Contribution discussing the negotiations concerning Greece dept problem using game theory

Content

1 Summary

To discuss the negotiation between the creditors (European central bank, IMF International Monetary Fund, Euro Group; without private investors) and Greece (the Greek Government) a game theoretical approach is used. The discussed question is: shall they opt for Grexit (Greece is leaving the euro zone) or for NotGrexit (Greece remains in the euro zone).

First we will see that under some circumstances a mixed strategy for Greece is possible (i. e. the player will choose a strategy with some probability) Mixed strategies can help to escape a deadlock situation. That means switching for example from a second best payoff for both to a better payoff for both. But we will see that this possibility is useless.

In most cases the payoffs leads for Greece to the option Grexit. Only in one scenario which is close to the Prisoner's Dilemma the option NotGrexit for both could be possible. But this situation would need a lot of trusting discussions and transparent information about the strategy of each player.

2 Introduction

After joining as twelfth member the euro zone 2001 Greece obtain loans at favourable terms. In 2004 the EU notes that Greece did not achieved the stability criteria when it joined the euro zone, and speaks of "significant errors in the financial reporting". The global financial crisis that was triggered by the bankruptcy of US investment bank Lehman Brothers in September 2008 , Greece hits hard. The rating agencies decrease the creditworthiness of its government bonds.
Mai 2010 EU, European Central Bank and the IMF decide a first bailout package of € 110 billion for Greece.
March 2012 a second package of € 130 billion is decided. And as reduction of debt € 107 billion results as the private creditors of Greece gave up 53.5 percent of their claims. (NZZ folio July 2013).

June 2015 the second package ends and to avoid state bankruptcy a third bailout package has to be discussed.

Greece dept of € 322 billion are allocated 44 percent to EFSF European Financial Stability Facility, 16.5 percent Euro States, 10.9 percent IMF, 8.4 percent European Central Bank and 20.2 percent private investors (FAZ March 2015)

End of June 2015 Greece starts with capital controls.

August 2015 the discussion about the third package of € 86 billion about three years seems to be settled. About € 25 billion are needed recapitalising Greek Banks. IMF would prefer a haircut for Greece's debt, arguing the country's debt is unsustainable without a massive restructuring. IMF decides in October 2015 about joining the third package. Alexis Tsipras (prime minister) demission and the announced new election (the third in a year) are bringing new instability into the negations. There seems to be no reason to relax about the Greece crisis.

To discuss the negotiation between the creditors (European central bank, IMF, Euro Group; without private investors) and Greece (the Greek Government) a game theoretical approach is used. The discussed question is: shall they opt for Grexit (Greece is leaving the euro zone) or for NotGrexit (Greece remains in the euro zone).

First we talk about the basic game situation between creditors and Greece and their payoffs. Discussing different scenarios of payoffs gives answers to the question how will they opt.

3 Basic Game Situation creditors and Greece

			Player Greece	Player Greece
			NotGrexit	Grexit
			y	$1 - y$
Player creditors	NotGrexit	x	(a,α)	(b,β)
Player creditors	Grexit	$1 - x$	(c,χ)	(d,δ)

3.1 Payoff discussion for creditors

a Creditors' strategy NotGrexit, Greece strategy NotGrexit: creditors won't get all credits back but more as long as Greece is interested remaining in the euro zone.

b Creditors' strategy NotGrexit, Greece strategy Grexit: creditors won't get nearly any credits back. Greece isn't interested remaining in the euro zone only if it is nearly for free.

c Creditors' strategy Grexit, Greece strategy NotGrexit: creditors would get all credits back. Greece wishes remaining in the euro zone at all prices and will pay all there credits back.

d Creditors' strategy Grexit, Greece strategy Grexit: creditors won't get nearly any credits back. Greece isn't interested remaining in the euro zone.

Following payoffs discussion above we can assume $b < a < c$ and $d < c$ and $d < a$. The payoff d in relation to b will be discussed below. The answer isn't so obvious.

3.2 Payoff discussion for Greece

α Greece strategy NotGrexit, creditors' strategy NotGrexit: Greece profits remaining in the euro zone even if they have to pay back some credits.

β Greece strategy Grexit, creditors' strategy NotGrexit: Greece doesn't pay their credits back and has the possibility remaining in the euro zone nearly for free.

χ Greece strategy NotGrexit, creditors' strategy Grexit: Greece profits remaining in the euro zone even if they have to pay all credits back.

δ Greece strategy Grexit, creditors' strategy Grexit: Greece doesn't profit remaining in the euro zone and doesn't pay their credits back.

Following payoffs discussion above we can assume $\chi < \alpha < \beta$ and $\chi < \delta < \beta$. For Greece the open question is $\delta > \alpha$ or $\delta < \alpha$ or $\delta = \alpha$. That will be discussed below.

4 Strategies discussion

According to the basic game situation the strategies for both players will be discussed.

First we talk about mixed strategies, i. e. each player will choose a strategy with some probability. With a mixed strategy you could escape a deadlock situation. You choose a strategy randomly and switch for example from a second best payoff for both to a better payoff for both.
As we will see depending on the payoffs there will be only a one shot-game strategy.

Second we discuss dominant strategies depending on the payoffs.

4.1 Mixed Strategies

A player chooses the strategy NotGrexit or Grexit with some probability.

Following the basis game situation above the creditors choose NotGrexit with probability x and therefore the strategy Grexit with probability $1 - x$.

The probability for Greece to choose NotGrexit is y and $1 - y$ for Grexit.

We will discuss real mixed strategies, i.e. $0 < x < 1$ and $0 < y < 1$.

The payoffs can be calculated as follow:

Payoff for Creditors: $p_{Creditors} = x \cdot (a \cdot y + b \cdot (1 - y)) + (1 - x) \cdot (c \cdot y + d \cdot (1 - y))$

Payoff for Greece: $p_{Greece} = y \cdot (\alpha \cdot x + \chi \cdot (1 - x)) + (1 - y) \cdot (\beta \cdot x + \delta \cdot (1 - x))$

The probabilities x and y can be found following the optimization problem:

$$\frac{\partial}{\partial x} p_{Creditors} = (a \cdot y + b \cdot (1 - y)) - (c \cdot y + d \cdot (1 - y)) = 0;$$

Therefore: $y = \frac{d - b}{a - b - c + d} = \frac{d - b}{d - b + a - c}$

$$\frac{\partial}{\partial y} p_{Greece} = (\alpha \cdot x + \chi \cdot (1 - x)) - (\beta \cdot x + \delta \cdot (1 - x)) = 0;$$

Therefore: $x = \frac{\delta - \chi}{\alpha - \chi - \beta + \delta} = \frac{\delta - \chi}{\delta - \chi + \alpha - \beta}$

First question does a real mixed strategy exists for the creditors?

Following the payoff discussion for Greece we have $\chi < \alpha < \beta$ and $\chi < \delta < \beta$..

Therefore $\delta > \chi$

For $x > 0$ we need $\delta - \chi + \alpha - \beta > 0$; so i.e. $\delta - \chi > \beta - \alpha$; as $\beta > \alpha$ we get $\beta - \alpha > 0$ and therefore $0 < \delta - \chi - (\beta - \alpha) < \delta - \chi$; therefore $x > 1$. So there is no real mixed strategy for the creditors.

Second question does a real mixed strategy exists for Greece?

Following the payoff discussion for creditors we have $b < a < c$ and $d < c$ and $d < a$.

As we saw below, the situation between Greece and the creditors isn't symmetrical, d isn't bigger then b for sure.

We will discuss both possibilities: $d < b$ or $d > b$

The consequences for a real mixed strategy for Greece are:

If $d > b$ then for $y > 0$ we need $d - b + a - c > 0$ so we get $d - b > c - a$ as $a < c$ we have $c - a > 0$ und therefore $0 < d - b - (c-a) < d - b$; therefore $y > 1$. In this situation we get no real mixed strategy for Greece.

If $d < b$ we rewrite the probability y

$$y = \frac{d-b}{a-b-c+d} = \frac{b-d}{b-d+c-a}$$

If $b > d$ then we get $0 < y < 1$. Because $b-d > 0$ and $c - a > 0$. Therefore the denominator of y is bigger than 0 and furthermore $b - d + c - a < b - d$; so $y < 1$. In this situation we get the possibility of a real mixed strategy for Greece.

So the results are, there is no real mixed strategy for the creditors. They choose NotGrexit or Grexit with probability 0 or 1 i.e there is only a one-shot strategy. If the payoff d for the creditors is bigger than b, Greece also chooses NotGrexit or Grexit with probability 0 or 1. If the payoff d is less then b, Greece has the possibility for a real mixed strategy.

4.2 Strategies in the situation $d < b$:

The assumption for this situation is:
Even as Greece isn't interested remaining in the euro zone creditors tries to keep them in. The price for let Greece going out is too high for creditors.

Us we discussed above Greece have the possibility for a mixed strategy. But the creditors have to choose between NotGrexit and Grexit with probability 0 or 1. Greece optimizes it payoff under this condition. The payoff α is less than β for sure, also χ is less than δ as well. The optimal strategy for Greece is Grexit. That means for the creditors they can choose as payoff between d and b. They will choose b. It means Greece chooses Grexit and the creditors choose NotGrexit. Greece gets its best payoff β and the creditors their second best payoff b. That means $x = 1$ and $y = 0$. The creditors and Greece stuck since the beginning 2010 (at least until July 2015) in these situation. The haircut 2012 followed this scenario.

A numerical example for this situation could be

			Player Greece	Player Greece
			NotGrexit	Grexit
			$y = 0$	$1 - y = 1$
Player creditors	NotGrexit	$x = 1$	$(a = 0, \alpha)$	$(b = -1, \beta = \alpha + 3)$
Player creditors	Grexit	$1 - x = 0$	$(c = 2, \chi)$	$(d = -2, \delta = \chi + 2)$

4.3 Strategies in the situation $d > b$:

The assumption for this situation is:
If Greece isn't interested remaining in the euro zone creditors let them going out. The price keeping them in is higher.

Us we discussed above Greece and the creditors have no the possibility for a mixed strategy. Both choose NotGrexit or Grexit with probability 0 or 1. As before the optimal payoff for Greece results choosing Grexit. The payoff α is less than β for sure, also χ is less than δ as well.

The optimal payoff for creditors is choosing Grexit as well. As Greece will choose Grexit the creditors end up with the payoff d which is higher than b. That means $x = 0$ and $y = 0$.

A numerical example for this situation could be

			Player Greece	Player Greece
			NotGrexit	Grexit
			$y = 0$	$1 - y = 1$
Player creditors	NotGrexit	$x = 0$	$(a = 0, \alpha)$	$(b = -2, \beta = \alpha + 3)$
Player creditors	Grexit	$1 - x = 1$	$(c = 2, \chi)$	$(d = -1, \delta = \chi + 2)$

4.3.1 Can there be an interest choosing NotGrexit for both

If $\delta < \alpha$ and $d < a$ there could be a better solution then choosing Grexit for both. As between Greece and creditors are a lot of discussion an agreement NotGrexit could be an option for both. So a further payoff discussion about $\delta < \alpha$ or $\delta > \alpha$ or $\delta = \alpha$ is needed. The payoff relation $d < a$ is obvious.

4.3.2 Situation $\delta > \alpha$

The assumption for this situation is:
Greece doesn't profit enough remaining in the euro zone and has no incentives paying back their credits. Greece is a small closed economy (Nzz 14. February 2015). The export to EU is about 6.6% of the GDP (12.1 Mrd Euro, GDP 182 Mrd Euro 2013 Germany Trade & Invest Stand November 2014). There is no need for Greece being part of a competitive euro zone.

In the case $\delta > \alpha$ the best choose for Greece is Grexit. Then they get β if creditors choose NotGrexit, which is the highest payoff for Greece or δ in the case creditors choose Grexit, which is the second best payoff for Greece.

A numerical example for this situation could be

			Player Greece	Player Greece
			NotGrexit	Grexit
			$y = 0$	$1 - y = 1$
Player creditors	NotGrexit	$x = 0$	$(a = 0, \alpha = \delta - 1)$	$(b = -2, \beta = \alpha + 3)$
Player creditors	Grexit	$1 - x = 1$	$(c = 2, \chi)$	$(d = -1, \delta = \chi + 2)$

4.3.3 Situation $\delta = \alpha$

The assumption for this situation is:
Greece doesn't profit very much remaining in the euro zone and has no incentives paying back their credits. But the profit or costs for Greece are the same for the situation remaining in the euro zone if the creditors wish the same, opting for Grexit if the creditors act for Grexit as well.

The question is, can there be an incentive switching to NotGrexit knowing the creditors would prefer this as $a > d$ for sure.

The answer is no. For Greece there is no incentive to switch to NotGrexit. With the strategy Grexit they would get the highest payoff β if creditors choose NotGrexit and the second best payoff δ if creditors chose Grexit. Greece would increase his risk switching to NotGrexit, ending up with a payoff of χ if creditors switche to Grexit.

A numerical example for this situation could be

			Player Greece	Player Greece
			NotGrexit	Grexit
			$y = 0$	$1 - y = 1$
Player creditors	NotGrexit	$x = 0$	$(a = 0, \alpha = \delta)$	$(b = -2, \beta = \alpha + 3)$
Player creditors	Grexit	$1 - x = 1$	$(c = 2, \chi)$	$(d = -1, \delta = \chi + 2)$

4.3.4 Situation $\delta < \alpha$

The assumption for this situation is:
Greece profits enough remaining in the euro zone as long as the creditors take the same action and has some incentives paying back their credits. After being faced with the consequences of the capital controls (end of June, July 2015) maybe this situation occurred.

This is a more or less a classical Prisoner's Dilemma situation. Prisoner's Dilemma is as really classic game which is discussed in countless publications. Strategic situations formulated as Prisoner's Dilemma are omnipresent, as for international trade and investment, public good, environmental problems, oligopoly collusion etc.

As remark, the classical Prisoner's Dilemma is more symmetrical with $a = \alpha$, $c = \beta$, $d = \delta$, and $b = \chi$, furthermore $b < d < a < c$ (or $\chi < \delta < \alpha < \beta$). The symmetry in our situation is not obvious. The one-shot solution for the Prisoner's Dilemma is (d, δ), known as the Nash equilibrium (definition

....). (a, α) would give a better payout for both. Without any discussion and transparent information this solution can hardly get achieved in a one-shot solution game.

In the case $\delta > \alpha$ the best choose for Greece is Grexit. Then they get β if creditors choose NotGrexit, which is the highest payoff for Greece or δ in the case creditors choose Grexit, which is the second best payoff for Greece.

In this case $\delta < \alpha$ for Greece and $d < a$ for the creditors is a chance to end up in a higher payoff for both. They have to switch simultaneously from Grexit to NotGrexit. That's the only situation motivating for choosing NotGrexit simultanously.

A numerical example for this situation could be

			Player Greece	Player Greece
			NotGrexit	Grexit
			$y = 0$	$1 - y = 1$
Player creditors	NotGrexit	$x = 0$	$(a = 0, \alpha = \delta + 1)$	$(b = -2, \beta = \alpha + 3)$
Player creditors	Grexit	$1 - x = 1$	$(c = 2, \chi)$	$(d = -1, \delta = \chi + 2)$

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