

Independence Games

“How will the Catalan Secession Process develop according to Game Theory Analysis?”

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ABSTRACT

This essay discusses the secession process of Catalonia through the lens of Game Theory. The research question it investigates is: how will the Catalan secession process develop according to Game Theory analysis?

In order to build the Game Theory model several primary sources were contrasted: enquiries and polls made by several official organizations, declarations of political leaders, analyses made by politics and economics scholars, and articles published in a broad range of newspapers. This resulted in a solid base of information from which it was possible to determine the players, the set of strategies and the payoffs (profit or motivation of a player) of the model.

A game is built through the analysis of the Catalan political scenario, from the 11th of September 2012 to October 2013 (as this process is ongoing). This game models the different actions that President Mas of Catalonia can carry out, and the response actions of Spanish premier Mariano Rajoy. In addition, a refinement of the game, which contemplates the possibility of Catalonia joining the EU if she was to declare independence unilaterally, was also devised to complement the analysis.

In order to answer the research question the game's equilibrium was analyzed using Game Theory tools. The conclusion attained through the analysis of the equilibrium is the following: if Spain believes with high enough probability that Catalonia is *strong*, she will reject the proposal of a non-binding referendum, and Mas will hold plebiscitary elections, and declare independence unilaterally if the elections are favorable. Otherwise, Rajoy would offer an asymmetric fiscal agreement (and/or Constitutional reform) to Mas. The conclusion attained through the analysis of the refined game is that Catalonia is less likely to achieve independence if she is believed to be *strong* with high enough probability and the EU would reject Catalonia's entry.

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INTRODUCTION

On the 11th of September of 2012, the international community turned its eyes to Catalonia. The massive demonstration, which attracted more than 1.5 million people to Barcelona¹, had as a motto: “Catalonia New State of Europe”. This was the first massive demonstration in favor of independence since the Spanish transition to democracy in 1975².

The nationalist sentiment in Catalonia had been growing steadily since the beginning of the current economic crisis, because the median voter realized that the fiscal treatment of Catalonia was unfair and because of the Spanish Constitutional Court rejection in 2010 of essential aspects of the Catalan Statute of 2006. It has been calculated that annually Catalonia transfers about 8 % of her GDP to Spain, without receiving the proportional public service and investments from the Spanish government³. This fiscal situation helped develop the public opinion that Catalonia needs and asymmetric fiscal agreement⁴.

According to polls made by the CEO (Centre d’Estudis d’Opinió),⁵ the percentage of people who chose “an independent state” when they were asked about their ideal political status for Catalonia increased from a rough 20% in 2008 to close to 50% by 2013⁶.

¹ As was noted by the Catalan Government spokesmen, Francesc Homs, in a press conference after the 11th of September demonstration.

² It was an inflection point in the political scenario of Catalonia. Mas’s center party turned towards pro-independence, and the Catalan political scenario became polarised between pro-secession and pro-status quo parties.

³ de la Fuente, Angel, “Cisne Negro o Pollo Del Montón? El Déficit Fiscal Catalán en Perspectiva”, CSIC (Instituto de Análisis Económico), 2012. Source contrasted with official information of the Generalitat de Catalunya.

⁴ An asymmetric fiscal agreement (“concert economic”, in Catalan) would grant Catalonia the power to regulate her own tax income without depending on the central Spanish government. This might imply a constitutional reform involving the Catalan economic status in Spain.

⁵ The CEO is a poll agency dependent on the Generalitat de Catalunya. Another is the ICPS (Institut de Ciències Polítiques i Socials).

⁶ 1st wave 29th Barometer of Public Opinion realized, CEO (Centre d’Estudis d’Opinió), February 2013.

Support for an Independent State, CEO, June 2013

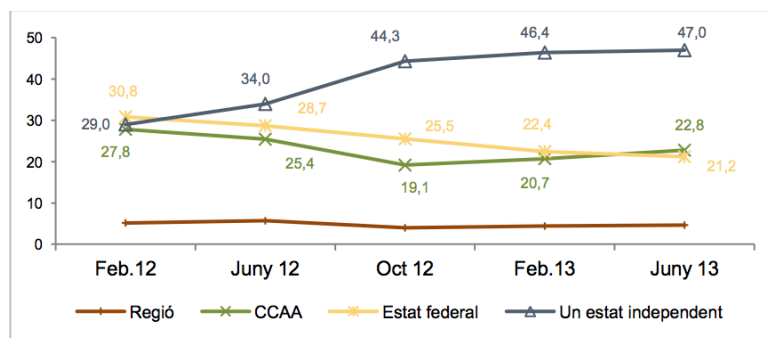


Chart 1⁷

As it can be seen in *Chart 1*, the support for the option independent state (marked in blue), raised significantly after the 11th of September 2012 demonstration of public support for independence. Nowadays the nationalist movement is at the center of the Catalan society. Several reports have been published about this process, many of them with a political motivation. The primary intention of this essay is to apply some game-theoretical sense into the situation and analyze its possible outcomes from an analytical point of view. All the information presented in this essay will be contrasted with opposing views to avoid bias, and the models will be explained in accordance to the events that have already happened. The goal of this analysis is not to defend a particular outcome to the secessionist process, but check the plausibility of certain outcomes according to Game Theory.

⁷ Ibidem.

THE GAME

To build a dynamic⁸ Game Theory model, we need to know who are the players, the order of moves, and for each player, the set of actions and the information she has available at each decision node⁹, and her payoff at any terminal node¹⁰.

The Players

The players are: Catalonia (CAT) and Spain (SP)¹¹. It is assumed that CAT can be of two different types of player¹²: *strong*, which means CAT aims at obtaining independence, and *weak*, which implies that CAT's goal is an asymmetric fiscal agreement, and/or a reform of the constitution. This dualism of CAT is appreciated if one analyses the polls that the CEO has made every 3 months for the past two years (2012-2013). It can be seen that although independence now is located at the center of the Catalan society, many people still advocate for an asymmetric fiscal agreement¹³. By taking into account this division in Catalan society¹⁴, the model/game will represent more accurately a situation in which SP doesn't know for sure CAT's preferences. Due to this fact the game will be Bayesian. A Bayesian game is an incomplete information game, which means that at least one player doesn't know the other players' payoff¹⁵. The consequence of this incomplete information scenario is that a third player, Nature, determines whether CAT is *strong* or *weak*, assigning a probability p to CAT being *strong* and $1-p$ to CAT being *weak*.

⁸ A dynamic game is a game in which players decide sequentially. Osborne, Martin J., "An Introduction to Game Theory", 2004, Oxford University Press, chapter 1.

⁹ A decision node is any point in the game in which a player has to decide between two or more actions.

¹⁰ A terminal node is the outcome of any sequence of actions of the players that may occur in the game.

¹¹ The pronoun *she* will be used instead of *it* to refer to these players.

¹² The *type* of a player determines the preferences of this player in a Bayesian Game. Osborne, chapter 1

¹³ Consell Assessor de la Transició Nacional, "La Consulta sobre el Futur Polític de Catalunya", Barcelona, 07/25/2013.

¹⁴ Castro, Carles, "El pacto fiscal y la tercera vía de Duran se alzan como opciones a la separación", La Vanguardia, 10/06/2013.

¹⁵ The players' payoff functions are not common knowledge. Gibbons, Robert, "A Primer in Game Theory", 1992, Harvester Wheatsheaf, chapter 3.

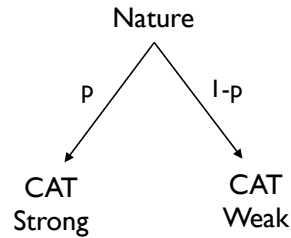


Figure 1

This initial node (*Figure 1*) will divide the game in two decision trees, one for the *weak* CAT and the other for the *strong* CAT, each tree will have different end payoffs for CAT, but the same for SP. This will make each node where SP has to play an information set (a set of decision nodes of a player that cannot be differentiated by this player)¹⁶. Through this incomplete information model we can rationalize SPs' uncertainty about CAT, and the mixed influences she is receiving, ranging from the conservative views of the newspaper EL MUNDO, to opinions that SP should reach an agreement with CAT in order to avoid the development of the secession process¹⁷.

The Strategies and the Payoffs

After the massive demonstration of the 11th of September 2012, Mas announced that if his proposal of a new fiscal agreement (NP, negotiation proposal) for Catalonia was rejected (R) by Spain, he would call early elections. In addition, he promised that if he won the elections (called for the 25th of November) he would carry out a popular consultation (NBR, non-binding referendum¹⁸) during his mandate to let the Catalan people decide over independence. SP rejected the proposal of a new fiscal agreement for Catalonia, and Mas held early elections as

¹⁶ Osborne, chapter 2. Therefore, SP doesn't know in which branch of the game she is, or against which type of CAT she is playing.

¹⁷ For example, by Josep A. Duran i Lleida, President of the Catalan party Unió Democràtica. This was noted in the article: "Duran Alerta de una Declaración Unilateral de Independencia", by Fernando Garea and Carlos E. Cué, published in the journal EL PAÍS, on the 17 of October.

¹⁸ A non-binding referendum is a referendum that has no legal repercussion; it's primarily purpose is to assess the public opinion (or of a group of people) of a certain topic.

promised. Mas' party, CIU, lost 12 MPs¹⁹, but was able to form a government with the support of ERC, the pro-independence party. The combined forces of CIU, ERC, and CUP, supportive of the secessionist movement, accounted for 55% of the Catalan Parliament (74 MPs out of 135)²⁰.

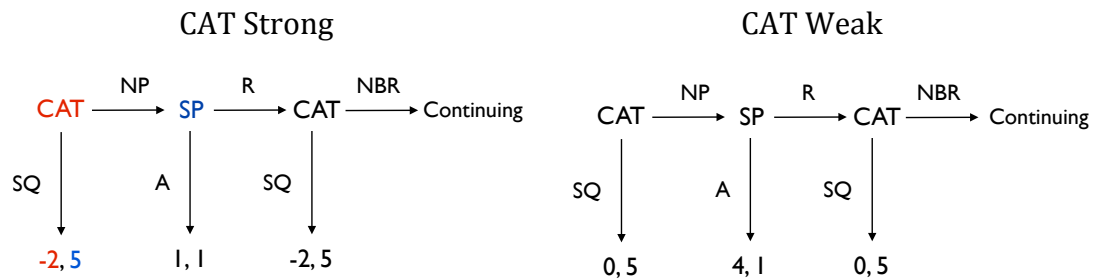


Figure 2²¹

Figure 2 describes a situation, in which CAT can propose an asymmetric fiscal agreement (NP), or remain submissive and stay with the status quo²² (SQ). Consequently, SP can either accept (A) or reject (R) the negotiation proposal. If she rejects it CAT has to choose between giving up (SQ) or going further and organizing a nonbinding referendum. The numbers displayed under the final nodes are the payoffs of each player (the first number, red, is the payoff of CAT, and the second number, blue, is the payoff of SP). The payoffs concord with the type of CAT; for example: a *strong* CAT has a payoff of 1 if SP accepts the NP, whereas a *weak* CAT has a payoff of 4²³, because her prime objective (asymmetric fiscal agreement) would be satisfied if SP accepts the NP. In both cases the least desirable outcome for CAT would be SQ because then CAT would giving up on its goal²⁴.

¹⁹<http://www.parlament.cat/web/composicio/resultats-electorals/resultats-legislatures>, multiple authors, Generalitat de Catalunya, 12/17/2012.

²⁰ Ibidem. It is assumed that within CIU the members of Unió Democràtica would also vote in favour of independence or, alternatively, that the negative votes within CIU would be balanced with the positives ones in other political parties such as the green leftist ICV or the socialist PSC.

²¹ The information sets are not shown because they would difficult the display in the figures, but it is assumed that every node where SP has to play is an information set.

²² Status quo is defined as the present situation or condition, according to the Cambridge English Dictionary.

²³ Note that the maximum payoff that a *weak* CAT can get is 4, while 5 is the maximum payoff for a *strong* CAT. The reward to achieving independence is larger than the one of an asymmetric fiscal agreement.

²⁴ That is why the payoffs for SQ are 0 and -2.

In *Figure 3* we can see the sequence of moves in which SP rejects the NBR, and CAT has the choice of SQ and PE, and knowing that SQ is the least desirable outcome CAT will play PE. SP has two other choices, rejecting and offering to negotiate (N)³², and accepting CAT's proposal of a NBR (A).

If SP decides to negotiate (*Figure 4*), CAT will have two options: accepting (A) or rejecting (R) the deal. A Catalan rejection would mean that SP would have to reconsider and maybe reject formally the NBR. The decision of Catalonia will depend on its type (strong or weak); a *strong* CAT would reject the offer, and a *weak* CAT would accept it.

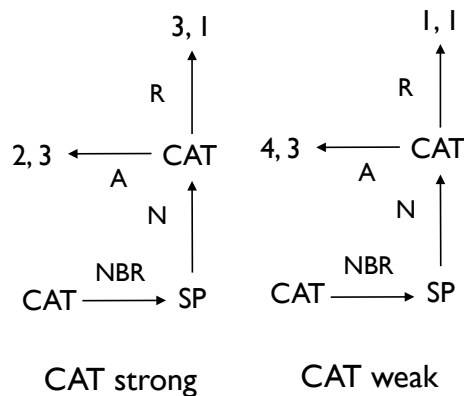


Figure 4

As it can be seen in *Figure 4*, a *weak* CAT would accept the negotiation proposal, because her payoff (4) is higher than the one of rejecting the proposal (1). On the other hand a *strong* CAT would reject the proposal for the same reason (payoff of R is 3 and of A is 2).

If SP decides to accept the NBR it would probably mean that SP thinks that a NBR won't have important political repercussions³³. In this scenario the question of the NBR wouldn't be direct, but general and negotiated with SP³⁴. An example³⁵

³² An offer of negotiation has to be understood as SP considering an asymmetric fiscal agreement proposal, and/or a modification of the Spanish constitution to improve Catalonia's status.

³³ CATN, chapter 5.

³⁴ All the ways of doing a NBR include the approval of SP, so only authorized questions would be accepted.

³⁵ Similar to the one proposed by Carles Casajuana, "Una propuesta para la consulta", *La Vanguardia*, 09/07/2013. Carles Casajuana is a Spanish reporter and writer.

could be: Do you agree with the Catalan government starting a constitutional reform procedure that makes independence possible?³⁶ According to surveys made by the CEO, 84% of the Catalans are in favor of the NBR, and 56% would vote yes to independence³⁷. Even the conservative EL MUNDO affirms that if the question was not directly about independence yes would win with a 71% on a NBR³⁸. With this evidence, and knowing that an NBR is not legally binding, it is assumed that if SP accepts the NBR, its outcome would be “Yes”.

From this node, CAT can continue (*Figure 5*) announcing the celebration of a binding referendum³⁹ (BR), or offering SP a negotiation proposal. Once again, depending on the type of CAT, the payoff of each action will be higher or lower.

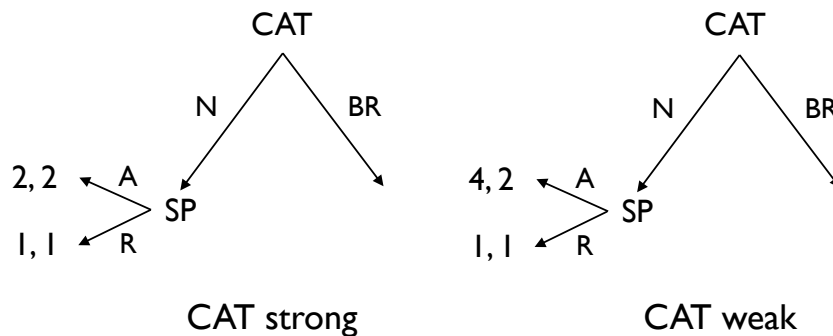


Figure 5

If CAT offers to negotiate, SP will have the choice of accepting or rejecting the proposal. In this scenario, SP knows that CAT is *weak*, because a *strong* CAT only aims for independence; and after having done a NBR, it would be seen as a defeat if Mas settled for something lower than independence⁴⁰. Therefore, SP would

³⁶ Francisco Rubio Llorente proposed a way to celebrate a referendum in his article “Un referéndum que nadie quiere”, published in EL PAIS, on the 11th of February 2013.

³⁷ <http://www.lavanguardia.com/politica/20120930/54352081233/84-catalanes-apoya-consulta-55-independencia.html>, Luis B. Garcia, LaVanguardia, 09/30/2012.

³⁸ <http://www.elmundo.es/elmundo/2013/10/10/barcelona/1381397520.html>, Victor Mondelo, EL MUNDO, 10/10/2013.

³⁹ Contrarily to a NBR, the result of a BR has legal repercussions and usually would imply a modification of the Constitution.

⁴⁰ This preference can be seen through the payoffs displayed in *Figure 5* for each type of CAT.

accept the proposal knowing that she is giving CAT what she wants, and hoping that the secession movement in Catalonia loses steam⁴¹.

If CAT opts for the BR (*Figure 6*), which is the logical follow up of a NBR, CAT reveals her type is *strong*, because a *weak* CAT would have negotiated. The actions for SP are the same as the ones after a NBR: Accepting, Rejecting, and Negotiating.

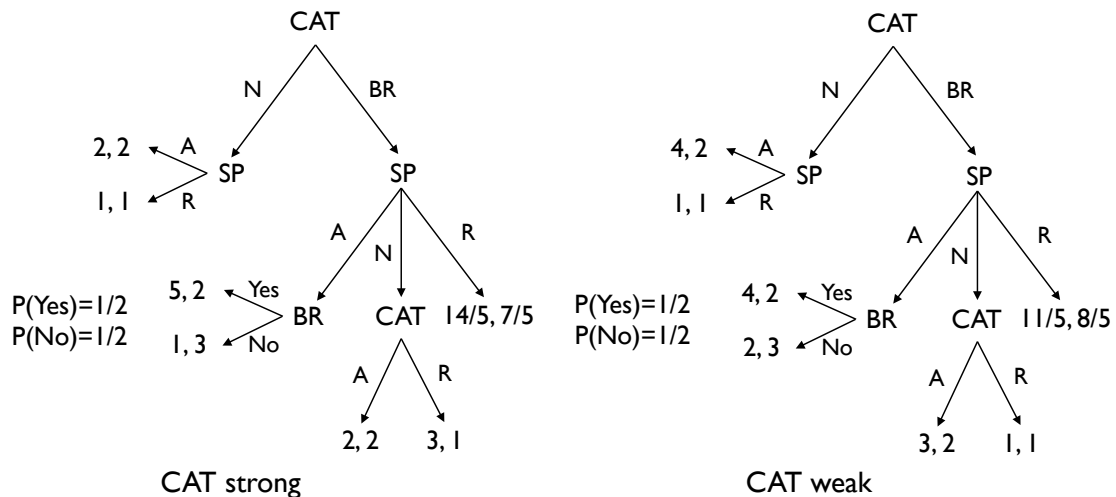


Figure 6⁴²

As it is seen in *Figure 6* if SP accepts a BR (A), Mas can organize a binding referendum on independence⁴³. The outcome of a BR for independence is uncertain⁴⁴. According to a CEO Political Barometer made, 55.6% of the Catalans would vote yes to a BR, as displayed in *Chart 2*.

⁴¹ We have to understand that reached this final node, a *weak* CAT would forget about independence, because its main objective was a deal with Spain.

⁴² Although only a *strong* CAT would propose a BR, it is mandatory to show both branches in order fulfil the sequential rationality requirements of a Bayesian Game.

⁴³ This would imply a reform of the Spanish Constitution, as a BR on independence currently requires a general vote in Spain. Without a constitutional reform Mas probably wouldn't propose a BR, because a general vote in Spain would favour No in detriment of Yes due to the Spanish nationalist sentiment.

⁴⁴ <http://www.lavanguardia.com/politica/20130503/54373776969/cis-33-7-catalanes-independencia-29-4-apuesta-autonomia.html>, David Ramos, LaVanguardia, 05/7/2013.

Estimated vote if tomorrow there was a BR on independence, CEO, 213

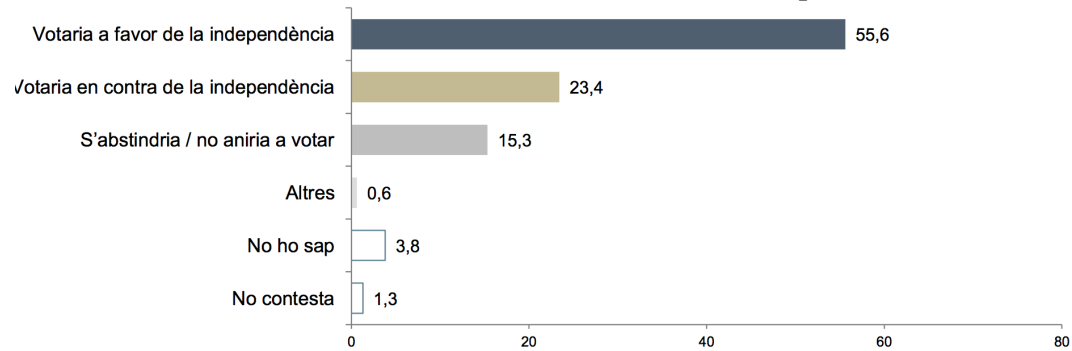


Chart 2⁴⁵

However, according to a Spanish opinion barometer only 33.7% of the Catalans wants independence⁴⁶. This broad range of results reflects the uncertainty that surrounds a BR. Therefore, it is assumed that the probabilities for Yes or No of the BR are balanced at $\frac{1}{2}$ (*Figure 6*). The probabilities do not change with the type of CAT because even a *weak* CAT would rather have independence than nothing so her citizens would have a similar dilemma than the citizens of a *strong* CAT, once at this decision node.

If SP rejects the BR, but is willing to negotiate with CAT (N) and offers an asymmetric fiscal agreement, CAT's action will depend on its type. A *strong* CAT would reject the proposal (consistent with the payoffs of *Figure 6*). A *weak* CAT would accept the proposal and achieve her primary goal⁴⁷.

Finally, if SP rejects the BR, CAT would follow the path as if SP had rejected the NBR (*Figure 3*). The payoffs shown in *Figure 6* for those final nodes (14/5, 7/5 with *strong* CAT and 11/5, 8/5 with *weak* CAT) are the expected payoffs⁴⁸ for both players following CATs' action PE (*Figure 3*) after SP's refusal of the NBR. In

⁴⁵ "If tomorrow there was a referendum over independence what would you do?" 2nd wave of the 30th Political Opinion Barometer, CEO, Generalitat de Catalunya, 31 May-13 June 2013.

⁴⁶ Barómetro Autonómico (III), Comunidad Autónoma de Cataluña, Estudio nº 2956, September-October 2012, CIS.

⁴⁷ *Weak* CAT's payoff isn't 4 because after proposing a BR accepting a negotiation proposal would be seen as a defeat internationally (*Figure 6*). The payoff of SP if CAT accepts N is not the same as the one after NBR, because we are taking into account the reputational cost for SP since she waited until a BR was on the table to offer to negotiate.

⁴⁸ The Expected Payoff is the expected reward of a set of strategies for a certain player. It is calculated considering the probabilities in the equilibrium. Osborne, chapter 2.

the case of SP, 1 is subtracted from her expected payoffs because of the cost of SP not being consistent with her actions⁴⁹.

After the rejection of the NBR; Mas could give up and remain with the status quo, or do as he promised and celebrate plebiscitary elections on 2016 (*Figure 3*). Giving up is not the optimal choice⁵⁰, so we can assume that Mas will go on with the PE. Then, SP would face a similar scenario than with the NBR, with the difference that the PE, although not being binding in any way, have a clear political aim: independence.

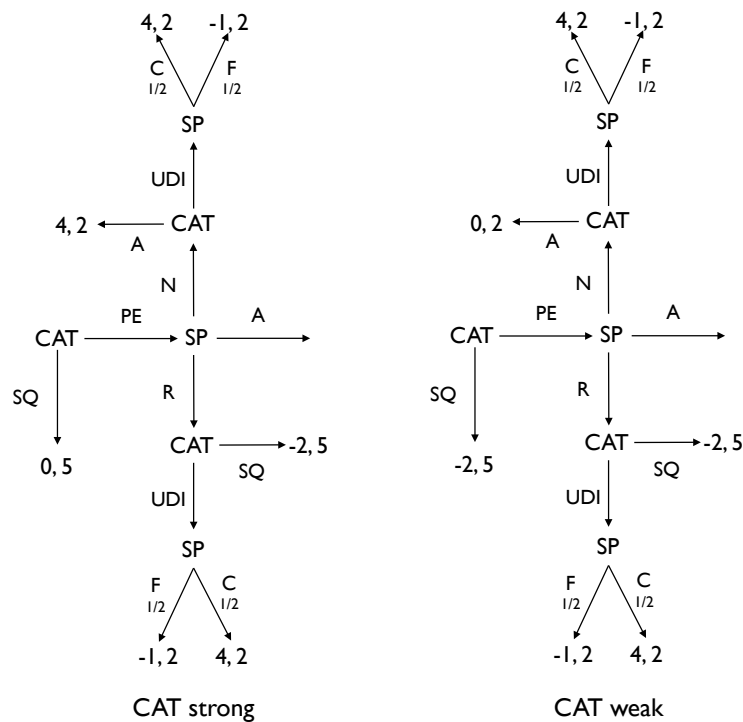


Figure 7

It is necessary to evaluate the possible consequences of the strategies that SP can follow. As it is shown in *Figure 7*, if SP decides to make the PE impossible (R), which may require a political takeover of the government of Catalonia⁵¹, both types of CAT would declare independence unilaterally (UDI⁵²), having the option

⁴⁹ How to find this expected payoff is explained in Appendix.

⁵⁰ Giving up would be seen as a political defeat.

⁵¹ CATN, chapter 7.

⁵² UDI stands for Unilateral Declaration of Independence.

of SQ a high reputational cost. This option is supported by views similar to the ones of Duran i Lleida who advised SP that rejecting the Catalan proposals could lead to an UDI⁵³. An UDI would mean that CAT is no longer bound legally to the Spanish Constitutional laws, but is subjected to the international legislation. Consequently, the only way that SP has to fight (F) an UDI is by developing boycott-like actions, or making it impossible for CAT to enter the EU or other international bodies⁵⁴. Although the Spanish nationalists might defend this strategy, SP does not want an open conflict with CAT, which would damage Spain's reputation and economy⁵⁵. This is why SP is indifferent between fighting and cooperating, randomizing $\frac{1}{2}$ F, $\frac{1}{2}$ C (*Figure 7*), when CAT's action is an UDI, even though she initially rejected the PE.⁵⁶ Cooperation (C) would mean that SP lets CAT achieve independence pacifically. The payoff of cooperating is 2 because even if Spain fails, by cooperating, at stopping the Catalan secession process, a peaceful transition ensures that the economic links between the two regions are maintained⁵⁷.

If SP decides to reject the PE but offer an alternative and negotiate (N), the reaction of CAT will depend on its type. If CAT is *strong*, the sequence of events preceding the negotiation proposal will be the same as for the Rejection of the PE⁵⁸. A *weak* CAT would accept SP's offer and forget about an UDI. (See the payoffs in *Figure 7*.)⁵⁹

⁵³ Garea and Cué.

⁵⁴ A military intervention is ruled out because in the EU it would highly improbable for a state member to invade militarily a region that wants to achieve independence.

⁵⁵ Catalonia has the 19% of the Spanish GDP, and more than 25% of the total exports of Spain, being in addition the commercial gate of the Iberian Peninsula to Europe. Barómetro Autonómico (III), Comunidad Autónoma de Cataluña, Estudio nº 2956, September-October 2012, CIS.

⁵⁶ It is assumed here that SP chooses F or C with equal probability.

⁵⁷ In this case CAT's type doesn't matter because if PE are rejected a change to a less aggressive nationalism would have a high reputation cost for the Catalan government.

⁵⁸ A *strong* CAT would see a negotiation proposal as a disguised rejection of PE.

⁵⁹ Once again, the payoff of SP if CAT accepts is lower than the one of an acceptance after the NBR (*Figure 4*) because of the reputational cost of waiting until PE are organized to offer to negotiate.

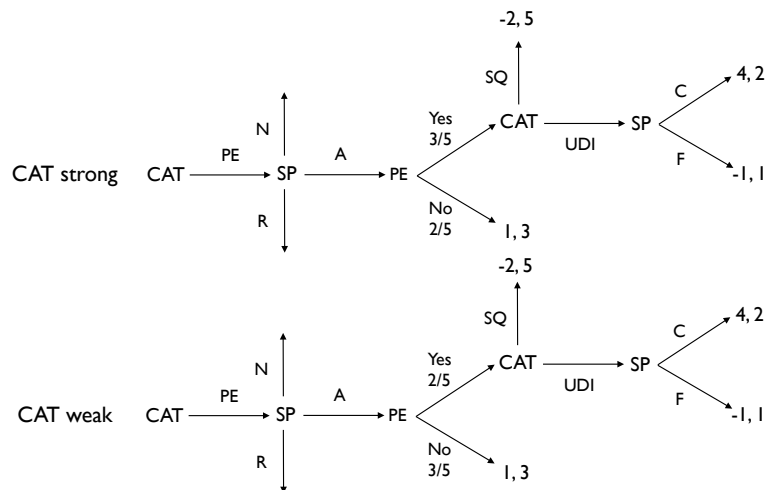


Figure 8⁶⁰

However, if SP decides to accept the PE, Mas will organize PE as he promised (Figure 8). The result of the elections is uncertain, although if CAT is *strong* pro-independence parties would win the PE (ERC-CUP-CIU).

There are surveys that show that if regional elections were held tomorrow, pro-independence parties (ERC-CUP-CIU) would control the Catalan Parliament.⁶¹

Estimated results if autonomic elections where held tomorrow, CEO, 2013

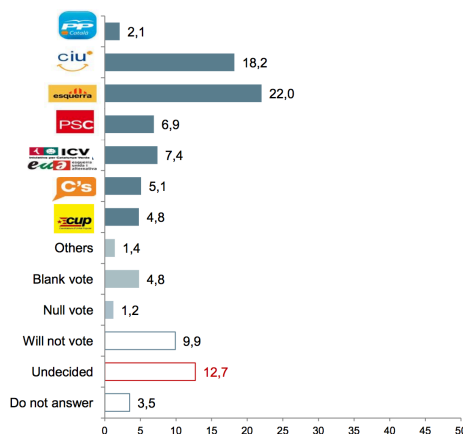


Chart 3

⁶⁰ SP's payoff if No wins in the PE is 3, because although No means that Catalonia wouldn't be independent, the long nationalist process and the concessions that SP would have to make to reach this node have a high reputational cost.

⁶¹ CIU and ERC would each get 36-37 MPs, and CUP 6. In total the MPs of the three parties together would be 78-80 MPs, surpassing the majority by 10-12 MPs.

<http://www.lavanguardia.com/politica/20131005/54390575258/mapa-electoral-catalan-transicion-pedazos.html>, Carles Castro, La Vanguardia, 10/08/2013.

As it is shown in *Chart 3*⁶², 45% of the surveyed declared that they would vote one of the three pro-independence parties (CIU, ERC, CUP)⁶³. This is significant because only 22.9% of the surveyed decided to vote non secessionist parties, and 32.1% were undecided or declared they wouldn't vote⁶⁴. Through the analysis of this data it is reasonable to think that if CAT is *strong*⁶⁵ the PE will have Yes (to independence) as an outcome with probability 3/5 and No with probability 2/5. However if CAT is *weak*, the general sentiment will be centered towards the parties that offer an alternative to independence, or promise the negotiation of an asymmetric fiscal agreement. Consequently, if CAT is *weak* the probability of Yes would be 2/5 and the one of No 3/5, as it is shown in *Figure 8*.

Finally, if Yes wins in the PE Mas will be bound to declare independence unilaterally (UDI) since SQ would be seen as a political defeat (*Figure 8*). This action follows for both types of CAT, because the aim of the PE is solely independence. In this case SP prefers to cooperate with CAT, given that it would be inconsistent to fight an UDI after allowing the PE. This situation is noted by the payoffs of SP in *Figure 8*, which completes the model. The figure in the next page displays the whole game.

⁶² "If elections to the Parlament de Catalunya were to be held tomorrow, what party or coalition would you vote for?", Political Opinion Barometer, CEO, 31 May-13 June 2013.

⁶³Ibidem.

⁶⁴ Note that some voters of Unió Democràtica may be against independence while some sectors of ICV and PSC may be in favour.

⁶⁵ A *strong* CAT only wants independence; therefore, more people would vote pro-independent parties than the ones portrayed in *Chart 3*.

Solving the Game

In order to solve a dynamic Bayesian game we have to find its perfect Bayesian equilibrium⁶⁶ (defined in Appendix 1). In this equilibrium strategies must be sequentially rational and beliefs consistent with strategies⁶⁷. This implies that SP only has to update her beliefs in the information set after CAT's NBR. Once we know this we find the probability p ⁶⁸, which would make SP indifferent between playing N or R after an NBR. The probability obtained is $2/9$; which means that if SP believes that CAT is *strong* with probability $2/9$ or higher, she will play R. However, if she believes that the probability of CAT being *weak* is $7/9$ or higher, she will offer to negotiate after a NBR. Along the equilibrium path we have that⁶⁹:

- If $p > \frac{2}{9}$, SP's strategies are (R after NP, R after NBR, A after PE, C after UDI) and CAT's strategies are (NP, NBR after R, PE after R, UDI after A), regardless of CAT's type⁷⁰.
- If $p < \frac{2}{9}$, SP's strategies are (R after NP, N after NBR) and CAT's strategies are (NP, NBR after R, A after N) if CAT is *weak*, and (NP, NBR after R, R after N) if CAT is *strong*.
- If $p = \frac{2}{9}$; SP is indifferent between R and N in the 4th node (after NBR).

In equilibrium, if SP rejects a NBR (because she thinks that $p > \frac{2}{9}$) CAT will achieve independence after an UDI (if Yes wins in the PE, which is likely if CAT is strong), with the cooperation of SP. Otherwise, if SP negotiates (because she believes that $p < \frac{2}{9}$) after a NBR a *weak* CAT (which is more probable) would agree with SP on an asymmetric fiscal agreement and/or constitutional reform, and a *strong* CAT would reject the negotiation proposal and continue with the secession process⁷¹. With this result we can show that the probability of

⁶⁶ Osborne, chapter 2.

⁶⁷ Both requirements are described in Appendix.

⁶⁸ The probability p is the one used by *Nature* at the beginning of the game as it is shown in *Figure 1*.

⁶⁹ The fact that there is only one node where the belief system has to be updated makes our Perfect Bayesian Equilibrium, a degenerated Bayesian equilibrium. See Appendix.

⁷⁰ In this case CAT's strategies are the same for both types of CAT.

⁷¹ The most likely continuation for a *strong* CAT would be the celebration of PE as if SP had rejected the BR. This consideration is not taken into account in this game.

Catalonia achieving independence increases with the belief that CAT is *strong* (p) provided that p is large enough:

$$\Pr\left(\text{Independence} \mid p \geq \frac{2}{9}\right) = \frac{2}{5} \cdot (1 - p) + \frac{3}{5} \cdot p = \frac{2}{5} + \frac{1}{5}p.$$

However, if CAT is believed to be *strong* with small probability ($p < \frac{2}{9}$) the probability of CAT achieving independence is reduced to 0⁷²:

$$\Pr\left(\text{Independence} \mid p < \frac{2}{9}\right) = 0.$$

The equilibrium described in the previous part assumes that if PE are celebrated, Yes wins, and CAT proposes an UDI, SP would cooperate with CAT and let her enter the EU. This is shown in the following figure:

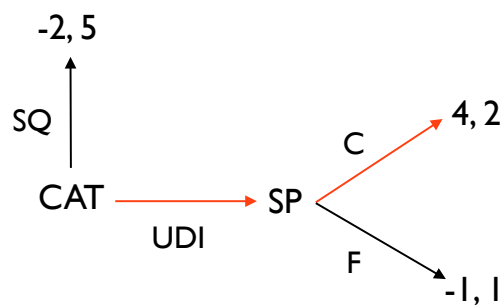


Figure 9

The game displayed in *Figure 9* is an example of the Chain Store game⁷³, and its credible equilibrium⁷⁴ is marked in red. What this equilibrium indicates is that if CAT declares independence unilaterally SP cooperates⁷⁵ and let's CAT achieve independence and enter the EU⁷⁶. The second player is denoted SP, but should be understood as the EU, because entry decisions in the EU have to be taken unanimously by all the member states, and therefore SP could vet the entry of CAT⁷⁷.

⁷² This is explained in detail in Appendix.

⁷³ Osborne, chapter 1.

⁷⁴ That is, a Subgame Perfect Nash Equilibrium, a refinement of Nash equilibrium which rules out incredible threats. Ibidem.

⁷⁵ Cooperation is understood as letting CAT enter the EU and other international organisations.

⁷⁶ The same happens in the Chain Store model where the players are a monopolist, incumbent in a market, and an entrant that wants to enter the monopolist's market.

⁷⁷ Other European states with objectives similar to the Spanish ones might also vet CAT's entry to the EU. This could be, for example, the ones that opposed Kosovo's independence (besides SP): Cyprus, Greece, Romania and Slovakia. Other countries worried about possible secession

If we take into account that there is more than one entrant that wants to enter the EU as independent state (for example, the Basque Country, Scotland or Flanders) the same accommodating equilibrium applies. This is the basis of the Chain Store Paradox (CSP)⁷⁸. However, if the entrants have doubts about the type of the incumbent (EU), the latter may have incentives to maintain a reputation for being tough, and a new equilibrium can be found in which the EU bases her actions (F or C) in a deterrence strategy⁷⁹. In this adapted model of the CSP the EU can be two types, *strong* or *weak*, with some probability. The *weak* type has the same payoffs as SP in *Figure 9*. The *strong* type always fights entry⁸⁰, and therefore has a higher payoff for fighting than for cooperating:

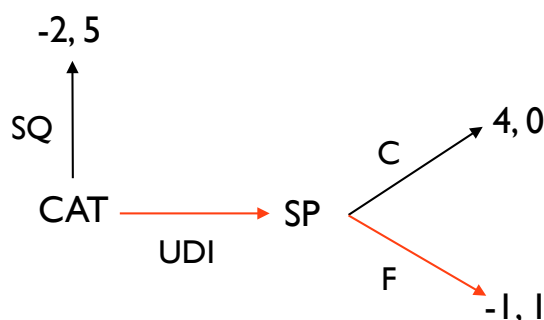


Figure 10

The equilibrium of this game (*figures 9 and 10*) was described by D. Kreps and R. Wilson⁸¹. In this equilibrium a *weak* EU (which has high probability) will fight all the entrants (appearing to be *strong*) until she accommodates (revealing her weak type), and then she will accommodate until the last entrant. This means that if CAT is one of the first entrants, it is likely that EU acts *strong*⁸². CAT would be one of the first entrants, so if we take into account this refinement of the game

processes in their territory (such as the UK and even France) could also exercise their veto power.

⁷⁸ Reinhard Selten, "The Chain Store Paradox", Biefeld University, July 1974.

⁷⁹ Ibidem.

⁸⁰ David Kreps and Robert Wilson, "Reputation and Imperfect Information", *Journal of Economic Theory (JET)*, 1981.

⁸¹ Ibidem.

⁸² Or "crazy" (Paul Milgrom and John Roberts, "Predation, Reputation, and Entry Deterrence", *JET*, 1982).

involving the CSP, we would have to change the payoffs of SP in *Figure 8*. It is worth noting that Joaquín Almunia, vice-president of the EU, stated that if CAT declared independence unilaterally she would not enter the EU⁸³.

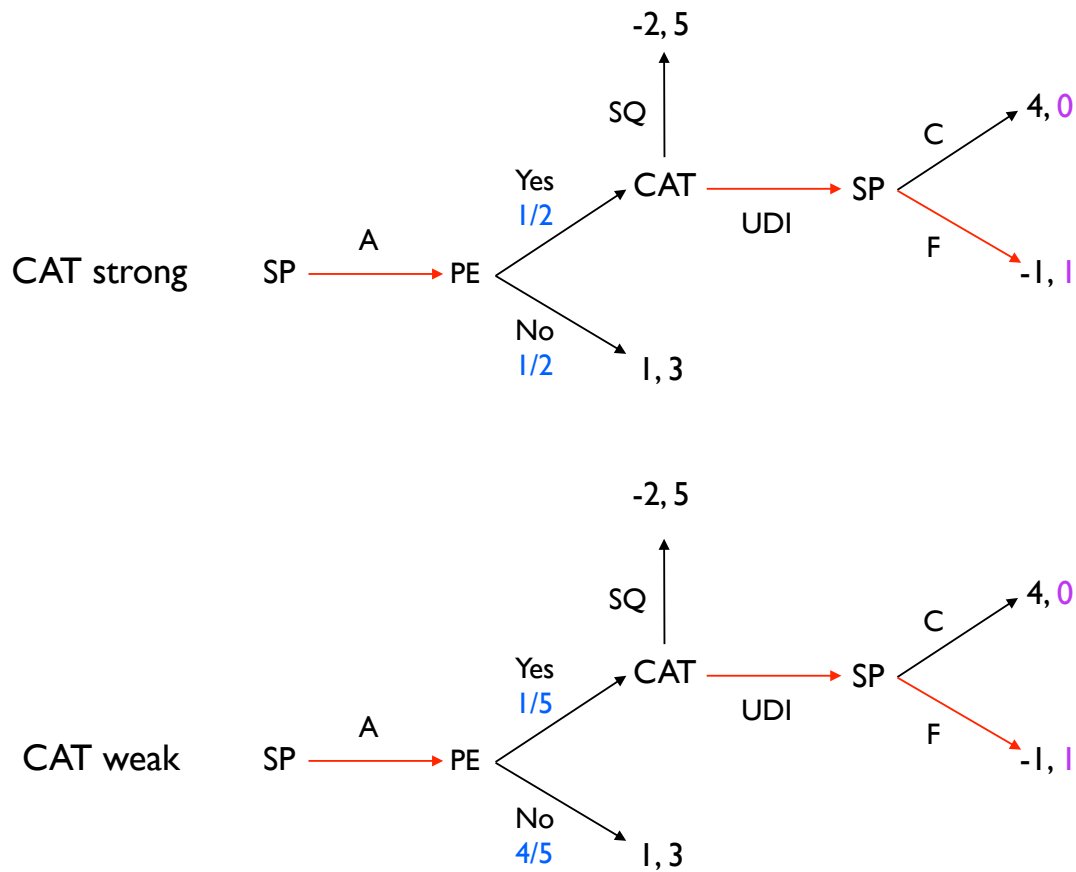


Figure 11⁸⁴

If SP is more prone to fight an UDI, as it is displayed in *Figure 11*, it is assumed that the probability of the PE having a Yes result is fifty-fifty⁸⁵ (noted in blue in *Figure 11*).

If we analyse the modified game the equilibrium that we obtain is different from the original one. For instance, SP would always play Reject in the information set

⁸³ <http://www.elmundo.es/elmundo/2013/09/16/barcelona/1379322361.html>, Europa Press, EL MUNDO, 16/09/2013.

⁸⁴ The payoffs in purple are the ones that have been changed from *Figure 8*. The equilibrium strategies are marked in red.

⁸⁵ This can be explained by the fact that a significant amount of people wouldn't be in favour of independence if they knew that CAT would not enter the EU after an UDI. This is supported by polls made by the CEO. 2nd wave of the 30th Political Opinion Barometer, CEO, Generalitat de Catalunya, 31 May-13 June 2013.

after CAT's NBR⁸⁶, and therefore a fiscal agreement between CAT and SP would never be reached. In addition, the type of CAT would not matter for the equilibrium, because both types of CAT would act in the same way⁸⁷. Finally, there would only be two outcomes to the *Game*, and they would entirely depend on the result of the PE. If Yes wins, CAT would achieve independence but would not enter the EU; otherwise the status quo would be maintained. Interestingly, if we analyse the probabilities of a PE having a Yes result⁸⁸ we can conclude that even if CAT was *strong* the result of the PE would be uncertain⁸⁹, and if CAT was weak the outcome would be a rejection of independence.

If we compute the probability of independence taking into account the refined equilibrium we obtain⁹⁰ that this probability is always between $\frac{1}{2}$ and $\frac{1}{5}$:

$$Pr(\text{Independence}) = \frac{1}{5} \cdot (1 - p) + \frac{1}{2} \cdot p = \frac{1}{5} + \frac{3}{10}p.$$

This implies, perhaps surprisingly, that $Pr(\text{Independence})$ will never be 0, in contrast to the one in the original game which is 0 if $p < \frac{2}{9}$. Furthermore, if $p > \frac{2}{9}$, independence will not be the most likely outcome of the refined game, and its probability will always be below the one in the original game.

⁸⁶ Therefore, there is no need to apply beliefs in the information set.

⁸⁷ The strategies that a *weak* or *strong* CAT would follow in the equilibrium path would be exactly the same, and therefore, CAT's type would not matter.

⁸⁸ 1/2 if CAT is strong, and 1/5 if CAT is weak.

⁸⁹ This is further studied in Appendix.

⁹⁰ This formulae and why the probability of independence never exceeds $\frac{1}{2}$ will be explained in Appendix.

CONCLUSION

To answer the research question: “How will the Catalan secession process develop according to Game Theory analysis?” we summarize the outcomes of the game presented and its refinement⁹¹.

The game describes the secession process of Catalonia through the interaction of Spain and Catalonia. Its equilibrium shows that there exist two possible outcomes to the Catalan secessionist process. The first one is Catalonia achieving independence through a unilateral declaration of independence, if the plebiscitary elections organized by Mas, after Spain’s rejection of his nonbinding referendum proposal, have a positive result. The second one consists on Catalonia getting a new fiscal arrangement and/or constitutional reform thanks to the negotiations started by Spain after the proposal of a nonbinding referendum.

If we take into account the refinement of the game, which models a situation in which Catalonia wouldn’t enter the EU if she appealed to join after an unilateral declaration of independence; the equilibrium of the game changes. The most likely outcome becomes the celebration of plebiscitary elections in a context in which independence is no longer the favorite option of the Catalan electorate.

To conclude, through the analysis of the Game Theory model, we see that the outcome of Catalonia’s secession process depends on her acceptance as a new member of the EU if she was to become independent, and that the probability of Catalonia achieving independence increases with the belief that Catalonia is *strong*. If the EU was to reject Catalonia’s entry, the probability of independence would be small, although it would never be zero. However, if the EU (and Spain) were to accept Catalonia, and Spain’s belief of the probability of Catalonia being

⁹¹ It is important to note that the results obtained are theoretical and are not intended to answer completely a more general question such as: how will the Catalan secession process evolve?

strong was large, Catalonia would most likely achieve independence after a unilateral declaration of independence, and the celebration of plebiscitary elections. Otherwise, if Spain believed that the probability of Catalonia being *strong* is low, independence would never be achieved, but Catalonia would reach an agreement with Spain on her fiscal status after the proposal by Mas of a nonbinding referendum.

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APPENDIX

How to find Expected Payoffs:

In order to find the expected payoffs of a certain action of a player we have to find the terminal payoffs of that action according to the backward induction algorithm. Once we know the payoffs, we have to take into account any probability node (node where a probability is assigned to every action) present in the backward induction path of the branch. If there is any, the expected payoff will be the probability weighted sum of each terminal payoff obtained after the probability node. If there isn't any probability node, the expected payoff will be the terminal payoff reached according to the backward induction algorithm.

In the game, the expected payoff of both players (CAT and SP) if CAT plays PE is calculated the following way:

- If CAT is *weak*:

$$EP_{SP}(R \text{ after } NBR) = \left(2 \cdot \frac{2}{5} + 3 \cdot \frac{3}{5}\right) - 1 = \frac{8}{5}.$$

Remember that $\frac{2}{5}$ and $\frac{3}{5}$ are the probabilities of PE having as a result Yes or No if CAT is *weak*. It is also important to note that 1 is subtracted from SP's expected payoff for a reputational cost that is further explained in the essay.

$$EP_{CAT}(PE \text{ after } R) = 4 \cdot \frac{2}{5} + 1 \cdot \frac{3}{5} = \frac{11}{5}.$$

- If CAT is *strong*:

$$EP_{SP}(R \text{ after } NBR) = \left(2 \cdot \frac{3}{5} + 3 \cdot \frac{2}{5}\right) - 1 = \frac{7}{5}.$$

$$EP_{CAT}(PE \text{ after } R) = 4 \cdot \frac{3}{5} + 1 \cdot \frac{2}{5} = \frac{14}{5}.$$

These are the payoffs that appear in *Figure 6* if SP decides to reject the BR.

The Equilibrium:

In order to solve a dynamic Bayesian game we have to find its Perfect Bayesian equilibrium⁹². An assessment⁹³, a pair consisting of a profile of behavioural strategies⁹⁴ and a belief system, is an equilibrium if the two following requirements are satisfied:

- **Sequential Rationality:** Each player's strategy is optimal whenever she has to move, given her beliefs and the other players' strategy⁹⁵. In the context of our extensive game, sequential rationality requires SP's strategies to be optimal in the part of the game that follows each of her information sets⁹⁶.
- **Consistency of Beliefs with Strategies:** Each player belief at each information set is consistent with the strategy profile and Bayes' rule.

In the game discussed in this paper there are only three information sets where the sequential rationality requires SP's strategy to be optimal, given the subsequent behaviour specified by CAT's strategy depending on her type. The three information sets are: the node after the NBR, the node after the BR, and the node after the PE (all of them after CAT's action). The last two don't need a probability update of SP's belief system because of two reasons. First, according to the consistency requirement the belief system is restricted to information sets reached with positive probability only, and the node after CAT's proposal of a BR is not on the equilibrium path, and therefore has zero probability⁹⁷. Second, the optimal action for SP after CAT proposes PE is always A, regardless of CAT's

⁹² Osborne, chapter 2.

⁹³ Osborne, pg. 325.

⁹⁴ A behavioural strategy in an extensive game is a function that assigns to each information set a probability distribution over the possible actions present in the information set, with the property that every probability distribution is independent of every other distribution. Ibidem.

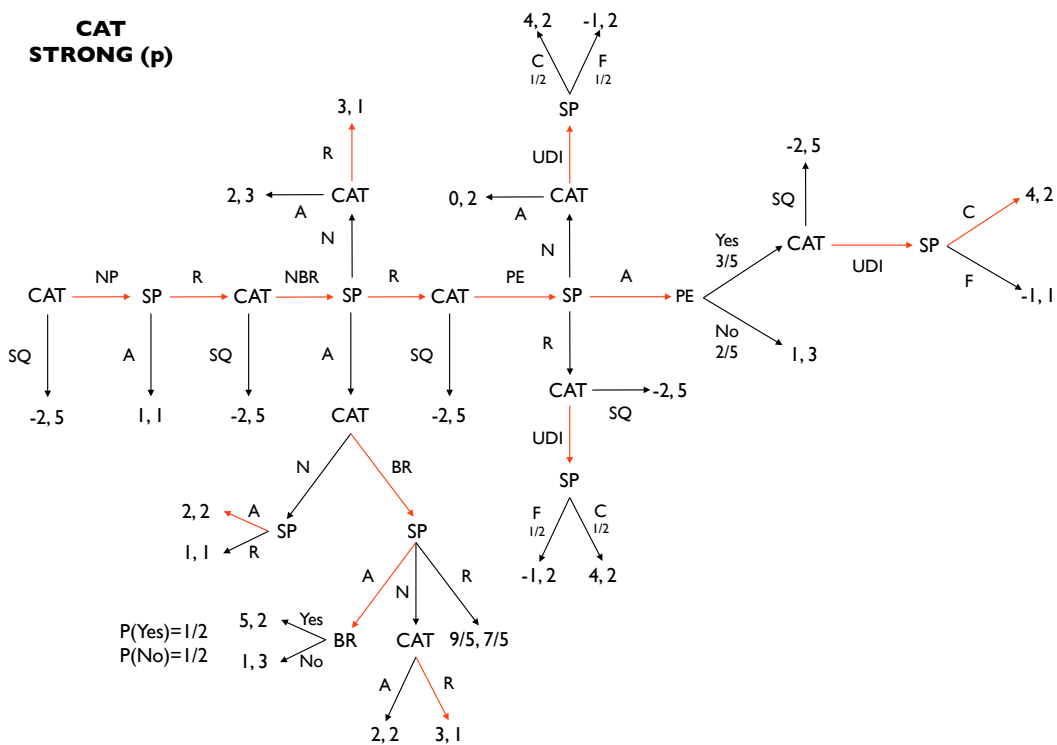
⁹⁵ The requirement of sequential rationality generalizes the requirement in a subgame perfect Nash equilibrium that each player's strategy be optimal in the part of the game that follows each history after which she moves, given the strategy profile, regardless of whether this history occurs if the players follow their strategies. Ibidem.

⁹⁶ Given the strategy profile, and given the player's belief about the history in the information set that has occurred, regardless of whether the information set is reached if the players follow their strategies. Ibidem.

⁹⁷ The probability to reach this node is zero, because if every player adheres to her optimal strategy, this information set will never be reached.

type; therefore SP doesn't need to apply beliefs in this node⁹⁸. The fact that SP only has to apply beliefs in one node of the equilibrium path (which is the first information set where a decision has to be made), makes of our perfect Bayesian equilibrium a degenerated Bayesian Equilibrium. This means that the Bayes updating formulae, which is usually required to find the probability of the belief update, is not going to be used to find the equilibrium of our game.

We obtain that if SP knew that CAT is *weak* she would offer to negotiate (N) after an NBR, and if SP were sure that CAT is *strong* she would reject (R) the NBR, and then accept the PE⁹⁹. All the equilibrium strategies, taking into account the different types of CAT, are displayed in the following two figures in red (with the understanding that the equilibrium path showed in the two figures is the set of equilibrium strategies if Spain would know for sure CAT's type):



Equilibrium strategies if CAT *strong*

⁹⁸ SP's action will always be Accept (A) after CAT's proposal of PE.

⁹⁹ These considerations are made taking into account that SP knows for sure CAT's type, and if our game was of complete information.

$$EP_{Sp}(R \text{ after } NBR) = EP_{Sp}(N \text{ after } NBR),$$

$$3 - 2p = \frac{13}{5} - \frac{1}{5}p.$$

From which

$$\frac{2}{5} = \frac{9}{5}p \rightarrow p = \frac{2}{9}.$$

The probability p obtained, which makes SP indifferent between N and R, characterizes the strategies on the equilibrium path:

- If $p > \frac{2}{9}$, SP's strategies are (R after NP, R after NBR, A after PE, C after UDI) and CAT's strategies are (NP, NBR after R, PE after R, UDI after A), regardless of CAT's type¹⁰⁰.
- If $p < \frac{2}{9}$, SP's strategies are (R after NP, N after NBR) and CAT's strategies are (NP, NBR after R, A after N) if CAT is *weak*, and (NP, NBR after R, R after N) if CAT is *strong*.
- If $p = \frac{2}{9}$, SP is indifferent between R and A in the 4th node (after NBR).

Knowing the probability p that makes SP indifferent between playing R or N after CAT's NBR allows us to relate the probability of CAT being *strong* with the possibility of CAT achieving independence. We can determine the probability of CAT achieving independence as a function of p :

$$Pr\left(\text{Independence} \mid p \geq \frac{2}{9}\right) = \frac{2}{5} \cdot (1 - p) + \frac{3}{5} \cdot p = \frac{1}{5}p + \frac{2}{5},$$

and

$$Pr\left(\text{Independence} \mid p < \frac{2}{9}\right) = 0.$$

These probabilities are calculated taking into account SP's action after NBR, and the probability of Yes after PE for both types of CAT's. Note that if $p < \frac{2}{9}$ the probability of independence is 0, because SP would play N after NBR and Catalonia would never reach independence. This result indicates that the

¹⁰⁰ In this case CAT's strategies are the same for both types of CAT.

probability of achieving independence increases with the belief that CAT is *strong*. However, if the CAT is believed to be *strong* with very small probability ($p < \frac{2}{9}$) the probability of CAT achieving independence is reduced to 0.

Another interesting result is that for the probability of independence to be $\frac{1}{2}$, p would have to be $\frac{1}{2}$:

$$Pr\left(\text{Independence} \mid p = \frac{1}{2}\right) = \frac{2}{5} \cdot \left(1 - \frac{1}{2}\right) + \frac{3}{5} \cdot \frac{1}{2} = \frac{1}{2}.$$

The probability of independence in the refinement of the game with the CSP changes. Firstly, in the refined game, SP always plays R after NBR without taking into account p . More importantly, though, the modifications in the probabilities of the outcome Yes in the PE showed in *Figure 11*, the probability of independence changes:

$$Pr(\text{Independence}) = \frac{1}{5} \cdot (1 - p) + \frac{1}{2} \cdot p = \frac{3}{10}p + \frac{1}{5}.$$

We see that in this case for the probability of independence to be $\frac{1}{2}$, p would have to be 1:

$$Pr(\text{Independence}) = \frac{1}{5} \cdot (1 - 1) + \frac{1}{2} \cdot 1 = \frac{1}{2}.$$

This result shows that in the refined game, independence would only be achieved if the belief over CAT's type is that it can only be *strong*. Therefore, if there is some uncertainty surrounding CAT's type, the most likely outcome is that CAT doesn't achieve independence.

If we compare the probability of independence of the game and its refinement, we obtain that for $p > \frac{2}{9}$, the probability to achieve independence is larger in the original game. Surprisingly, if $p < \frac{2}{9}$ the probability of independence is higher in the refined game, because in the original game if the belief of CAT being *strong* is lower than $\frac{2}{9}$ independence is never achieved ($Pr\left(\text{Independence} \mid p < \frac{2}{9}\right) = 0$).

This result implies that for a small p CAT would most likely achieve independence if the EU was determined to reject CAT's entry, than if it wasn't.