Distress propagation from financial sector to real economy through supply-chain network in Japan for the period of 1980 and 2015 – Spin network model for global macro-prudence analysis –

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Economic crisis in 2008 showed that conventional micro-prudential policy to ensure soundness of individual bank was not sufficient and prudential regulations to cover the whole financial sector were desired. The prudential regulations to cover the whole financial sector attract rising attention and policy related to the regulations is called macro-prudential policy. The purpose of the macro-prudential policy is to reduce systemic risk in the whole financial sector by regulating relationship between the financial sector and real economy. In this paper, using a spin network model, we study channels of distress propagation from financial sector to real economy through supply-chain network in Japan from 1980 to 2015, and discuss a good indicator for macro-prudential policy.

Stock price $p\_{i,t}$ is surrogate variable to indicate soundness of each company and bank. Spin variable $s\_{i,t} $was estimated from log return of daily stock price $r\_{i,t}$: $s\_{i,t}=+1 $($r\_{i,t}\geq 0$) and $s\_{i,t}=-1$ ($r\_{i,t}<0$). Spin variables of companies interact with spins of other companies through supply-chain network and interacts with banks through lending network. Data of the supply chain network and the lending network are prepared by Tokyo Shoko Research, Ltd. Hamiltonian of the system is $H=-\sum\_{i\in C}^{}H\_{C}s\_{i}-\sum\_{i\in B}^{}H\_{B}s\_{i}-\sum\_{i\in C,j\in C}^{}J\_{C}a\_{ij}s\_{i}s\_{j}-\sum\_{i\in C,j\in B}^{}J\_{CB}a\_{ij}s\_{i}s\_{j}$, where $HC$ and $HB$ are the external field acting on companies and banks, respectively. $a\_{ij}$ is elements of adjacency matrix. When spins are set on external field $H\_{ext}$, effective field $H\_{eff}=H\_{ext}+H\_{int}$ acts on each spin. By calculating interaction $H\_{int}$ considering nearest neighbor interactions, external field $H\_{ext}$ was estimated by $\frac{\sum\_{i}^{}s\_{i}}{Nμ}=\tanh(\left(\frac{μH\_{ext}}{kT}+\frac{zJ}{kT}\frac{\frac{1}{z}\sum\_{ij}^{}\left(a\_{ij}+a\_{ji}\right)s\_{i}}{Nμ}\right))$, where $T$ is temperature and $z$ is average degree, for six major communities: financial sector, C4 (agriculture, forestry and fisheries, mining, construction, transportation equipment, precision machinery), C5 (petroleum and coal, rubber, ceramic, steel, non-ferrous metal, metal product), C11 (textile, pulp and paper), C15 (chemical, pharmaceutical product, wholesale and retail trade, real estate), and C23(machinery, electric machinery) identified by analyzing the supply chain network.

The obtained external field acting on financial sector shows that large negative shocks at the beginnings of $T\_{c1}$(1989) and $T\_{c2}$ (1997), but no large negative shock at the period of $T\_{c3}$ (2008). This is interpreted that the effect from US subprime loan crisis to Japanese economy was introduced through shock in real economy (e.g. the sudden decrease of export to the US), not by shock in financial sector directly. For communities C4, C5, and C23, no large negative shock was obtained at the beginnings of $T\_{c1}$(1989) and $T\_{c2}$ (1997). We note that $M\~-1$ is observed for these communities at the beginnings of $T\_{c1}$(1989) and $T\_{c2}$ (1997). These are interpreted as evidence of the channels of distress propagation from financial sector to real economy through supply-chain network in Japan from 1980 to 2015.

Furthermore, relationship between external fields (acting on financial sector, C4, C5, C11, C15, and C23) and macroeconomic variables (Monetary base, Call rate, Exchange rate, Money stock, Bank lending, Land price index, and Number of bankruptcy) were examined using Vector Auto Regression analysis. Causal networks among these variables were constructed with directed links from explanatory variables to explained variables in the periods of bubble and crisis. Path length, in-degree, and out-degree were estimated for the causal networks in the periods of bubble and crisis. These quantities were used to characterize change of the causal relationship from the bubble period to the crisis period. The results are as follows: (1) External fields acting on C5 and C15, Monetary base, Money stock, Bank lending, Number of bankruptcy caused delay and Exchange rate caused lead at the bubble burst. (2) Call rate, Exchange rate, Money stock, Land price index obtained larger in-degree and Bank lending obtained smaller in-degree at the bubble burst. (3) External fields for other than financial sectors, Call rate, Exchange rate, Money stock, Land price index obtained larger out-degree and Monetary base and Bank lending obtained smaller out-degree at the bubble burst. In summary we can say that monitoring temporal change of the external fields and the causal relationship among the external fields and macroeconomic variables will provide good indicators for macro-prudential policy.



Fig.1 Magnetization and the estimated external fields acting on banks (financial sector), C4, and C5.