Annex A.

Social unrest and agent based models

In the same way as financial markets are complex systems and show potential systemic large-scale effects, dynamics of social unrest do. As argued above, agent based models - provided they capture essential features - allow for an understanding of a series of fundamental issues of dynamics of social unrest. In particular these models may help to estimate the role of certain conditions that lead to the outbreak of phases of large-scale non-cooperative behaviour. One of these models, which was mentioned in the context of financial markets, is on the verge of becoming sophisticated enough to be of actual use.

For a discussion of the agent based model see Epstein (2002). In his strongly simplified "world" there exist two types of actors, agents A, and cops C. The agents, representing people in a society can be found in two modes, they are either silent or they engage in rebellious acts, they take part in "revolutionary" actions against their e.g. political or economical system. In the model it is not specified, what these systems are, the focus rests entirely on the dynamics of social unrest. Also what social unrest means in this context is not further explained in the model, all that counts is the number or fraction of agents actively participating in "revolutionary" actions at a given point in time. Let us call these agents "active" which are in the revolutionary mode, while the others are called "silent".

The role of the other type of actors, the cops is simply to remove (to "jail") the active actors. Cops can spot active agents within a given range, and will arrest them when they encounter them. Each cop can arrest one active agent per time unit only, meaning that if many agents are active within a region with a limited number of cops around, the individual risk for active agents to be arrested becomes small. The agents can sense the presence of cops, which influences their decision of whether they are in the active or silent mode. The essence of models of this kind is the way agents decide in which mode they operate. In Epstein's model the decision process works as follows. Each agent has a certain "grievance" which characterizes her. Grievance G is modelled as a product of hardship H and illegitimacy of a present regime I, $G = H * I$. The more hardship one has to bear the more grieve, the more illegitimate a certain regime, or certain surroundings are, the harder it is to bear these surroundings.

Any agent in the model that decides to become active faces the risk of being arrested, this risk being proportional to the ratio of cops versus active agents within a given region. The higher the number of police the higher the risk of being arrested, the higher the number of activists, the less likely the risk. Agents are further characterized by a random risk-aversion factor, quantifying their readiness to become active, given a certain probability of being arrested. The net risk for an agent to be arrested is called N. Agents are allowed to change their mode and their positions in the model. They change their mode from silent to active, whenever the difference of their grievance with respect to

their risk of being arrested exceeds a pre-specified threshold, T, i.e. $S \to A$ if $G - N > T$. Cops are only allowed to change their positions.

These rules can be implemented in a simple computer algorithm to study the emerging properties of the model. Even though the model is undoubtedly a severe oversimplification of reality, surprisingly, it captures a series of known features of dynamics of social unrest. Again, as before, the agent based setup can now help to identify the key components, conditions and scenarios that lead to outbreaks of social unrest. It is not the intention of the model to predict a specific outbreak, or the time of an outbreak - which would be certainly impossible for any system. What can be studied, however, is the probabilities and detailed mechanism how, and under what circumstances social unrest unfolds, propagates and eventually ceases.

Some of the lessons that can be immediately learned from the model of Epstein (2002) are:

- Free assembly of agents facilitates revolutionary outbursts
- Revolutionary outbursts tend to happen whenever a measure for social tension builds up. This measure is basically derived from an average of agent's grievance their risk aversion, paired with a high frequency of extreme grievance agents
- Abrupt legitimacy reductions correspond with large risk of outbursts, whereas gradual reduction (or decline) of legitimacy, such as constant reports on corruption within a regime, is much more stable in terms of outbreaks of social unrest.
- The distribution of drastic events over time (inter-event time of large scale outbursts) follows an approximate Weibull distribution
- The size distribution of drastic events (number of agents being active during an outburst) shows a nontrivial peak at high numbers, meaning that if there outbreaks of unrest they tend to be big.
- Effects on the reduction of the number (density) of cops in the system can be explicitly studied.

In summary, the findings of Epstein (2002) suggest that the key elements for develop outbreaks of social unrest are associated with three elements: (i) Economical, social or political grievance which is composed of perceived hardship and perceived illegitimacy of the system. (ii) low risk of consequences of taking part in revolutionary action and (iii) low risk aversion and mobility of agents. The agent based model teach that not one of these factors is sufficient alone to dominate the risk of unrest, but indicates that certain ratios and combinations are able to determine when a system is “ripe” for social unrest. A system which is ripe for unrest then just needs a “triggering” event which starts a large-scale outbreak - as spark.

It is maybe within reach to design models as the above and isolate relevant measures which allow to estimate the risks for potential outbreaks of social unrest. It may also be possible with the use of novel data-mining techniques and data sources (such as mirrors of opinions on specific issues such as blogs, or opinion fora such as facebook, twitter, etc.)[5] to access some of the relevant parameters in real life so that the ripeness can be

[5]One such approach is followed in recent exploratory research activity at IIASA, involving the author.

actually estimated. The actual triggering events for outbreaks, of course, will most certainly never be predictable.

Finally, let us mention that extensions to this model particular model are applicable to study unrest between groups, such as inter-group violence, dynamics of ethnic cleansing, and the role and usefulness of peacekeepers (Epstein, 2002). Again here it is by no means intended to apply these models to real situations such as what happened e.g. in the Yugoslav war, but to point out the core elements of dynamics, and parameters which - if they were accessible - could be used to manage the scale and the unfolding of inter-group violence.

Questions to be asked: What are typical pathways to social unrest? How can parameters for risk of outbreaks be accessed? How can the unfolding of social unrest be managed?

A.1 Pathways toward social unrest: Linking financial crisis and social unrest through agent based frameworks

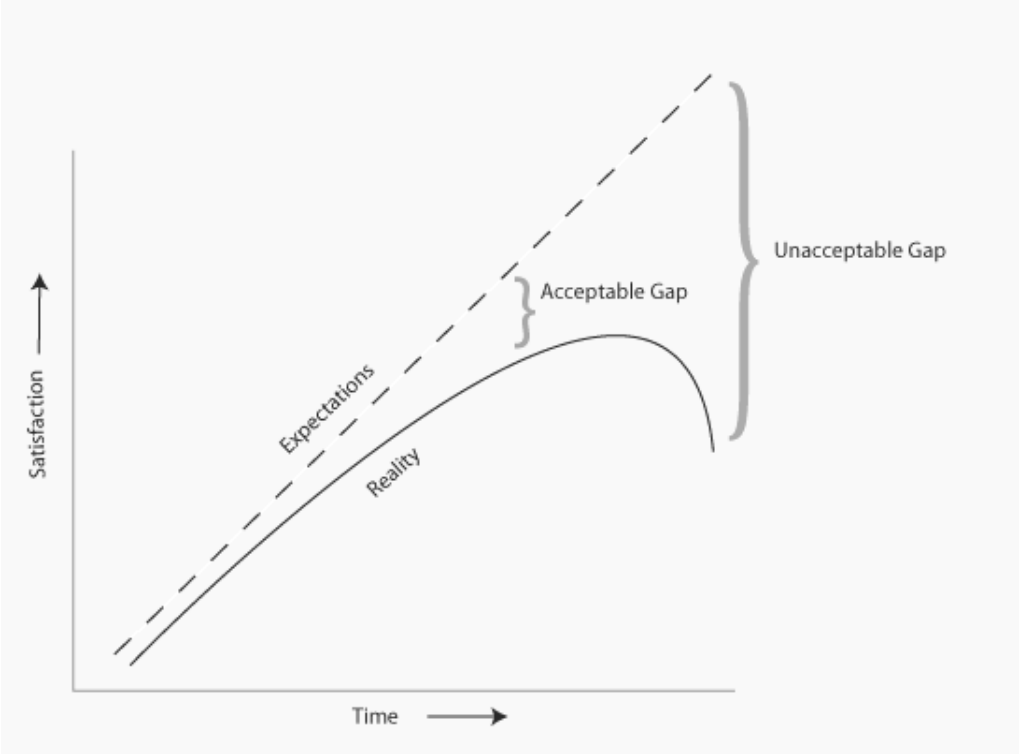
In an increasingly globalised world, financial crisis undoubtedly has regional and in severe cases global consequences. Financial crises can contribute to a series of risks eventually leading to social unrest, be it directly or indirectly. The following sketches some pathways for this interaction. A particular model of financial agents and the role of leverage in financial markets will be presented in Section 2. Similar to the model of social unrest mentioned above this model will show how certain circumstances can lead to drastically inflated levels of risk for financial collapse. Whether collapse then occurs or not depends whether a triggering event of a certain type will take place or not. In case it does, and crisis unfolds it is known that often a process of deleveraging follows, which can have direct impact on social mood, and grievance as discussed above.

Examples of how painful this process can be has been seen in times following the financial crisis of Argentina in 2001, South East Asia in 1997 and lately in Greece 2009-2010, all involving outbreaks of social unrest of some kind and scale.

Pathways to high grievance: destroy expectations

High levels of grievance are often associated to unfulfilled expectations of people. Effects can be especially pronounced if the times needed for "disillusioning" are short. It has been noted long ago, that (Davies, 1962) "... Revolution is most likely to occur when a prolonged period of rising expectations (material and non-material) and rising gratifications is followed by a short period of sharp reversal, during which the gap between what people want and what they get quickly widens and becomes intolerable ..."

Figure A1.1. Davies J-curve



Source: http://www.globalpost.com/dispatch/commerce/090206/peasant-revolution-20.

This concept has been made intuitive by the so-called Davies J-curve, see Figure A1.1. On the y-axis the expectations of people are shown. The straight line corresponds to extrapolations of expectations people have; the full line represents reality, what people actually *can* have at a certain point in time, due to the present political, social and financial circumstances of the system. The size of the gap can be directly related to hardship, which plays an important role in the level of grievance in the above discussed model of social unrest. It is clear that the state of the financial system has direct implications on the gap. Financial crisis and its consecutive periods of a potential economic crisis and / or deleveraging can lead to a sharp downturn of the "reality" curve. In particular if the financial crisis has implications on basic needs of housing grievance can increase sharply. Drastic decreases in real estate prices can lead to mortgages which become unrealistic to repay leaving a feeling of financial inflexibility and potentially to lifelong debt and irrecoverable poverty. The same holds true for potentially lost private savings, e.g. through a hyperinflation scenario, which becomes realistic in times economies approach insolvency or when public money is used for recovery programs whose outcome is unsuccessful.

Ways to reduce legitimacy

Legitimacy can be seen as a major component for social unrest. Finance-related mechanisms which lead to a decline of legitimacy of a systems are not hard to find: Use of tax money to bail out defaulted financial institutions. Taxpayers are aware that they have had no share in profits of these firms, but find themselves now financing the risk of the "rich". Linkages of the political and financial worlds, such as the role of Wall Street

in the bailout program, the role of former Goldman Sach employees in political decisions related to bailouts, etc. Further handling and open fraud of national accounts Greece by Wall Street firms. The actual and perceived lack of consequences of large scale fraud in politics and finance, bonuses paid with tax money, failure and corruption within regulatory bodies, etc.

A.2 Pathways to social unrest not directly related to financial crisis

There exist several important factors that directly affect the systemic risk of social unrest, which are not directly related to financial.

Reducing risk of consequences, "reducing cops"

In the Epstein model it was shown that the reduction of "cops" (i.e. the consequences for actions against the system) can have a severe effect on the outbursts of social unrest. In the real world this does of course not necessarily mean real policemen, but the perceived negative total value of the consequences following the discovery of an action against the system. This involves education, deterioration, etc.

Reduce risk aversion

A relevant parameter is the risk aversion, i.e. how much they fear the consequences for subversive behaviour against a regime or system. Risk aversion is often seen as a parameter which depends on the levels of wealth of an individual. The poorer a person the more risk averse she is. Risk aversion also largely depends on how much a person perceives to be able to lose in a particular action or decision. Risk aversion in this sense bears an educational component to a certain degree.

Mobility: physical and information

Finally, mobility (physical or the ease of communication spreading) has been known to be a relevant factor for social unrest. The model of Epstein (2002) produces further evidence for this and provides insight in the mechanism of why this is so.

References

Davies J.C. (1962), "Toward a theory of revolution", in *American Sociological Review*, Vol. 27, pp. 5-19.

Epstein, J.M. (2002), "Modeling Civil Violence: An agent-based computational approach" in *PNAS*, Vol. 99, Suppl. 3, pp. 7243-7250.