Modeling international crisis synchronization in the World Trade Web

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The study of financial crises has always attracted a fair amount of interest, specially since the bankruptcy of Lehman Brothers in September 2008, but we still know very little about them. Minsky[1] defined financial crises as a natural consequence of changes in the economic cycle and the fragility of the structure of debt. Recent theories of financial fragility link globalization with economic cycles, i.e. when local crises coincide with bad credit regulation and failures in international monetary arrangements. Here we analyze how the effects of globalization can affect the financial crisis spread. To this end, we use the network of international trade (WTW)[2] where we will represent each country economical cycle with a oscillator and the interaction between them will be performed through the commercial channels. We analyze how this synchronization is driven at the mesoscopic scale, by the existence of modules in the network representing stronger associations of trading between certain groups of nations.

WTW is formed by N nodes, one for each country, and L links that correspond to weighted trade flows. To model the economic cycle of each country we associate a Mirollo and Strogatz Integrate-and-Fire oscillator (IFO)[3] to every node. These oscillators are characterized by a monotonic increasing state variable $x \in [0, 1]$ that evolves according to a phase $\phi \in [0, 1]$. When the variable x of a node attains the threshold $x = 1$ it is said to *fire*, and it is instantly reset to zero, after which the cycle repeats. This node, in turn, transmits to all its neighbors j an excitation signal of magnitude $\varepsilon_{ij} > 0$, thus leaving their state variables with value $x_j^+ = x_j + \varepsilon_{ij}$, or 0 if node j also fires.

When a nation *fires*, it propagates the problem to other countries by boosting their own evolution to a crisis. WTW presents a large diversity in the economic weights, and it is reasonable to think that a shock in a small country is not spread to a large country with the same intensity than vice versa. To reflect this dependence we set the excitation signal of node i to its neighbors j as

$$\varepsilon_{ij} = \frac{w_{ji}}{s_j^{\text{out}}}\,, \tag{1}$$

which is the fraction of total exports of country j going to the firing node i.

To simulate this system we have choosen two snapshots of the WTW network belonging to the pre-globalization period (1970) and to the globalization period (2000). To evaluate the interaction dynamics, we follow the classical analysis of the order parameter r that indicates the degree of synchronization of the system. In our setup, synchronization will reflect the scope of the crisis at the international level. The order parameter, which only depends on the phases ϕ_j of the oscillators, is

$$r = \left| \frac{1}{N} \sum_{j=1}^{N} e^{2\pi i \phi_j} \right| . \tag{2}$$

In Fig. 1 we show the comparison of the results of r of the WTW in front of that of each community of the network (r_α). The dispersion along the diagonal shows the discrepancies between the mesoscopic view and the global view. In 2000 the signs of globalization are clear, the dynamic effect of the mesoscopic structure is practically collapsed to the global world scale behavior. These observations allow us to conjecture that the effect of topological borders of the communities have almost no effect after globalization emerges.

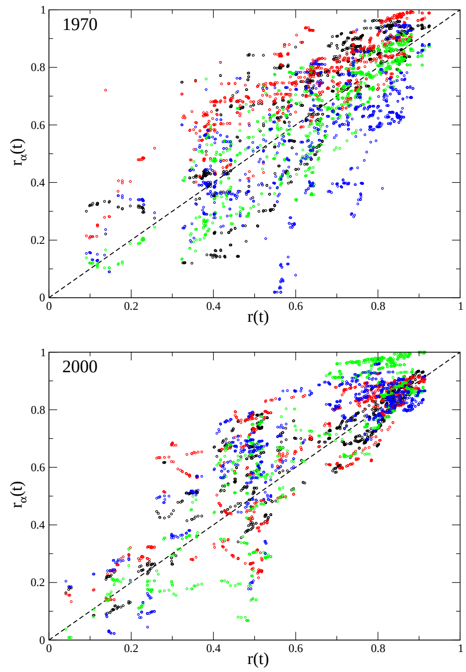

FIG. 1. Deviation of the synchronization of the communities r_α in front of the global r. Colors correspond to the communities found by modularity maximization[4].

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[4] `http://deim.urv.cat/~sgomez/radatools.php`