Role of social media in bringing people together for revolutions, elections or any large gatherings – a game-theory model

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1. Introduction

Social media such as YouTube, Facebook, Twitter, Instagram, and Snapchat can be a powerful way to distribute information to loosely affiliated groups of people with a common interest. In many scenarios, it has been regarded as the driving force behind the spread of revolution throughout the world, as new protests appear in response to success stories shared from those taking place in other countries. A typical example of this is the Arab Springs. In Egypt, nearly two-thirds (65%) of the total population do not use the internet. Though most of the country is disconnected from the internet, 84% of those who are online say they visit social networking sites for news about Egypt's political situation (Brown, *et al.*, 1).

Another familiar situation where Social media played a predominant role in shaping the course of major events is the United States presidential elections in 2016. Candidates and users both would share information that influence or change people's views on a specific issue. Survey conducted by Anderson indicates that in US presidential elections overall 20% of social media users say they've modified their stance on a social or political issue because of material they saw on social media, and 17% say social media has helped to change their views about a specific political candidate (1).

From these example, we see that Social media is the big new tool of the Internet, for business, politics, etc, and as of yet there is no one single reason on how it works.

This paper uses game theory concepts from prisoner's dilemma, the Nash equilibrium to see if these strategies can help us understand better how social media works. This paper also analyzes the role of social media in strengthening coordination among players and compares scenarios without social media where coordination failures could happen even if majority of people have common beliefs and goals.

2. Applying Game theory concepts in Social Media

2.1 Efficiency and Pareto Optimality

A resource allocation is Pareto Optimal if it is not Pareto dominated by any other allocation (Berry and Johari, 177). In Game Theory, we say that Pareto Optimal is a state of allocation of resources from which it is impossible to reallocate so as to make any one individual preference better without making at least one induvial preference worse. In social media, if individuals share information where everyone gains some benefits (like a genuine health article) than all individuals have best payoffs and they further retweet or share the news.

2.2 Nash Equilibrium

Social media can be viewed as a network of N players where each player i produces x_i unit of information. Creating a news has a cost, $C_i(x_i) = h_i x_i$, where $h_i > 0$ is a user specific parameter. Each player i connects with E other players(his friends). Hence, this system can be denoted as a connected graph G(V,E) where V = {1,….,N} denotes the set of players and $E \subset V X V$.

Each player receives a payoff of v_i for every unit of x_i if at least one of the user's friends read it where v_i is a user specific parameters.

The utility of player i : $U_i\ (x_i,h_i,v_i) = 0$, if no friend reads the message

$= h_i x_i - v_i\, x_i$, if at least one friend read the message

The system is in equilibrium when every player tries to maximize his payoff and hence generates message such that at least one his friends it. When all individuals in the network generate quality message then there is a higher probability at least one of friends read it and this the Nash equilibrium in social network. Salehisadaghiani in his paper "Nash Equilibrium in Social Media" describes the network model and shows a mathematical example of Nash Equilibrium in social media (3).

2.3 Prisoner's Dilemma

In Prisoners dilemma, it is best for both players to stay silent. But the problem is that both fear by staying silent, the other person will take advantage of the choice and testify against each other. Because, both fear that, both defect and get a lower payoff.

How this dilemma applies to online social media? Social media generate exponentially more content per minute than what can be consumed. The messages generated in social media though would have quality can be missed because the overall quantity of data being generated is so huge. Prisoner's dilemma shows that it's in our best interest to generate quality data than quantity. Users presume quantity gives more payoff and all users end up generating more data and this results in low quality, giving all users the lower payoff in the system (see table 1).

Table 1

Payoff matrix for messages generated by two players in social media:

	Player 2		
		Quality	Quantity
Player 1	Quality	-1, -1	-3, 0
	Quantity	0, -3	-2, -2

Further, whether cooperation or defection (or neither) comes to dominate in social media depends on a multitude of factors: the values of the payoffs, the initial distribution of strategies, the relative speed of the adjustments in strategy and interaction probabilities, and other properties of evolutionary dynamics and much of these remains unknown(Kuhn,1).

3. Revolution as a game theory model and Social media influence

In this section, we analyze the effect of communication technology, especially social media to overthrow a dictator. Subsequently we compare information sets in mass media and social media and conclude on which provides a higher rate of success for revolution to happen.

Below we analyze a game setup adopted from Kiss's "Overthrowing the dictator: a game-theoretic approach to revolutions and media."

3.1 Game Setup

- Players
    - Finite set of individuals, N = {1,2,….,n}, and a dictator

- Strategies
  - Each individual chooses an action $a_i \in \{r,s\}$, r-> revolt, s->stays at home
- Type
  - Each individual is either of type $\tau_i = w$ (willing to revolt)
  - Or $\tau_i = x$ (unwilling)
  - W is the number of individuals who are willing to revolt
    - $\#\{i: \tau_i = w\} = W$, $W \in (0,n)$
  - Individuals decide in a sequence. given by Type vector $\tau = (\tau_1, \tau_2, ...,\tau_n)$
- Utility of each individual depends on individual's type and the outcome of the revolution.
  - A willing individual who participates in the revolt and the revolt succeeds receives a higher payoff ($u_{w, r, R}$) than the individual who is willing at stays at home ($u_{w,s}$). A willing individual who participates in the revolt and the revolt fails receives the lowest payoff ($u_{w, r, F}$), we can visual this a punishment from the dictator.
    - $u_{w, r, R} > u_{w, s} > u_{w, r, F}$
  - A unwilling individual receives a greater payoff if he stays at home, i.e. doesn't participate in the revolt compared to the unwilling individual who participates in the revolt.
    - $u_{x, r} < u_{x, s}$

Note that in the utilities, the first subscript refers to the type of the individual, the second to the action that he undertakes, whereas the third one indicates the outcome. R represents a successful revolution, while F denotes that it has failed.

When is the revolution successful? - If at least t individuals decide to revolt (i.e., $\#\{j \in N: a_j = r\} \geq t$) otherwise the dictator will remain in power even if there are sufficient willing individuals in the society to change the regime. In this game overthrowing the dictator is efficient, but the change requires coordination.

The research consists of showing how different communication technologies, like no technology, mass media technology – radio, newspaper, television and social media technology would affect the outcome of the revolution. Definition and comparison of information set on each of these technologies is as in table 2. Subsequently the Extensive-form representation of the game with each type of media is as in fig. 1, 2 and 3

Table 2
Comparison of Information sets with different types of media
where φ_i denotes the information that individual i has and
p_i represents the number of individuals who have decided to revolt up to individual i

No technology	Mass Media	Social Media
individuals only know their own types, but nothing about other individuals' decisions.	individuals know the amount of predecessors who decided to participate in the revolt, and the number of individuals who decided to stay at home	Individuals know each of the predecessors decision in order
$\varphi_i = \{\tau_i\}$	$\varphi_i = \{\tau_i, p_i, i-p_i-1\}$	$\varphi_i = \{\tau_i, \{a_j, \forall j<i\}\}$

Fig 1. Extensive-form representation of the game with no technology

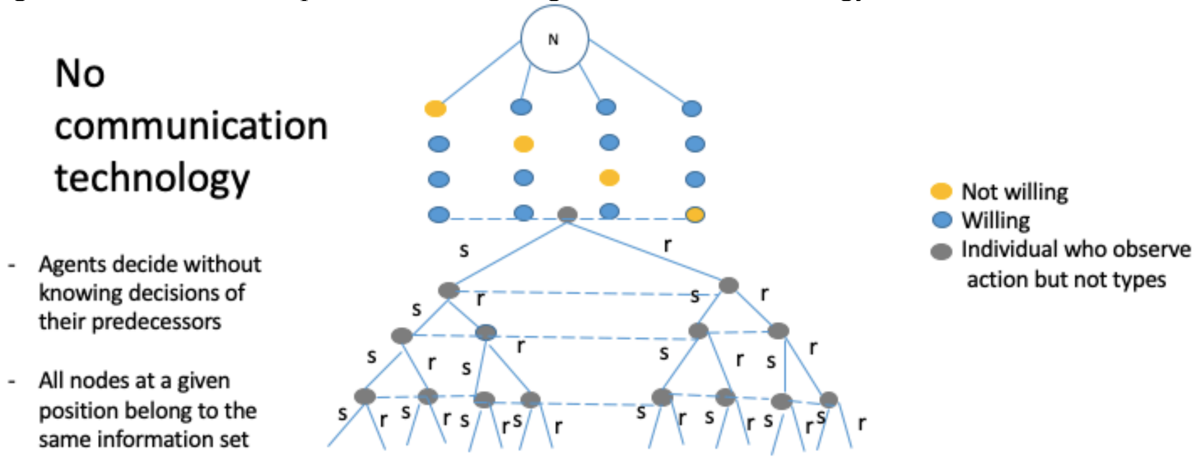


Fig 2. Extensive-form representation of the game with mass media

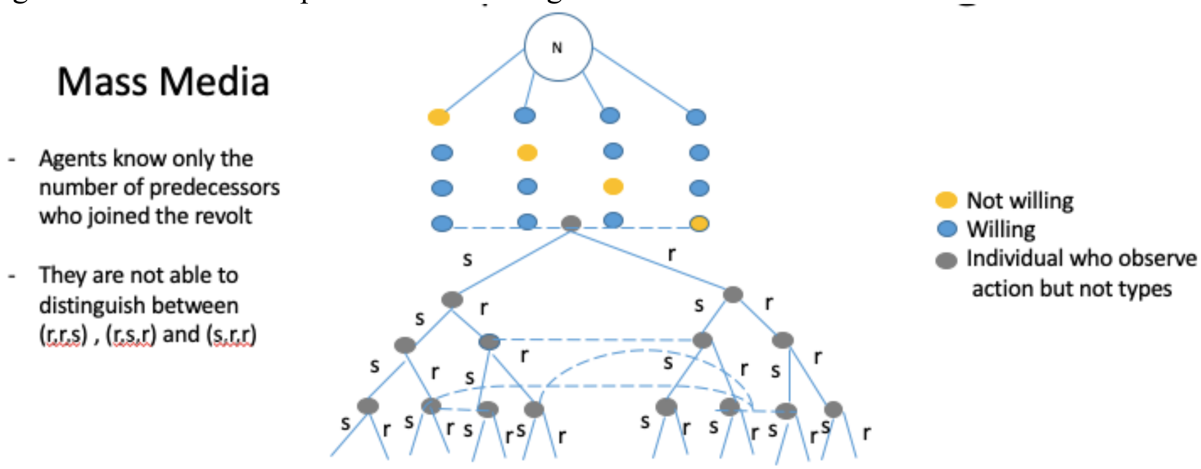
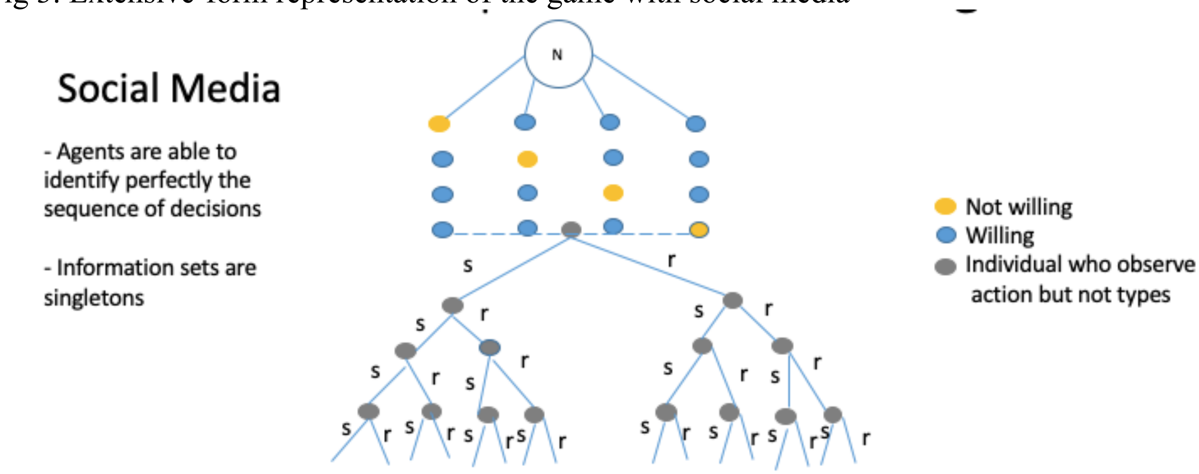


Fig 3. Extensive-form representation of the game with social media



The game becomes more sequential as we move from the case without communication towards social media.

3.2 Analyzing the game with simulations

This section describes implementation of the game and recording the observations. For this purpose, I developed a simulation of the game in Python. The complete code can be found in Github (https://github.com/nlakshmanan/revolution_game). The major parameters and functions of the game are as below:

Parameters

1. n: Total number of players
2. t_percent: Percentage of players needed for the revolt to succeed
3. w_percent: Percentage of players willing to revolt
4. frequency_deviation: This is a major feature that sets the percentage of willing individuals who deviate from revolting thinking the revolt would fail. For example if n=10 and frequency_deviation = 2 , then for every 10 individuals willing, 2 people deviate

Functions:

1. set_force_revolution_possibility(self,mandatory):

   This function ensures that w_percent is always greater than or equal to t_percent, so that there is a possibility for the revolt

2. get_suceess_rate(self):

   Returns percentage of willing people who revolted against the number of people needed for the revolt to succeed. If the success rate is greater than or equal to 100% than the revolt triumphs.

By varying parameters t_percent, w_percent and frequency_deviation for any n, we can accommodate various results for different types of media (see table 3)

Table 3
Results of simulation depicting revolution success or failure

n	t_percent	w_percent	Frequency_deviation	Result	Figure
1000	40	50	0	Revolt succeeds, this is the case of social and mass media with type as public	4
1000	40	50	1	Revolt fails as every willing individual deviates – no technology case	5
2000	50	55	5	Revolt fails even when there are sufficient number of willing individuals (Mass media with type as private)	6

Note: In all graphs the blue line shows number of people participating in the revolt while the yellow line depicts t (minimum number of people required for revolt to succeed).

Fig 4. Graph depicting success of revolution – mass and social media with type as public

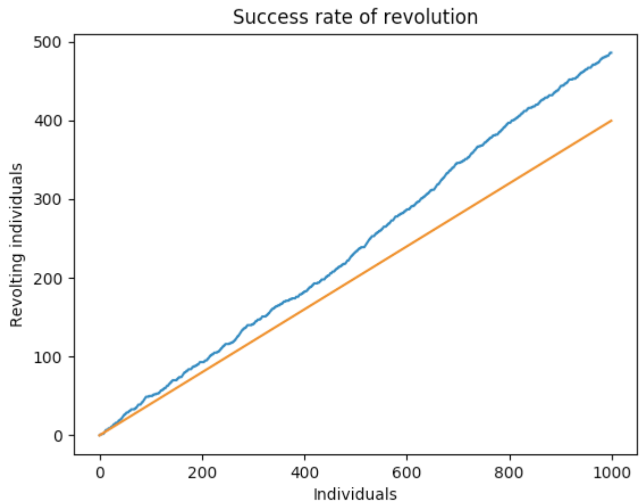


Fig 5. Graph depicting failure of revolution – where all willing individuals deviate (no technology case)

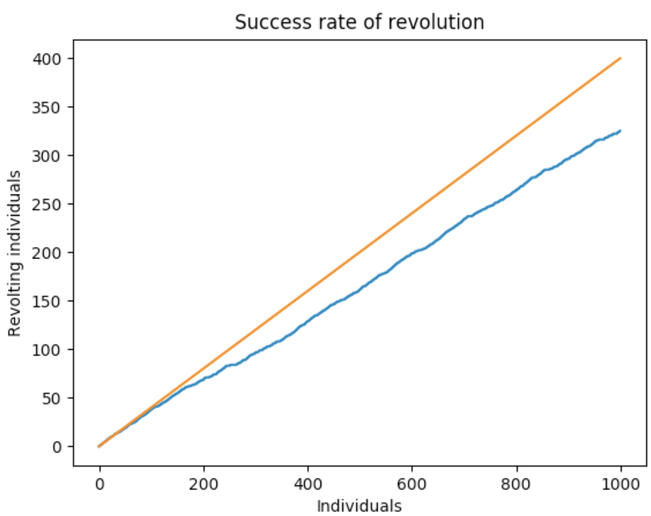
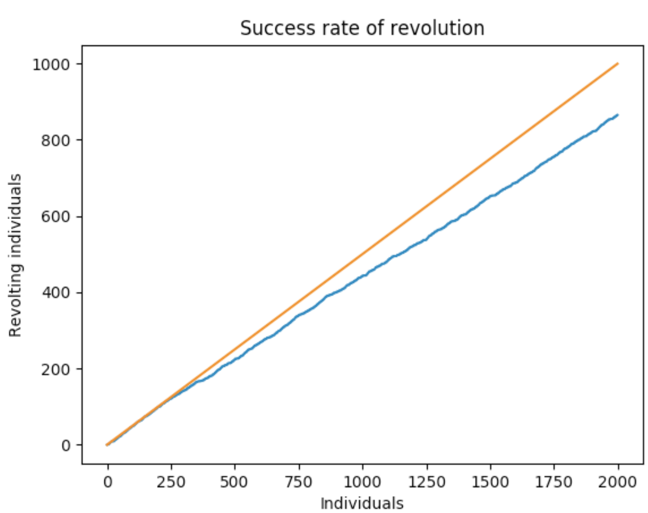


Fig 6. Graph depicting failure of revolution – even when there are sufficient number of willing individuals (Mass media with type as private)



3.2.1 No communication technology

In this setup there are multiple equilibria - there are two symmetric equilibria: one in which all willing individuals participate in the revolution; and another one in which no willing individual participates. Since, $u_{w,\mathbf{r},\mathbf{R}} > u_{w,\mathbf{s}} > u_{w,\mathbf{r},\mathbf{F}}$ for the willing individuals it is optimal to revolt if the other willing individuals are revolting, while it is optimal to stay at home if nobody else is revolting and this result does not depend on whether type is a public information or not.

3.2.2 Mass and Social Media with type as public information

This is a dynamic game with perfect information setup in which the willingness to revolt is transmitted by the communication technology. In this setting, an individual who observes an action will know whether a willing or an unwilling individual took it. Every willing individual tends to revolts in any subgame perfect equilibrium under both communication technologies.

The rational behavior of a willing individual is to join the revolution if she observes t-1 individuals have revolted. A willing individual who observes t-2 people participating in the revolution decides to revolt if she knows that after her there is at least one more willing individual. This setup guarantees that revolution triumphs.

3.2.3 Mass and Social Media with type as private information

This is a dynamic game with imperfect information as the individuals are unable to distinguish between "willing and stay at home" and "unwilling" people. With Mass media, the information set being $\varphi_i = \{\tau_i, p_i, i\text{-}p_i\text{-}1\}$individual knows only his type and how many have revolted before him. With Social media, the information set is $\varphi_i = \{\tau_i, \{aj, \ \forall j<i\}\}$ where the individual knows exact sequence of decisions but cannot perfectly the type of his predecessors (i.e. who have revolted or stayed at home? – willing or unwilling".

In this setup, under social media being truthful is the unique equilibrium profile. The unique Nash equilibrium being staying at home when an individual is unwilling (as it will give him the highest utility, hence he won't deviate) and revolting when willing.

Hence, we can conclude that in social media, if the number of willing people meet the requirement t, the revolt will always succeed in equilibrium.

Under mass media revolution succeeds only when a willing individual believes that there are at least t-1 people along with him to participate in the revolt. Based on n, W and t, each willing individual generates a Bayesian payoff and if there is no unilateral deviation gives a better off, he participates in the revolt. Hence, here a Bayesian Nash equilibrium exists.

The difference between mass media and social media when type is private is that in social media individual are able to distinguish the histories (r, s) and (s, r) while with mass media individuals may believe that (with some positive probability) the one who stayed at home is a willing individual.

4. Conclusion

From above experiments and study, we can conclude that there is an equilibrium in revolution where a revolt happens provided the individuals in revolutions use social media. With mass media, a revolt may happen at Bayesian Nash equilibrium and with no technology communication there is a coordination failure where all willing individuals could prefer not to revolt. Comparison of social media with other two types of communication shows the impact social media has on revolutions.

5. Future Work
   We can model social media as a network with multiple groups consisting of individuals. Each group shares a common opinion and what are conditions in which equilibrium can occur. Other way to alter the model is to introduce punishment from dictator, this could reduce the success rate of social media. We can further extend this game model to analyze guest behavior in large social gatherings.

6. Works Cited

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