive value added while a non-viable firm produces negative value added.

[4] See Gaddy and Ickes (2000), Gaddy and Ickes (1998)

b can be treated as taxes/subsidies levied on transactions involving viable enterprises. There will be a benchmark case where all parameters equal one. If *a, b* > 1, then, compared with the benchmark case, transactions involving VR or VNR firms are taxed, and the proceeds are forwarded to the NVR enterprises. One can rationalize this by assuming that NVR firms use their relational capital to extract subsidies – directly or indirectly - from their competitors. If, on the other hand *a, b* < 1, the opposite happens. Transactions involving NVR firms are taxed and the competitors of NVR enterprises are given these payments as subsidies. Parameter *c* regulates the profitability of transactions within the value producing sector, and parameter *d* regulates the profitability of transactions within the value destroying sector. If both parameters are high, then inter-sector trade is relatively unprofitable; if both parameters are low, then inter-sector trade is more profitable than intra-sector trade.

Table 2. Normalized profits from trade

	VR	VNR	NVR	NVNR
VR	**5*c/a***	**6*c/b***	**3/*a***	**4**
VNR	**4*c/a***	**5*c/b***	**2/*b***	**3**
NVR	***a***	***b***	**3*d***	**4*d***
NVNR	**0**	**1/*b***	**2*d***	**3*d***

2.3 Dominance in the Stage Game

Throughout the paper I assume that 0 < *a, b, c, d* ≤ 3.01. This assumption, on the one hand keeps numbers relatively simple, on the other hand allows the representation of sufficiently large differences in relative profits, and therefore it does not restrict the analysis to special cases. Also, since dominance relationships in the stage game determine the equilibrium properties of the dynamic game, the exact values of the payoffs are not important as long as all relevant dominance possibilities can be represented with a given parameterization. In fact, this parameterization allows the investigation of *all* important cases, which is not to say that in the above stage game all strategies can become dominant. Given the above restrictions on parameters, certain dominance relationships are not possible, for example VNR or NVNR can never become a dominant strategy. It is possible however that for some parameter values these strategies are not dominated by any other strategy.

A special case is when *a* = *b* = *c* = *d* = 1. This benchmark case will serve as a reference point reflecting a "common sense" ranking of profitability of transactions among different enterprises. In this case VR strictly dominates VNR and NVNR, and weakly dominates NVR, while NVNR is dominated by all other strategies.

Let us take a closer look at the dominance relationships among strategies for different parameter values. I used eight inequalities (see in Appendix 1) to summarize how the values of the four parameters affect dominance in the stage game. Table 3 presents the results. Considering dominance 11 cases can occur. Each case can be defined by a unique set of rationalizable strategies. The second column of the table lists these rationalizable, strictly undominated strategies. Within each case I defined different scenarios. A scenario is given by a true/false combination of the eight conditions defined in Appendix 1. Columns 3 – 8 in Table 3 show a summary of the scenarios. "T" (True) means that a given condition holds; "F" (False) means that it does not hold; "TF" in the "Conditions" columns indicates that an inequality may or may not hold for certain strategies to be undominated. Given the parametric payoff matrix defined by Table 2 and the eight conditions in Appendix 1, there are 107 scenarios[5] that produce the 11 cases.

Because of iterative dominance, further simplifications are possible. In case 3, after the removal of the dominated NVR and NVNR strategies, VR becomes strictly dominant, while in case 6 NVR becomes iteratively dominant. In case 8, after the removal of NVR, VNR becomes iteratively dominated, therefore this case is identical to case 5. In case 9, once VNR is strictly dominated, NVNR becomes dominated by NVR, so this case becomes identical to case 4. It can also be shown (omitted here), that in 77 out of 107 scenarios, because of direct or iterative dominance, either one strategy dominates the other three, or the

[5] In theory one can produce $2^8 = 256$ scenarios based on the eight conditions. In fact, because of the restrictions on the parameter values and that some conditions cannot be true or false at the same time, only 107 scenarios can occur.

stage game can be reduced to a 2 X 2 game, or it can be reduced to a 3 X 3 Rock-Scissors-Paper (RSP) game[6].

Table 3. The definitions of the eleven cases and a summary of the 107 scenarios

Case	Rationalizable strategies	Conditions[7]								Number of scenarios
		1	2	3	4	5	6	7	8	
1	VR	T	T	T	TF	T	F	F	TF	4
2	NVR	F	F	TF	T	TF	T	T	T	4
3	VR-VNR	T	T	T	TF	F	TF	F	F	4
4	VR-NVR	TF	TF	TF	T	TF	TF	TF	TF	28
5	VR-NVNR	T	T	F	F	T	F	F	F	1
6	NVR-NVNR	F	F	F	F	TF	T	T	T	2
7	VR-VNR-NVR	TF	TF	TF	TF	F	TF	TF	TF	22
8	VR-VNR-NVNR	T	T	F	F	F	F	F	F	1
9	VR-NVR-NVNR	TF	TF	TF	F	TF	TF	TF	TF	23
10	VNR-NVR-NVNR	F	F	F	F	F	T	T	F	1
11	All	TF	TF	TF	F	F	TF	TF	TF	17
	Sum									107

2.4 The evolutionary game

Consider an evolutionary game with the above players, parametric payoff matrix, and with continuous, non-overlapping replicator dynamics as a selection mechanism. The mathematical representation of this game is a four dimensional system of first order, ordinary, non-linear differential equations. The definition of the replicator dynamics I use and the model can be found in Appendix 2.

3 Solutions and the Dynamic Stability of the Game

Solutions of an evolutionary game with continuous, non-overlapping replicator dynamics exist and are unique (the Existence and Uniqueness Theorem[8] applies). I used theorems on the dynamic stability of evolutionary games[9] along with numerical methods (fourth order Runge-Kutta method) for the approximation of solutions in order to derive the dynamic properties of the game for different parameter values[10].

3.1 Theoretically Predictable Cases

The replicator dynamics eliminates all strictly dominated or iteratively strictly dominated strategies[11]. This implies that in cases 1 and 3 the VR vertex of the strategy simplex is a universal attractor, while in cases 2

[6] See Weissing (1991).
[7] See the conditions (inequalities) in Appendix 1, and a detailed list of the scenarios in Exhibit 1 at https://sites.google.com/site/pbodo11/home/income-redistribution.
[8] See Weibull (1995).
[9] See Weibull (1995) and Samuelson (1997).
[10] I could not find closed form solutions for this game.
[11] See Weibull (1995), Theorem 3.1 on page 82.

and 6 the NVR vertex is a universal attractor. In case 5, if $d < 0.75$, the VR vertex becomes the universal attractor.

The dynamic properties of the game are also predictable if, through iterative dominance, the stage game can be reduced to a 2 X 2 game. In the following I will use the classification of symmetric 2 X 2 games presented by Weibull[12] for finding the equilibria in these cases. In case 5, when $d > 0.75$, the game becomes a category II. game with two basins of attractions with VR - NVR attractors. In the scenarios of case 4 both conditions 1 and 7 should be either T or both F. In scenarios where conditions 1 and 7 are both True, the game becomes a category II game with two basins of attraction and two attractors on the VR and NVR vertices. When conditions 1 and 7 are both False, the game becomes a category III. game with one universal attractor[13] on the VR – NVR edge of the strategy simplex. Case 7 is more complex. There are 22 scenarios that can produce this case. In seven of the 22 scenarios, the game can be reduced to a 2 X 2 game. In three scenarios it can be reduced to a RSP game. In these ten scenarios the stability properties of the game can be predicted. Considering the possible types of the equilibria scenarios can produce, case 8 is identical to case 5, and case 9 is the same as case 4.

In sum, in eight of 11 cases one can unambiguously predict the equilibrium properties of the game. In an additional case (case 7) some scenarios' equilibrium implications are predictable. This leaves two and a "half" cases unexplained. The next section outlines how I approximated equilibria in these cases.

3.2 Theoretically Unpredictable Cases

In the remaining cases I used computer simulations to get some insights about the dynamic stability of the game. For each scenario in cases 10, 11, and for the 12 scenarios in case 7 I generated 50 random parameter combinations with random initial conditions. Then I used the Runge-Kutta method and derived the numerical approximations of the solutions for each parameter-initial condition vector[14]. In 12 scenarios (out of 30) solution patterns and the corresponding equilibria were inconclusive, while simulation in 18 scenarios produced unambiguous patterns. However, simulations in the 12 inconclusive cases allowed at least some weak statements about the most frequent types of equilibria in these cases[15].

3.3 Visual Summary of the Dynamic Properties of the Game for the Relevant Parameter Values

I created a graph that summarizes and visualizes the effects of 47,089 parameter combinations on the equilibrium properties of the system[16]. The graph helps in finding those parameter regions that produce similar equilibria. Also, it reveals certain patterns, and highlights those parameter regions that need further investigation (scenarios in which simulations produced inconclusive results). The following analysis of the implications of the different corporate income policies on industry structure will be based on this graph.

4 Corporate Income Policies and Some of their Long Term Implications

4.1 The Benchmark Case

When all parameters are equal to one the VR vertex becomes a global attractor[17]. For some very small changes in the values of the parameters equilibrium may change. For example, when all parameters equal to 1.01 the game will produce equilibrium with two basins of attraction and the VR and NVR vertices will be the attractors. A closer look at the equilibria in these cases reveals, that except for a few, extreme initial

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[12] See Weibull (1995), page 74.

[13] $Pvr = (4d - 4)/(4d - 4 + 5c/a - a)$; $Pnvr = 1 - Pcr$; $Pvnr = Pnvnr = 0$.

[14] I used the computer software Mathematica in generating the solutions. In some cases when Mathematica could not find the solutions, I applied Matlab.

[15] Exhibit 1 at https://sites.google.com/site/pbodo11/home/income-redistribution summarizes the equilibrium properties of the game for all the 107 scenarios, and also indicates whether or not the equilibrium properties produced by the scenario in question is based on theorems or simulations, and whether or not the simulation results were inconclusive.

[16] See Exhibit 2 at https://sites.google.com/site/pbodo11/home/income-redistribution.

[17] See Exhibit 3 at https://sites.google.com/site/pbodo11/home/income-redistribution.

conditions, where the initial shares of the VR and VNR types are very low (close to 1 percent), and at the same time the NVR type firms' initial share is high (above 70 percent), there exists only one attractor, the VR vertex.

If one reduces *a* or *a* and *b* or *c* and *d* or all the parameters, the VR vertex remains the universal attractor. If one slightly increases *a*, or *b*, or *a* and *b*, or *c* and *d*, or all the parameters, the basin of attraction with the NVR vertex as attractor grows but not significantly[18]. These latter cases require, among other conditions, that the initial share of VR enterprises not exceed 1 percent, which makes the NVR dominance very unlikely in a neighborhood of the benchmark case. Therefore, even in a not-so-small neighborhood of the benchmark state the equilibrium properties of the game look identical. If the benchmark case characterizes dominance relationships considering profitability among firms well, then without changing income distribution the economy approaches a system in which viable enterprises with significant relational capital acquire most of the productive assets and run the economy. There is, however, a small chance that instead of VR the NVR type will become dominant.

What are the most important economic characteristics of this outcome? In the long run in the neighborhood of the benchmark case the economy is dominated by large, well connected firms. As the standard theory of industrial organization points out, firms' conduct is largely affected by the market structure, and high overall market concentration is not conducive to an efficient, flexible and fast growing market economy.

4.2 The Effects of Taxing or Subsidizing Viable Enterprises on Industry Structure

Assume that $b = 1.01$. A subsidy to VR transactions ($a < 1$), regardless of its size makes the VR vertex the universal attractor[19]. However, if transactions involving VR enterprises are taxed, the equilibrium properties of the game will change. As *a* increases the basin of attraction with the NVR vertex as attractor grows steadily. For $1 < a < 2.31$, if the initial proportion of the NVR firms, $X0^{NVR}$, is low, then $X0^{VNR}$ has to be low as well for NVR to become an attractor. While relatively low taxes seem to be inefficient regarding their impact on the equilibrium, high taxes on VR enterprises do make a difference considering the equilibrium properties of the game. Moreover, equilibrium patterns suddenly change when *a* exceeds 2.31. For $a > 2.31$, NVR becomes a global attractor.

It is interesting that, *ceteris paribus*, subsidies given to and taxes taken from VNR enterprises are inefficient. Consider first the effect of a significant subsidy on VNR transactions. This subsidy will actually strengthen the position of the VR enterprises, because it weakens their main antagonist's, the NVR firms' positions. If VR firms are strong, a subsidy that supports the VNR transactions at the expense of the NVR firms in order to strengthen the market sector will eventually help to bring down the NVR *and* the VNR firms, make the VR vertex a universal attractor and the VR takeover faster. Similarly, a significant tax on transactions involving VNR firms will not help significantly NVR firms, even if the proceeds of the tax are given to them. Again, the relative weakness of the VNR enterprises helps mostly the VR firms to consolidate their grip on the economy. Doubling the value of *b* (from 1.01 to 2.01) will result only minor changes in the dynamic properties of the system (compared with the benchmark case). Thus VR remains practically a global attractor[20].

What happens if one changes the values of parameters *a* and *b* simultaneously? If *a* is reduced, no matter how *b* changes, the dynamic properties of the game will not change – the VR vertex remains the global attractor. If one increases the value of parameters *a* and *b* at the same time there will be category II. equilibria with growing NVR basin of attraction. If one goes beyond $a = 2.31$, the NVR vertex becomes a global attractor. These changes are very similar to the patterns already discussed.

There is a way, however, to drastically change the dynamic properties of the game. This would involve combining significant taxes on transactions with VR enterprises with significant subsidies to transactions involving VNR firms. Again 2.31 is a critical value that *a* has to exceed[21]. Below that, no matter how low *b* is, in the long run VR enterprises take over. The situation will change if $a > 2.31$. If at the same time $b < 0.61$, the game eventually becomes an RSP game with VR, VNR, and NVR strategies. For some *b* values (given that $b < 0.61$ and $a > 2.31$) the game has a global repellor, for some other *b*'s the game has a global

[18] See Exhibit 3 at https://sites.google.com/site/pbodo11/home/income-redistribution.

[19] See Exhibit 4 at https://sites.google.com/site/pbodo11/home/income-redistribution.

[20] See Exhibit 4 at https://sites.google.com/site/pbodo11/home/income-redistribution.

[21] See Exhibit 2 at https://sites.google.com/site/pbodo11/home/income-redistribution.

attractor, and in both cases these points' X^{VR}, X^{VNR}, and X^{NVR} coordinates are greater than zero[22]. What this means is, that with high taxes on VR transactions and high subsidies to VNR transactions one can produce an economy, which is dynamically stable, and where three of the original players coexist while one, the NVNR type disappears in equilibrium. Also, it can be seen, that with some other selective tax/subsidy combinations one can generate an economy that periodically moves from one state in which one enterprise type dominates to another state in which another enterprise type dominates (RSP game with a global repellor). The sequence of these states is as follows: first VR dominates the economy, then NVR takes over, then VNR takes over, the VR takes over again, etc.[23]

What are the most important consequences when in an economy the proportion of VR, VNR, and NVR firms are stable? To maintain this state of the world, one has to imagine a constantly active, vigilant government that reallocates income from the competitive sector to the non-competitive sector, and at the same time reallocates income from VR to subsidize VNR firms. It is questionable how such government policies can be maintained in the long run when it is in the well-connected players', the VR and NVR firms' interest to get rid of the third player, the VNR types. When well-connected players' have opposing interests the government's neutrality may be maintained; however, when their interests coincide, this seems impossible.

The possibility that with well chosen *a* and *b* values one can generate an RSP game with a universal repellor creates a chance for making permanent structural; changes with the help of income redistribution. After determining the right values of *a* and *b*, one has to wait, until the VNR firms dominate the population. VNR dominance means that the population share of the other types is close to zero. This implies that their market and political power are also close to zero. While this is only a temporary state of the world one could use this period to change the rules of the game without the resistance of enterprises with a vested interest in maintaining a corrupt status quo, which implies that during this period institutional reforms, like financial and bank reforms, and a reform of the legal system have a chance to succeed. These institutional changes could redefine the rules of the game, anchor the essential market institutions once and for all, and put the economy on a different trajectory leading to a dynamic, faster growing economy.

4.3 The Effects of Selectively Taxing/Subsidizing Viable Industries

Assume that transactions involving viable firms are heavily taxed. Imagine an export tax, or some selective taxes in viable industries that were introduced in Hungary recently. Suppose that these taxes considerably reduce the profitability of value producing firms; let $c = 0.01$. If the other parameter values are 1.01, such a tax will make the NVR vertex a global attractor, indicating the expected implications of this move[24]. A simultaneous increase in both *a* and *b*, given $c = 0.01$, or a small decrease in *b* alone will not change the type of the equilibrium. However, if the tax on value producing enterprises is coupled by other changes in the income distribution among firms, the dynamic properties of the game will change significantly.

Suppose next that high taxes on transactions involving viable firms in general are coupled with a populist anti-corruption campaign and a strong support of smaller, efficient, competitive enterprises (the VNR types). This direction of economic policy can be characterized by low *c* and low *b* values. If $b \leq 0.61$, the type of the equilibrium will quickly change[25]. Unfortunately these parameter values result in scenarios in which simulations produced inconclusive results. For this reason I ran additional simulations[26] with narrower parameter ranges that included the parameter values in question. The results of these simulations were conclusive and produced the following results. When $0.41 < b \leq 0.61$, a point on the VNR – NVR edge becomes a global attractor; when $0.01 < b \leq 0.41$, a point on the VNR – NVR – NVNR face of the strategy simplex becomes a global attractor, while within a very small neighborhood of the point $b = 0.01$, the NVNR vertex practically becomes a global attractor.

What are the economic implications of these outcomes? When c is low profits of viable firms are low in general. However, when $b < 1$, VNR firms, and firms dealing with VNR firms, receive a subsidy at the expense of value destroying firms with significant relational capital. Until a certain point this alone will not make a difference, because the low *c* parameter's devastating effect outweighs the beneficial effect of

[22] See Exhibit 4 (i) at https://sites.google.com/site/pbodo11/home/income-redistribution.
[23] See Exhibit 4 (iv) at https://sites.google.com/site/pbodo11/home/income-redistribution.
[24] See Exhibit 5 (i) at https://sites.google.com/site/pbodo11/home/income-redistribution.
[25] See Exhibit 5 (i) and (ii) at https://sites.google.com/site/pbodo11/home/income-redistribution.
[26] 50 simulations of different parameter combinations with 50 with random initial conditions each.

subsidies; with or without a subsidy, when $b \geq 0.71$ and $c = 0.01$, *ceteris paribus*, NVR enterprises dominate the economy in the long run. The situation will quickly change if the value of b gets less than or equal to 0.61: the VNR strategy appears in equilibrium and coexists with the NVR strategy[27]. As b decreases, the population share of NVR goes down while VNR's share grows for a while. Then, as b continues to decrease, suddenly NVNR appears in equilibrium. If b decreases even further, both VNR's and NVR's equilibrium proportions will decrease, while NVNR's equilibrium proportion increases. When b is very low NVNR wipes out the other strategies and dominates the population in equilibrium.

An intuitive explanation of the possibility of NVNR dominance is as follows. A very low c hurts VR firms and reduces their proportion fast. When b is very low this hurts NVR firms and reduces their population proportion fast. VNR firms can make a "kill" if they trade with NVR enterprises, but NVR's proportion quickly becomes low therefore profit from these transactions is limited. On the other hand, NVNR's low profit from transactions with VR and NVR firms is less damaging because of these strategies' low population shares. If c is low and b is low, NVNR will receive a relatively high payoff while trading with VNR. At the same time VNR's profit against NVNR enterprises is relatively low, and NVNR firms' profit against their own types is relatively high. At the end all this will lead to a state of the world in which value destroying firms without relational capital proliferate and all other types disappear. This, as a result of policies, that, in order to implement the market system, aimed to support the most competitive, market oriented group of entrepreneurs at the expense of oligarchs in the other sectors.

In sum, these results show that substantial corporate income redistribution in the "right direction" can do more harm than doing nothing. Doing nothing will most likely result in a VR and less likely in a NVR hegemony and slowly improving economic inefficiency. Large, vertically integrated firms will eventually restructure, which could facilitate some economic growth. NVNR dominance in equilibrium, on the other hand, will conserve inefficiency both in the short and long run, and eliminate even the possibility of a future change in the path of the transition by wiping out the market oriented enterprises.

5 Summary

This paper presented an evolutionary game for the analysis of the structural impacts of excessive corporate income redistribution. Upon deriving the dynamic properties of the game for the relevant parameter values the paper analyzed the effects of different income policy regimes on the equilibrium. The paper argued that the reference scenario implies that large, value producing, well connected enterprises dominate the economy in the long run. Policy makers may try selectively taxing viable firms in order to finance restructuring and simultaneously supporting small viable enterprises to enhance competition but this policy could actually backfire: it can wipe out the value producing enterprises. In this case market concentration in equilibrium is not high, but long run equilibrium with small, non-viable, value destroying enterprises is the worst possible outcome that excessive corporate income redistribution can lead to. On a happier note, the paper showed that under some conditions using taxes and subsidies it is possible to generate an environment, at least temporarily, in which the influence of well-connected players with vested interest in maintaining the status quo is weak, and they cannot resist effectively much needed institution building attempts.

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[27] See Exhibit 5 (iii) at https://sites.google.com/site/pbodo11/home/income-redistribution.

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Appendix 1

Eight Conditions that Define 107 Scenarios

(1) $c > \frac{a^2}{5}$	(2) $c > \frac{b^2}{3}$	(3) $c > \frac{1}{6}$	(4) $b > \sqrt{0.5}$
(5) $b > \frac{2a}{3}$	(6) $b > \frac{1}{a}$	(7) $d > 1$	(8) $d > \frac{2}{3b}$

Appendix 2

The Replicator Dynamics

$\frac{dx_i}{dt} = x_i(\pi(i,x) - \bar{\pi}(x))$, where

x_i = the proportion of players playing the *i*th strategy; x = the vector of proportions playing the various strategies; $\pi(i,x)$ = expected payoff of strategy i given x; $\bar{\pi}(x)$ = expected payoff in the population given x.

The Model

$$\frac{dx_1}{dt} = x_1(\frac{5c}{a}x_1 + \frac{6c}{b}x_2 + \frac{3}{a}x_3 + 4x_4 - \bar{\pi}), \quad \frac{dx_2}{dt} = x_2(\frac{4c}{a}x_1 + \frac{5c}{b}x_2 + \frac{2}{b}x_3 + 3x_4 - \bar{\pi}),$$

$$\frac{dx_3}{dt} = x_3(ax_1 + bx_2 + 3x_3 + 4x_4 - \bar{\pi}), \qquad \frac{dx_4}{dt} = x_4(\frac{1}{b}x_2 + 2x_3 + 3x_4 - \bar{\pi}),$$

where

$$\bar{\pi} = x_1(\frac{5c}{a}x_1 + \frac{6c}{b}x_2 + \frac{3}{a}x_3 + 4x_4) + x_2(\frac{4c}{a}x_1 + \frac{5c}{b}x_2 + \frac{2}{b}x_3 + 3x_4) +$$
$$x_3(ax_1 + bx_2 + 3x_3 + 4x_4) + x_4(\frac{1}{b}x_2 + 2x_3 + 3x_4).$$

Exhibits posted at https://sites.google.com/site/pbodo11/home/income-redistribution

Exhibit 1 List of the 11 cases, 107 scenarios, and the corresponding equilibria

Case	Scen #	Conditions								Equilib.		Eq. Type	Eq.sign	Overlap/ **Inconcl?**
		1	2	3	4	5	6	7	8	pred	unpred			
1	1	T	T	T	F	T	F	F	F	X		A		
	2	T	T	T	F	T	F	F	T	X		A		
	3	T	T	T	T	T	F	F	F	X		A		
	4	T	T	T	T	T	F	F	T	X		A		
2	5	F	F	F	T	F	T	T	T	X		B		
	6	F	F	F	T	T	T	T	T	X		B		
	7	F	F	T	T	F	T	T	T	X		B		
	8	F	F	T	T	T	T	T	T	X		B		
3	9	T	T	T	F	F	F	F	F	X		A		
	10	T	T	T	F	F	T	F	F	X		A		Y - w C7
	11	T	T	T	T	F	F	F	F	X		A		
	12	T	T	T	T	F	T	F	F	X		A		Y - w C7
4	13	F	F	F	T	F	T	F	T	X		B		Y - w C7
	14	F	F	F	T	T	F	F	F	X		C		
	15	F	F	F	T	T	F	F	T	X		C		
	16	F	F	F	T	T	F	T	T	X		C		
	17	F	F	F	T	T	T	F	T	X		B		
	18	F	F	T	T	F	T	F	T	X		B		Y - w C7
	19	F	F	T	T	T	F	F	F	X		C		
	20	F	F	T	T	T	F	F	T	X		C		
	21	F	F	T	T	T	F	T	T	X		C		
	22	F	F	T	T	T	T	F	T	X		B		
	23	F	T	T	T	F	T	F	T	X		B		Y - w C7
	24	F	T	T	T	F	T	T	T	X		B		Y - w C7
	25	F	T	T	T	T	F	F	F	X		C		
	26	F	T	T	T	T	F	F	T	X		C		
	27	F	T	T	T	T	T	F	T	X		B		
	28	F	T	T	T	T	T	T	T	X		B		
	29	T	F	F	T	T	F	F	F	X		A		
	30	T	F	F	T	T	F	F	T	X		A		
	31	T	F	F	T	T	F	T	T	X		A		
	32	T	F	F	T	T	T	T	T	X		D		
	33	T	F	T	T	T	F	F	F	X		A		
	34	T	F	T	T	T	F	F	T	X		A		
	35	T	F	T	T	T	F	T	T	X		A		
	36	T	F	T	T	T	T	F	T	X		D		
	37	T	F	T	T	T	T	T	T	X		D		
	38	T	T	T	T	T	F	T	T	X		A		
	39	T	T	T	T	T	T	F	T	X		D		
	40	T	T	T	T	T	T	T	T	X		D		
5	41	T	T	F	F	T	F	F	F	X		A		

6	42	F	F	F	F	F	T	T	T	X		B	
	43	F	F	F	F	T	T	T	T	X		B	
7	44	F	F	F	T	F	F	F	F		X	E	**Yes**
	45	F	F	F	T	F	T	F	F	X		E	
	46	F	F	F	T	F	T	F	T	X		B	Y - w C4
	47	F	F	T	T	F	F	F	F		X	E	**Yes**
	48	F	F	T	T	F	T	F	F	X		E	
	49	F	F	T	T	F	T	F	T	X		B	Y - w C4
	50	F	T	T	F	F	F	F	F		X	F	**Yes**
	51	F	T	T	F	F	T	F	F	X		J	
												G	
	52	F	T	T	F	F	T	F	T		X	B	
	53	F	T	T	F	F	T	T	F	X		J	
												G	
	54	F	T	T	T	F	F	F	F		X	F	**Yes**
	55	F	T	T	T	F	T	F	F	X		J	
												G	
	56	F	T	T	T	F	T	F	T		X	B	Y - w C4
	57	F	T	T	T	F	T	T	T		X	B	Y - w C4
	58	T	T	T	F	F	F	T	F	X		A	Y - w C11
	59	T	T	T	F	F	T	F	F	X		A	Y - w C3
	60	T	T	T	F	F	T	F	T		X	A	
	61	T	T	T	F	F	T	T	F		X	A	Y - w C11
	62	T	T	T	F	F	T	T	T		X	D	Y - w C11
	63	T	T	T	T	F	T	F	F	X		A	Y - w C3
	64	T	T	T	T	F	T	F	T		X	D	
	65	T	T	T	T	F	T	T	T		X	D	
8	66	T	T	F	F	F	F	F	F	X		A	
9	67	F	F	F	F	F	T	F	T	X		B	
	68	F	F	F	F	T	F	F	F	X		C	
	69	F	F	F	F	T	F	T	F	X		C	
	70	F	F	F	F	T	F	T	T	X		C	
	71	F	T	F	F	F	T	F	T	X		B	
	72	F	T	F	F	F	T	T	T	X		B	Y - w C11
	73	F	T	F	F	T	F	F	F	X		C	
	74	F	T	F	F	T	F	T	F	X		C	
	75	F	T	F	F	T	T	T	T	X		B	
	76	F	T	T	F	F	T	T	T	X		B	Y - w C11
	77	F	T	T	F	T	T	T	T	X		B	
	78	T	F	F	F	T	F	F	F	X		A	
	79	T	F	F	F	T	F	F	T	X		A	
	80	T	F	F	F	T	F	T	F	X		A	
	81	T	F	F	F	T	F	T	T	X		A	
	82	T	F	F	F	T	T	T	T	X		D	
	83	T	T	F	F	T	F	T	F	X		A	
	84	T	T	F	F	T	F	T	T	X		A	

	85	T	T	F	F	T	T	T	T	X		D	
	86	T	T	T	F	T	F	T	F	X		A	
	87	T	T	T	F	T	F	T	T	X		A	
	88	T	T	T	F	T	T	F	T	X		D	
	89	T	T	T	F	T	T	T	T	X		D	
10	90	F	F	F	F	F	T	T	F		X	H	**Yes**
11	91	F	F	F	F	F	F	F	F		X	I	**Yes**
	92	F	F	F	F	F	F	T	F		X	H	**Yes**
	93	F	F	F	F	F	T	F	F		X	I	**Yes**
	94	F	T	F	F	F	F	F	F		X	I	**Yes**
	95	F	T	F	F	F	F	T	F		X	H	**Yes**
	96	F	T	F	F	F	T	F	F		X	I	**Yes**
	97	F	T	F	F	F	T	T	F		X	K	**Like RSP**
	98	F	T	F	F	F	T	T	T		X	B	Y - w C9
	99	F	T	T	F	F	T	F	F		X	J	
	100	F	T	T	F	F	T	T	F		X	J	
	101	F	T	T	F	F	T	T	T		X	B	Y - w C9
	102	T	T	F	F	F	F	T	F		X	A	**Yes**
	103	T	T	F	F	F	T	T	F		X	A	
	104	T	T	F	F	F	T	T	T		X	D	
	105	T	T	T	F	F	F	T	F		X	A	Y - w C7
	106	T	T	T	F	F	T	T	F		X	A	Y - w C7
	107	T	T	T	F	F	T	T	T		X	D	Y - w C7

Notations: the types of equilibria

A VR takes over or VR-NVR cat. IV*.

B NVR takes over or VR-NVR cat. I.

C VR-NVR cat III.

D VR-NVR cat II.

E VNR-NVR cat III.

F VR-VNR-NVR int. eq

G RSP with a VR-VNR-NVR int. point as global repellor

H NVR-VNR-NVNR int. eq

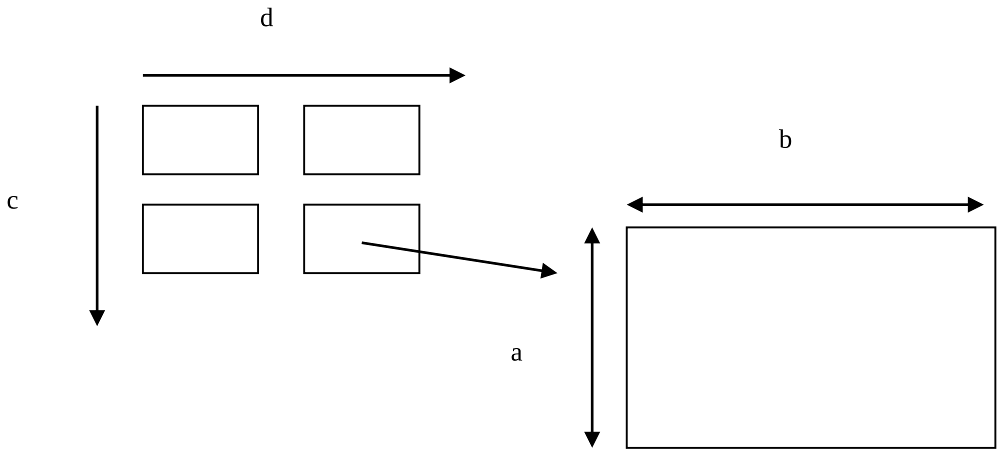
I All-In int. eq.

J RSP with a VR-VNR-NVR int. point as global attractor

K NVR-VNR-NVNR int. point as global attractor or global repellor (

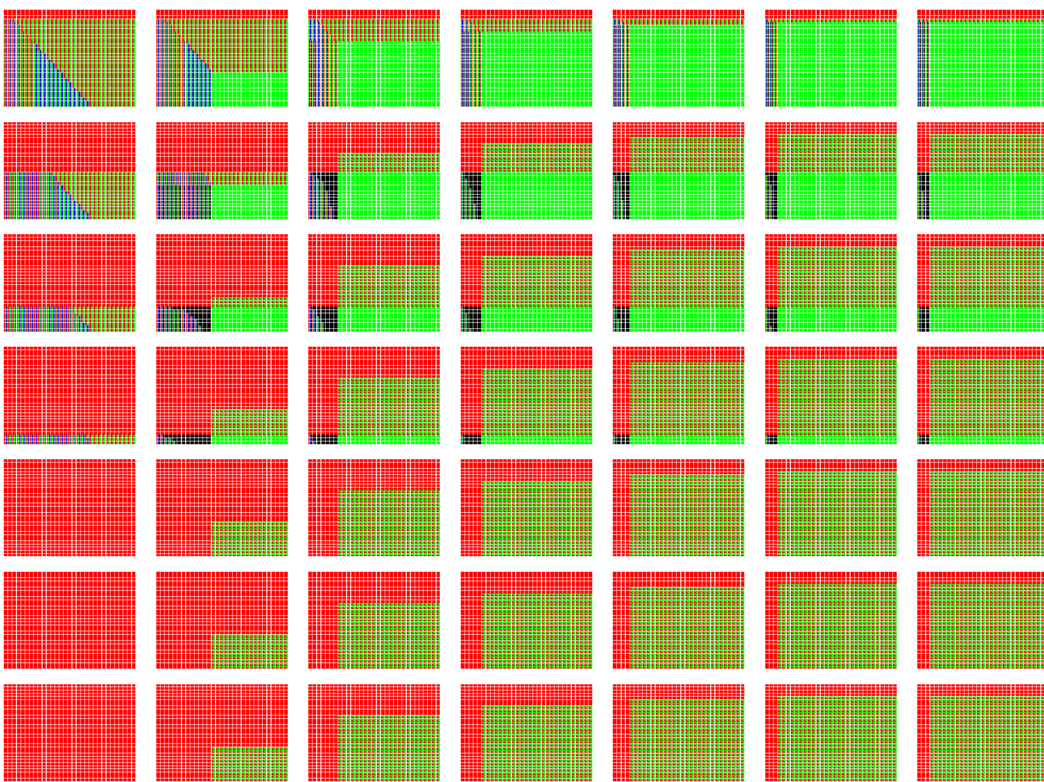
Exhibit 2

The structure of the graph depicting the equilibria for different parameter values



Equilibria for the relevant parameter values

$$a, b = 0.01, 0.11, 0.21, \ldots, 3.01$$
$$c, d = 0.01, 0.51, 1.01, \ldots, 3.01$$



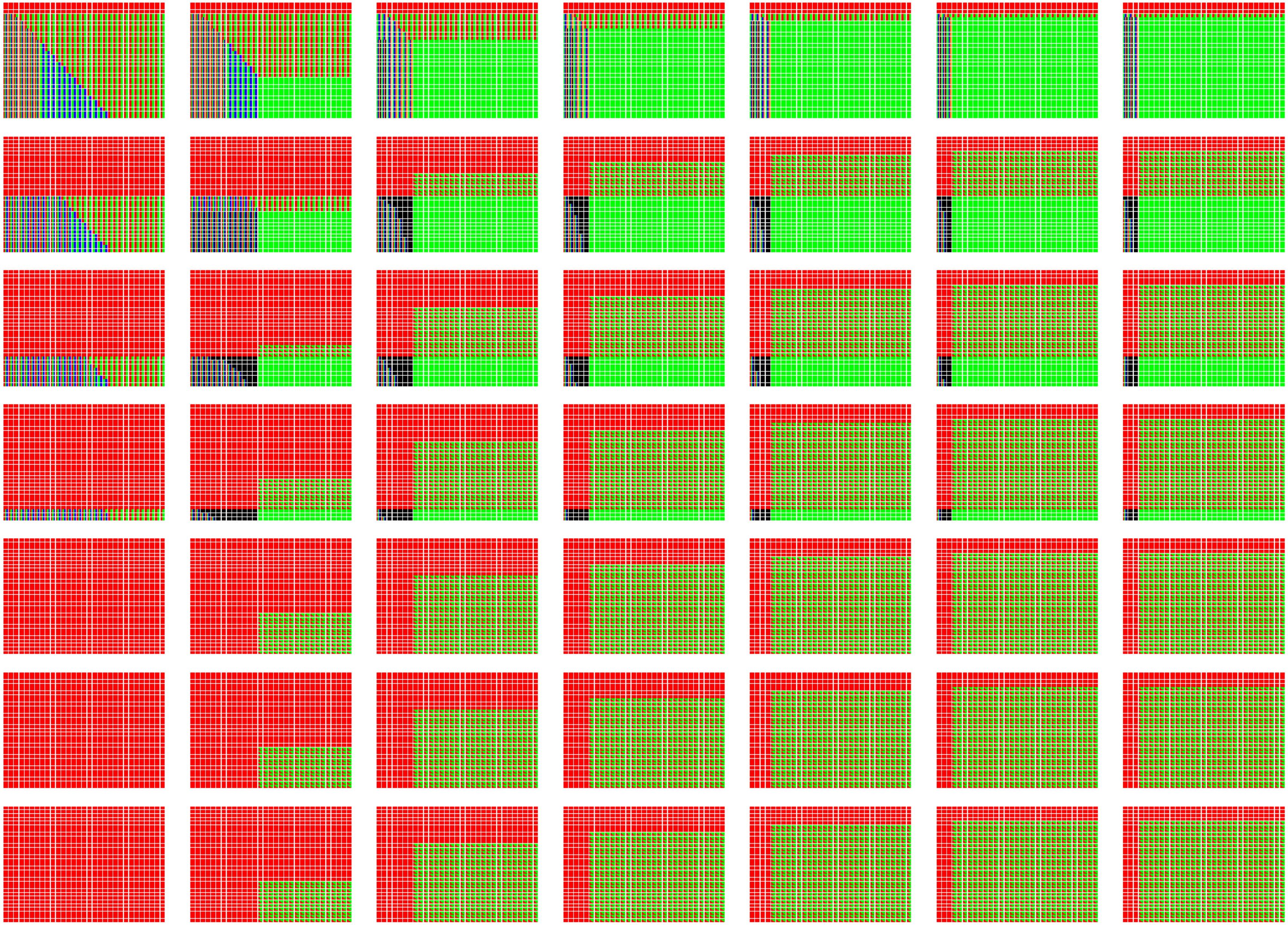
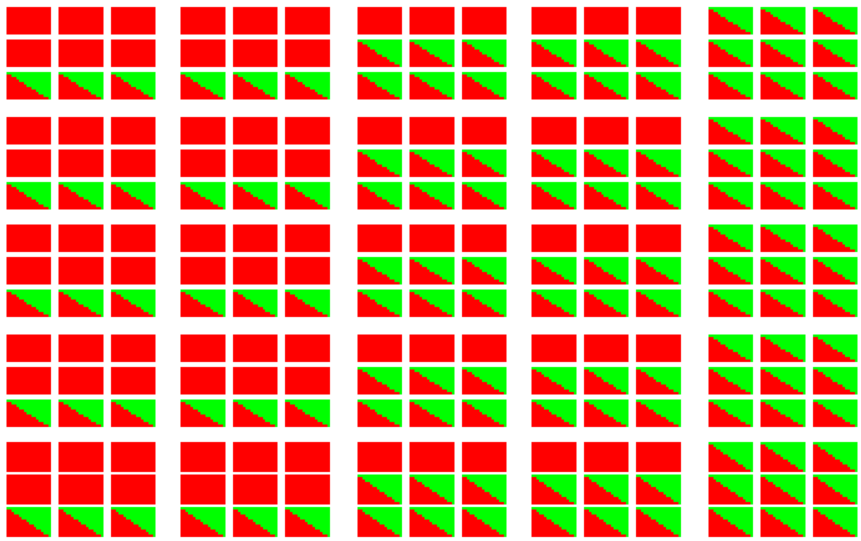


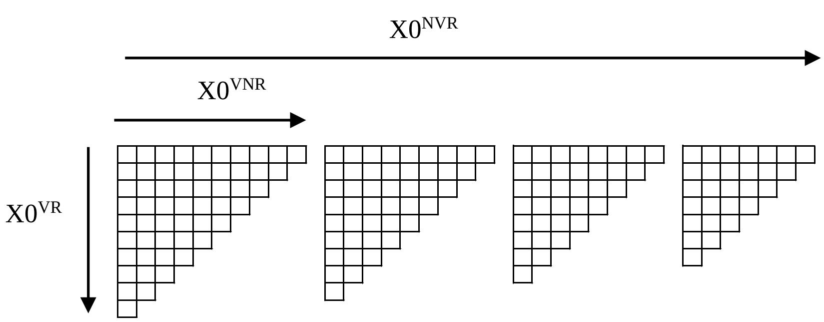
Exhibit 3

(i) The neighborhood of the benchmark case

***a*, *b* = 0.91, 1.01, 1.11;**
***c*, *d* = 0.91, 0.96, 1.01, 1.06, 1.11.**

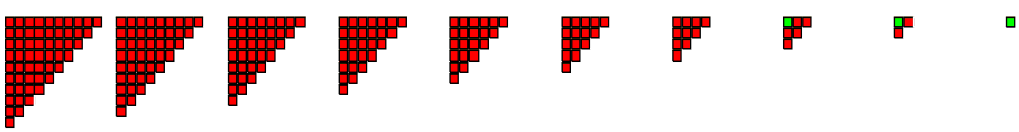


(ii) The structure of the graphs showing the effect of different initial conditions on equilibrium for a given parameter vector

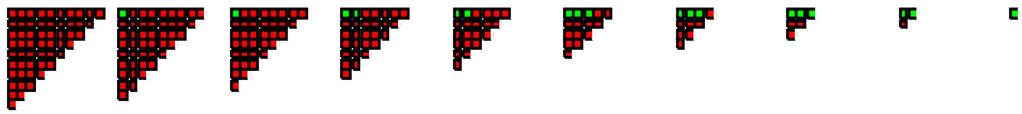


(iii)

Equilibra if $a = b = c = d = 1.01$, and $X0^{VR}$, $X0^{VNR}$, $X0^{NVR}$, $X0^{NVNR}$ = 0 .01, 0.11, 0.21, … , 0.91.



Equilibra if $a = b = 1.11$, $c = d = 1.01$, and $X0^{VR}$, $X0^{VNR}$, $X0^{NVR}$, $X0^{NVNR}$ = 0 .01, 0.11, 0.21, … , 0.91.



Equilibra if $a = b = 1.01$, $c = d = 1.11$, and $X0^{VR}$, $X0^{VNR}$, $X0^{NVR}$, $X0^{NVNR}$ = 0 .01, 0.11, 0.21, … , 0.91.

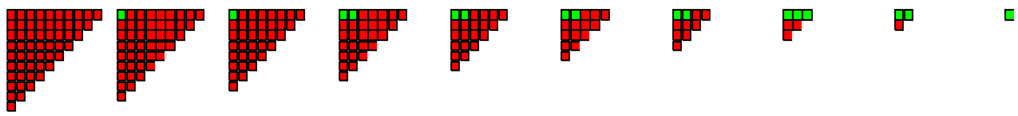
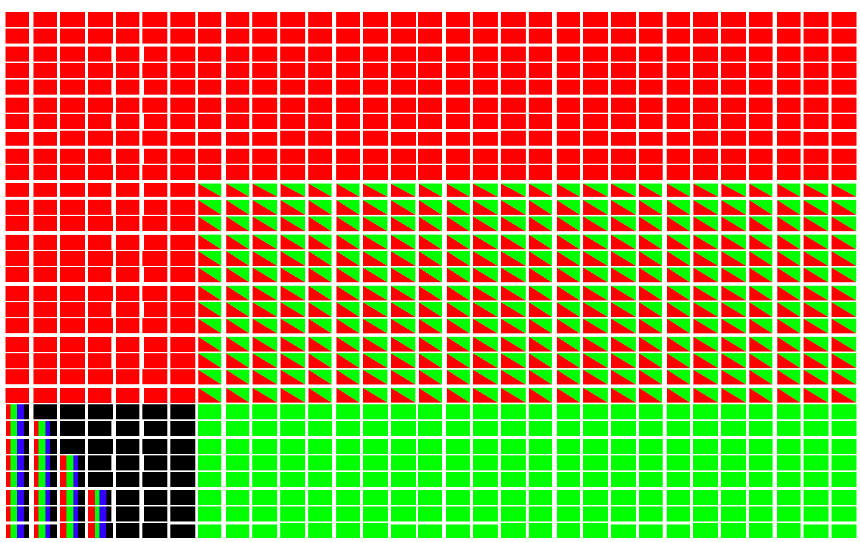


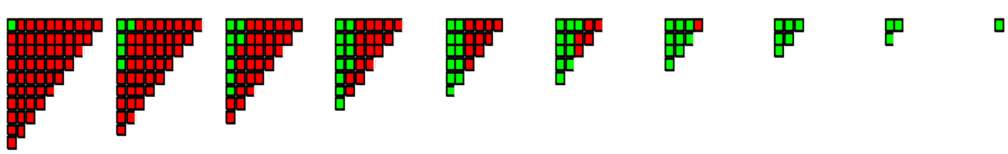
Exhibit 4

(i) Equilibra if $a = b$ = 0.01, 0.11, 0.21, .. , 3.01; $c = d = 1.01$

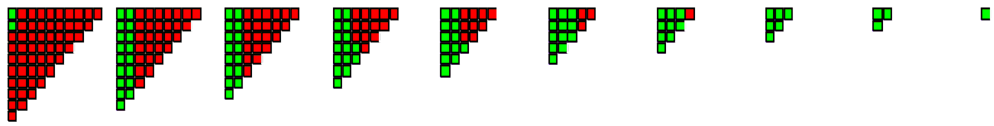


(ii)

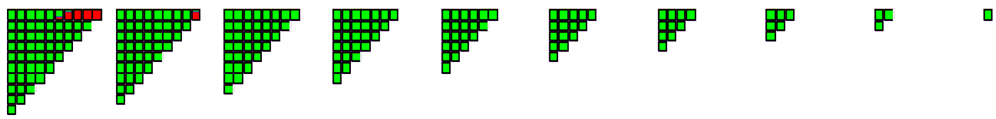
Equilibra if $a = 2.01$, $b = c = d = 1.01$, and $X0^{VR}$, $X0^{VNR}$, $X0^{NVR}$, $X0^{NVNR}$ = 0 .01, 0.11, 0.21, … , 0.91.



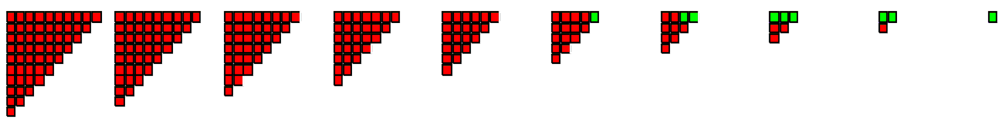
Equilibra if a = 2.21, b = c = d = 1.01, and $X0^{VR}$, $X0^{VNR}$, $X0^{NVR}$, $X0^{NVNR}$ = 0 .01, 0.11, 0.21, … , 0.91.



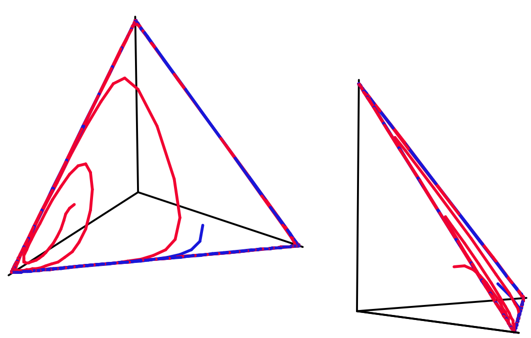
Equilibra if a = 2.31, b = c = d = 1.01, and $X0^{VR}$, $X0^{VNR}$, $X0^{NVR}$, $X0^{NVNR}$ = 0 .01, 0.11, 0.21, … , 0.91.



Equilibra if b = 2.01, a = c = d = 1.01, and $X0^{VR}$, $X0^{VNR}$, $X0^{NVR}$, $X0^{NVNR}$ = 0 .01, 0.11, 0.21, … , 0.91.

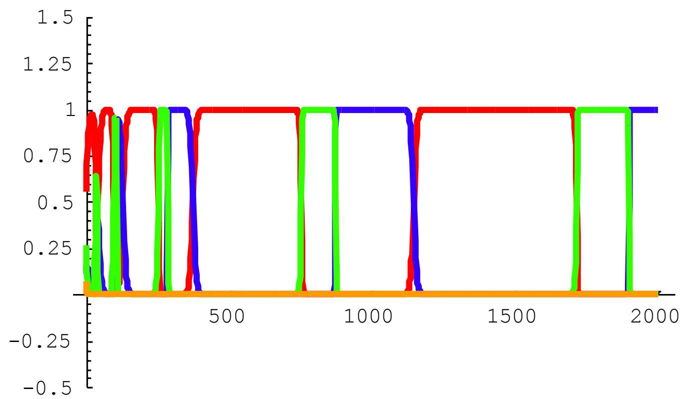


(iii) Equilibra for two arbitrary initial conditions if a = 2.51, b = 0.41, c = d = 1.01 (RSP with global repellor)

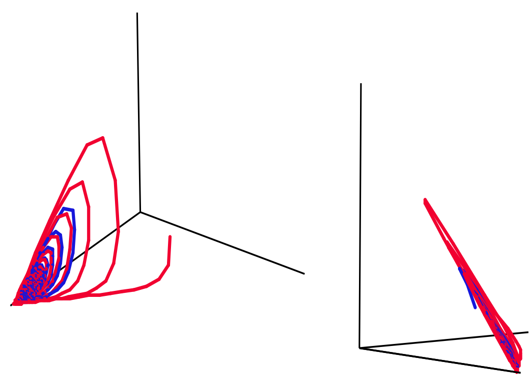


(iv)

a = 2.51, b = 0.41, c = 1.01, d = 1.01
$X0^{VR}$ = 0.55 $X0^{VNR}$ = 0.11, $X0^{NVR}$ = 0.26, $X0^{NVNR}$ = 0.08



(v) Equilibra for two arbitrary initial conditions if a = 2.81, b = 0.21, c = d = 1.01 (RSP with global attractor)



(vi)

a = 2.81, b = 0.21, c = 1.01, d = 1.01
$X0^{VR}$ = 0.11 $X0^{VNR}$ = 0.52, $X0^{NVR}$ = 0.07, $X0^{NVNR}$ = 0.3

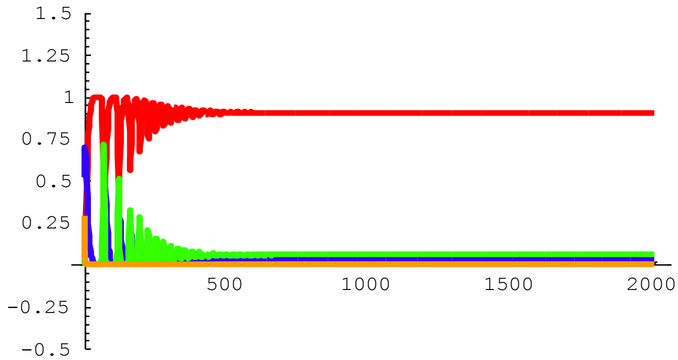
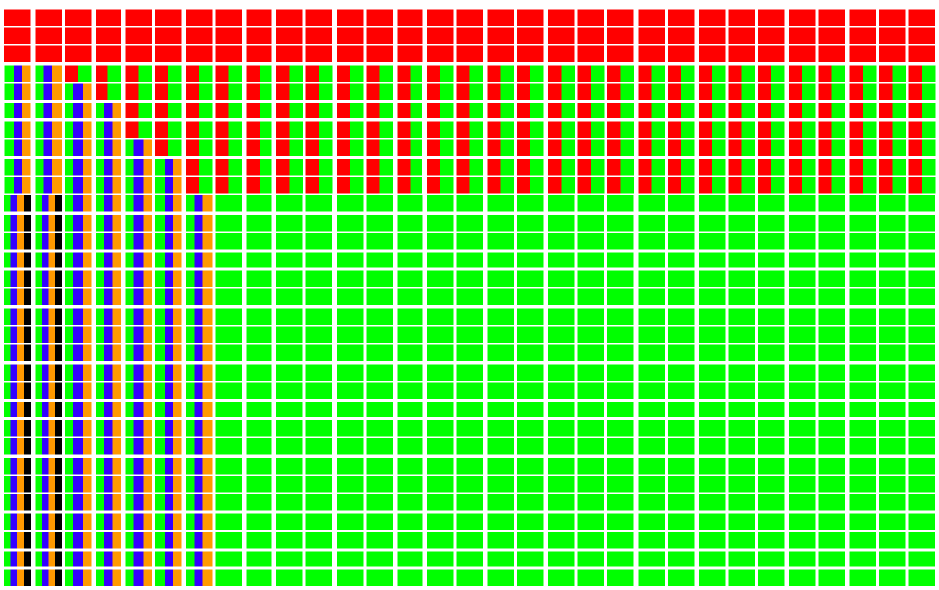
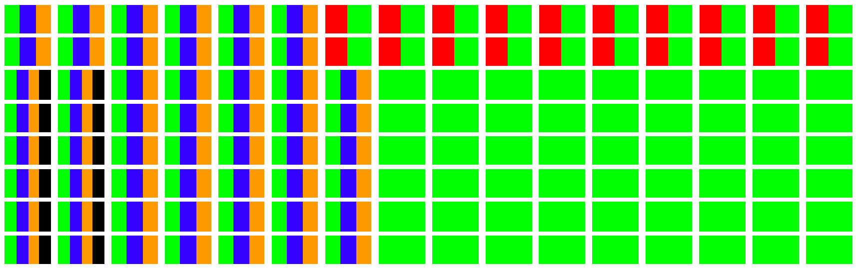


Exhibit 5

(i) Equilibra if *a* = *b* = 0.01, 0.11, 0.21, .. , 3.01; *c* = 0.01, *d* = 1.01



(ii) Equilibra if *a* = 0.81, 0.91, 1.01, .., 1.51, *b* = 0.01, 0.11, 0.21, .. , 1.51; *c* = 0.01,
d = 1.01



(iii) Equilibra for some b parameters if $a = d = 1.01$, $c = 0.01$, with random initial conditions