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**Declining Trust in Growing China.
A Dilemma between Growth
and Socio-Economic Damage**

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PREFACE

Dear Reader,

The *IN-EAST School of Advanced Studies* constitutes a joint enterprise of researchers at the IN-EAST and colleagues in various faculties and research networks at the University of Duisburg-Essen. It has been founded in order to explore the issue of innovation in East Asia from a multi-disciplinary perspective that allows for the generation of new knowledge and the advancement of new methodological approaches.

The *IN-EAST School of Advanced Studies'* **research agenda** takes the embeddedness of processes of *innovation* in society as a whole as its general interest. In this context the focus lies on the interdependent topics of *electro-mobility* and *urban systems*. All research activities take East Asia (China, Japan, Korea) as subject of their analysis, but provide interfaces for international comparisons and comparative research agendas.

Innovation is understood as a social phenomenon that does not only cover the act of technological innovation but must be embedded in specific 'social technologies' that create innovation-inducing environments and promote the diffusion of new technological solutions in the socio-economic system in order to succeed. The starting point of the research effort may therefore be seen in the trans-disciplinary innovation literature highlighting the institutional foundations of national, regional, sectoral as well as technological innovation regimes. These specific institutions can be interpreted as 'capital goods' determining the productivity of individual and social innovation efforts. But as these embedding institutions are existing in specific national cultures and follow different cultural, political and technological path dependencies, innovation in general must be understood as a process that is very much determined by ideosyncratic national and cultural characteristics.

Based on this understanding we believe that a systematic collaboration between different systemic disciplines and area studies can generate significant advances in our knowledge of innovation in general and the parameters of national, regional, sectoral as well as technological competitiveness.

The **organization of research** is based on the research group concept already well established in the natural sciences but still new to social sciences. The *IN-EAST School of Advanced Studies* has at its core feature six research groups, which are constituted by one Junior Professor / Postdoc and two PhD students each. Each of these research groups works on one specific aspect of the overall research agenda. Communication and exchange of ideas, results and insights between the groups are facilitated by a series of workshops and joint events as well as a team of mentors coming from the University of Duisburg-Essen as well as leading international institutions. These mentors do not only become the formal PhD supervisors in the respective faculties and provide advice and support for specific research activities but also provide intellectual bridges between the research groups and work on meta-topics devised to establish a coherent picture of the joint research effort.

Starting with this issue of the Working Papers on East Asian Studies we are beginning to present some results of the work of the *IN-EAST School of Advanced Studies* to the scientific community for discussion. All feedback is highly welcomed.

Markus Taube
Director, *IN-EAST School of Advanced Studies*

CONTENT

SHUANPING DAI / WOLFRAM ELSNER:

Declining Trust in Growing China.

A Dilemma between Growth and Socio-Economic Damage

Abstract

Declining general trust has become a serious social issue in China in recent years. This paper attempts to understand and analyze this social phenomenon from a social interaction perspective. Based on a repeated prisoners' dilemma game on networks, it finds that the evolution of general trust is dependent on changes of the social interaction structure, and the increases of both social and spatial distance may explain a decrease of the levels of cooperation and general trust. In addition, we find that the traditional Chinese family and clan networks culture has an ambiguous effect on general trust, and simple reactive social "homing behavior" might be critical for China's future economic development. In order to recover the general trust level, a major strategic option for China, and for fast growing countries in economic transition in general, is to (re-)develop appropriate network structures and properties, as our model indicates.

1 INTRODUCTION

There has been a long discussion in economics about the *distributional effects of longer periods of transition and growth*. The famous *Kuznets Curve*, for instance, suggests that phases of fundamental structural and systemic transitions, such as the transition from agrarian feudalism to industrial capitalism, are connected, through complex socio-politico-economic causations, with, at first, an *increasing unequal distribution of income, wealth, and power* (see Kuznets 1955).[1]

The process of so-called *economic transition* of the ex-state-socialist countries to more or less radically neoliberal systems in *Middle and Eastern Europe* (MEE) during the 1990s and 2000s, and – with some qualifications – also in mainland China (and even since the late 1970s), may be considered a similarly fundamental systemic transition as industrialization and capitalization, and the same phenomena can be observed. What is different, though, in the case of MEE, is that these processes were heavily controlled from outside, i.e. largely influenced by foreign dominating countries, while the preexisting institutional arrangements were torn down in an extremely short period of time, compared to the longer historic processes as in the case of the birth of capitalism in the 18th and 19th century.

As the systemic transition in *China* has been more internally controlled and developed over a longer time period, it has experienced a historically unprecedented *growth surge* rather than the breakdown of GDP and sluggish growth in the MEE countries. Nevertheless, the long-run growth push in China has been accompanied by a parallel unprecedented surge in *unequal distribution* and related *social disintegration, deterioration of traditional institutions*, and huge internal

(rural to city) *migration waves*, i.e. a *spatial mobility* and a *disembedding* of hundreds of millions of workers from their homeland networks.

Chinese long-lasting institutional, structural and systemic transition has combined lasting high growth with considerable deterioration of traditional institutional arrangements, high spatial mobility and uprooting of large parts of the population, unequal distribution and social disintegration – and thus, not surprisingly considering the above, *declining levels of general trust*. China has indeed suffered steadily declining levels of general trust since the beginning of the 1980s.

During recent years in China, a number of events affected general trust seriously, and the trust level in China is declining dramatically. For instance, the melamine–milk scandal in 2008 was a food safety incident, which led to six infants dying and a further 860 babies hospitalized, involved most of the milk companies. They had added melamine intentionally to increase the apparent protein content of their watered-down milk. A number of criminals, including management and governmental officials, were punished. Unfortunately, similar scandals are still occurring. In 2010, an eleven-year-old pupil conducted a test on food security with the help of his teacher in Beijing. He found that 13 out of 14 mushrooms he chose randomly in markets had been bleached. Official reports claimed that 97 % of mushrooms were not bleached, and safe to health. An online survey showed only eight of 1100 voters believed the official results. Because of these incidents, ordinary citizens become more sensitive and self-protective, relying on their close relations, while a lack of trust in strangers and government increases. According to the *Social Mentality Report in Contemporary China* in 2013, only about 20–30 % Chinese trust strangers; especially trust among different social classes, groups and professions is declining more, which, in turn, leads to lots of

social conflicts (Yang / Wang 2013). Therefore, it is a major public discussion about a trust crisis in China now.

As a *kinship-based* and Confucianism-educated community, Chinese basically are prone to trust each other depending on moral obligations and reputational incentives, which are usually enforced by informal institutions (Greif / Tabellini 2010), and this type of traditional Chinese culture, social value system, and organizational formation has positively affected China's development. For example, the *Guanxi circle* has sustained economic development, especially during the initial starting period (e.g., Granovetter 1995). Trust in specific Chinese *family structures* provides a proven mechanism for stabilization of expectations in unstable and uncertain environments. Such mechanisms and preferences for close kinship can produce stronger motivations and aspirations to be successful for the sake of the whole family. In this context, the investment based on "entrepreneurial familism" can minimize start-up financial cost and allow rapid and flexible responses to changing environments. A reflection of this is, for instance, that *family enterprises* played a notable role in the earlier reform period, which depended on an informal financial system based on non-contractual cooperation, kinship and friendship, provided launching capital and access to credit for entrepreneurs. In this respect, cheating behavior was reduced and cooperation encouraged. For example, Peng (2004) and Ke / Zhang (2003) show that trust and kinship networks have a significantly positive effect on protecting private entrepreneurs and helping to promote economic development in China.

A *national dilemma* may occur for *China* between (1) the intentions of a continuing growth on the one hand and (2) the deterioration of critical foundations for it through the very process of transition as it has been installed (see also, e.g., Hodgson / Huang 2013). Deploying our socio-economic knowledge, it appears highly dubious whether China will be able to continue transition and growth if it does not care much more

for re-building the critical foundations for institutions of cooperation and related general trust – an orientation in stark contrast with what the neoliberal economic mainstream steadily is recommending to China.

In this paper, we use *cooperative behavior* in social interactions as an indication of *general trust*, and investigate the dynamics of general trust levels and the effect of the social arena, platform or *network structure* on that dynamics. We develop a model of agents playing repeated *prisoners' dilemmas* (PD), *on networks* in order to explore the effect of different topologies (including spatial and social *distance*, neighborhoods, and network formation) on such cooperative behavior and general trust.

Our model highlights the following features: (i) the effects of social-economic changes on the dynamics of general trust. The *theoretical* starting point and motivation here is that the economic transition of China has led to a *change of the interaction structures*, i.e. of the *structural properties of social networks*. (ii) The evolution of trust in China is endogenously resulted from its economic development and the transition of different social, economic and organizational formations. This will be presented through a *repeated prisoners' dilemma (RPD) game on networks*.

As an overview of our main argument, based on the definition of the Nash equilibrium (NE) of a network game, we find that, *first*, the *socio-economic change* has provided plenty of opportunities and economic incentives for agents to *switch networks*. In this process, agents will try to maximize their payoffs and adjust their connections, given their opponents' strategies and linkages. Therefore, achieving a NE of a network PD, the agents will not cooperate with all neighbors, and are becoming untrustworthy.

For the *Chinese* case, as people are (geographically and socially) extending their connections after the economy has been de-regulated in a number of critical aspects (e.g., re. labor migra-

tion), it has become rational for them to be defective in order to protect themselves and/or to try to exploit others if possible. Hence, it is not surprising to observe the declining trend of general trust in China.[2]

We will also argue that the traditional Chinese *family and clan networks* culture has an ambiguous effect on general trust and can be considered both a basis (or starting point) and a substitution (and thus impediment) for larger social networks and more general trust. This applies also to the *Guanxi* culture. Guanxi is a special kind of social network; it stresses more on the interpersonal relationships, with the embeddedness of private belongings, such as kinships and friendships. Hence, it is ambiguous sometimes for both parties involved and independent on their social (professional) exchanges. While agents defect in social exchange, they will be prone to return to the network that they are familiar with and trust; whereas in a non-Guanxi culture, people could not easily find that kind of substitution.

Second, by investigating the effects of three types of networks, i.e. *star, circle and multi-center networks*, on the NE of the games, we find that different network structures may *provide distinct avenues* for agents to behave when pursuing their interests. For example, the cooperation level on a star network, which may reflect the centralized aspects of the social and political structure in China, of course depends on the strategies of the central agent. Multi-center networks,

however, may better maintain a socially learned cooperation level and even rebuild deteriorated general trust. We assume that the profound tradition of trust has not been fundamentally destroyed in contemporary *China* considering the short transition in comparison to the long Confucianism tradition, but that the decreasing general-trust level has been induced "just" by a strong preventative motivation of people. Hence, as the social structure would *(re-)gain adequate network properties*, the general trust level indeed may recover. Further, we will argue that the increase of both *social distance* (e.g. inequality) and *spatial distance* (spatial mobility, migration) that accompany economic transition have led to a decrease of the levels of cooperation and general trust.

Finally, different *overlapping and layered systems of networks* of proper *"meso" size*, as indicated in the *Danish* case, which are expected to positively influence the levels of cooperation and trust, will be recommended as a basis for improving the general trust level and, with this, longer-run and self-sustaining socio-economic performance.

The rest of this paper will be structured as follows. The next section will review related literature in two perspectives, the variation of trust levels and their impact on economic performance in general, as well as the changes of trust levels in transition countries are specifically. A network game theoretical model will be established and discussed in the third section, in which we mainly address the relationship between elements of economic transition and social interaction. The last section will offer a conclusion.

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2 We have to note that the World Values Survey (WVS) data show an around 10 % declining trend of trust in China from 1990 to 2007 and an unexpected 10 % increase in 2012, according to the question "Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?". The unexpected increase of trust contradicts most of the other research, e.g. Yang / Wang (2013), and the Chinese public discussions. In the Chinese Academic Journals (CNKI) database, there are 759 papers and theses from 1997 to 2013 having "trust crisis" in their titles, of which 540 were published after 2007.

2   THE VARIATION OF TRUST

In the present paper, we define trust in a simple way as a cooperative behavior in a general sense. However, it is undoubted that there is not a common understanding on the term "trust" still (for a recent survey, see Nannestad 2008). Here, we simply define trust as generalized trust and leave the distinction of the diversified understandings of it side and pay more attention at the variation of trust levels as the World Value Surveys show mentioned above across areas and countries. In general, the variation of trust levels is determined by many influence factors (Nannestad 2008), for instance,

1 voluntary associations and civic activities are the source of trust, (compare Putnam et al. 1993; Brehm / Rahn 1997). Theoretically, civil society is a totality composed of shared interests, values and beliefs, which totally are distinct from those in the state and market root in the structure of self-interests and authority. Here, the establishment of interpersonal trust can obtain some support from specific mechanisms of voluntary organizations and shared values, and such kind of trust is termed as "moralistic trust" in Uslaner (2000). On contrary, in the societies or communities, where are characterized as inequality in economies and opportunities, the people there are tend to cheat, rather than to trust each other (Alesina / Ferrara 2002; Rothstein / Uslaner 2005);

2 the quality of institutions determines the trust level (compare Farrell / Knight 2003 and Levi 1996). As the result of interactions, the trust level is affected by its context. For example, foreign direct investments in different countries are undertaken at different levels of non-systematic risk, such as being cheated by officials and individuals, owing to the lack of a mature legal system in some underdeveloped countries. We can say that the good institutions can create and main-

tain specific mechanisms and environment for behaving trust worthily, where cheating agents can be easily revealed and punished by other agents based on the respective institutions. For another example, Bohnet et al. (2001) argue that the probabilities of contract enforcement affect the level of trust. This argument also indicates that institutional arrangements have influences on trust among agents. However, that trust is at the same time also a prerequisite of an emergence of institutions should be pointed out as well. For instance, not everyone could establish a credit institution in a society without a high degree of trustworthiness among the members of it. Furthermore, the rules and the norms have significant effects on trust, but trust also can be treated as norms, so one possible question is how trust emerges in a society without honesty norms. Additionally, institution quality cannot be subjectively and endogenously measured (Nannestad 2008), which leaves some aspects of the argument open to criticism;

3 the cultural interpretation, for instance, Uslaner (2000, 2002) argues that the cultural norms, such as religious one, determine the generalized trust via the socialization processes agents undergo. In the studies on the declining trust among younger American, he argues that one reason for this effect is the rise of Christian fundamentalism, which is a phenomenon of religious polarization, as the fundamentalists only engage in activities with their own kind, which leads to a drop in trust in people from different religious beliefs. Nunn / Wantchekon (2011) find that the slave trade brought a negative effect to the trust of modern Africans through changing the internal norms, beliefs and values of the ethnic groups. Because the slave trade deteriorated the local legal and political institutions in the long term, and people form the

regions where were heavily affected was increasing able to cheat others more easily. As a collective sequence, individual now are becoming less trusted because people around are less trustworthy;

4 an ethnic and linguistic heterogeneity explanation (compare Bahry et al. 2005, Marschall / Stolle 2004, Anderson / Paskeviciute 2006 and Dincer 2011). The consensus of most scholars is that the level of generalized trust is influenced by the degree of ethnic diversity, however, depending on the specific relationship; it can be positive or negative. Some scholars, e.g. Bahry et al. (2005) and Nannestad et al. (2008) argue that it is a positive relationship; some scholars, e.g. Putnam (2007) and Pennant (2005), suggest an opposite relationship. More recent research by Dincer (2011) shows there are two measures of ethnic diversity, a fractionalization index (FI) and a polarization index (PI), have different effects on trust. In his study, PI has strong negative effects on trust, but an interesting finding is there is a U-shaped relationship between ethnic fractionalization and trust. A remaining problem is how to find the turning point in the society, as the U-shaped relation is not constant across different groups.

Experimental approach also is an important way to investigate the determinants of trust. Berg et al. (1995) report a result of an investment game with history treatment, where they find that agents that received contributions will provide more to others in the earlier rounds. Cox (2009) reports results of investment games regarding the effects of social change on trust, reciprocity, and altruism. It is found that the first mover's behavior is partly motivated by trust in a weak social context, but there is no support in a strong social context where involves a second task as a treatment for controlling future behavior of players. Dal Bó / Fréchette (2011) investigate the evolution of cooperation in infinitely repeated games via a series of experiments. They find that the level of cooperation has to do with the experienc-

es of agents: the agents will attempt to establish more cooperative relationship as they are gaining experience, however, the property of agents, risk attitudes, and structure of games also have an influence on the level of cooperation. More evidences that are experimental can be found in the mentioned research above. One instrument from them is that a game theoretical approach can be applied in studies of cooperation.

The trust of transition countries, for instance, from totalitarianism to democracy, as cases studies also offer an avenue to understand the dynamics and varieties of trust. In general, the societies in transition are full of widespread destabilization and distrust (Latusek / Cook 2012). For instance, Kornai / Rose-Ackerman (2004) and Kornai et al. (2004) explore the issues of trust in post-communist countries, in which distrust and dishonesty due to the lack of institutions in transition are addressed in interdisciplinary approaches. Radaev (2004) inquiries into the emergence of trust when institutions and individuals are not trustworthy, in a case study based on data from Russia. He argues that the non-transparent and non-predictable state policy is the main source of institutional instability, which will lead to uncertainty and asymmetric trust in formal institutions, in the process of marketization. In a distrustful business context, entrepreneurs have to take many measures to establish a stable environment, such as precautionary measures, finding trustworthy business partners and forming networks, as well as building conventions in the business sectors.

Hakansson / Hargreaves (2004) present a detailed investigation on the generalized trust of Bosnia and Herzegovina during its transition process, where the WVS data depicts a process of decreasing trust. They argue that factors, such as looseness of membership of political, trade and other professional associations, decreasing institutional trust, have led to this decline. However, effects of increasing income and ethnical diversity are not clearly identifiable. Raiser et al. (2003) employ the prepayment demanded

by firms from their customers as the measure of trust in transition countries. It shows that fair and honest third party enforcement through the legal system has positive effects on trust. Furthermore, business network-based kinship and membership is beneficial to trust establishment, as opposed to networks based on enterprise insiders and government agencies. Economic inequality is a factor that cannot be neglected and has negative effects on trust in the process of transition and development. For example, Uslaner (2000) argues that one reason for Americans becoming less trusting is the rising economic inequality over decades, while the Scandinavian countries with lower *Gini index* values are more trusting.

Still, the elements of civil spirits, as well as cultural, ethnic and linguistic heterogeneity are stable in very long term, and therefore cannot be drawn upon to explain the phenomenon of dramatic trust changes in a short term, such as in China during the last three decades. A possible explanatory element is the institutional factors referred to above which stand at the center of the analysis in the present paper from a game theoretical perspective. Game theoretical and experimental approaches inspire us to address the issues of trust in an interactive context. Moreover, for the cases of transition studies, most of them are approached in a traditional economic analysis, and do not investigate from a micro interactive perspective.

3   A MODEL OF DECLINING TRUST

3.1   THE PRISONERS' DILEMMA ON NETWORKS

Network game theory is an approach to study interactive situations in social networks. Social networks have many impacts on our lives, most decisions, for instance, the decision of an individual whether or not to install a new document processing software, attend a conference, is usually influenced by the choices of her or his colleagues and collaborators. A large volume of theoretical and empirical studies has investigated the role of networks in game theoretical models. For a comprehensive literature review on the development of this approach, we can refer to, for example, Galeotti et al. (2010). Furthermore, in terms of social trust, Coleman (1988) has investigated the role of social networks on the formation of social capital. He argues that the closure of the social structure, which is one significant hallmark of social relations, can provide a channel of collective action for establishing mechanisms to ensure trustworthiness because all agents can monitor each other and avoid "free riders" by "community enforcement" in such a network structure.

In sum, the approach of network analysis has been applied in some economic purpose of social interactions.

In the standard prisoners' dilemma game with complete information, the strategy defect (*D*) dominates cooperate (*C*) for each player, this game has a unique Nash equilibrium (*D, D*), that is, however, Pareto-dominated by the result achievable through cooperation (*C, C*). We therefore can say that the strategy defection is a sub-optimal choice in the collective sense, and the strategy cooperation is the optimal choice in the social or collective context correspondingly.

Consider a finite set of agents $N = \{1, 2, ..., n\}$, who are rational and perfectly informed, connected on a network *g*. A network is represented by a graph, where each node stands for an agent and the links, $l_{ij} = \{ij \mid i, j \in N \text{ and } i \neq j\}$, between agent *i* and *j*, represent social interactions or potential opponents. The connected agents ($l_{ij} = 1$) are called neighbors. The set of pure strategies is $a_i \in A = \{C, D\}$. Let $|C| = |\{i \in N \mid a_i = C\}|$ be the number of agents choosing *C*, $|C| / N = \alpha$ therefore is the cooperation rate in the whole con-

nected population, where $0 < \alpha < 1$. In a single shot game, the rational agents would choose the 'defection' strategy, which means $\alpha = 0$, in the resulting Nash equilibrium.

We assume that agents can play one out of two strategies, cooperation and defection. There are three types of agents. One always chooses defection, and a second is a variant of tit-for-tat (*TFT*) in which the choice of cooperation or defection depends on the experience in the previous interactions and independent on whether this occurred with the agents faced in the current interaction or with another one (Axelrod 1984/2006). The third type of agents will choose the strategy according to the cooperation rate in their networks. We assume that the agents are bounded rational, and they do not have perfect knowledge of the game, in other words, the agents just adjust their behavior relying on their information of what other agents are currently doing or have done during previous periods on the networks. Thus, the cooperation rate of each round can be considered as one kind of threshold value for the strategic decisions of the agents. Furthermore, if the agents can observe the cooperation rate and make decisions based on it, which means the information of the distribution of the strategies is open to all agents on the same network, at each round. It is natural to assume that the agents move simultaneously based on their calculations.

We define the shortest path between agents i and j ($i \neq j$) as the distance of them denoted by $d(i, j)$ on the networks. For instance, in a star network (see Figure 2 below) any two peripheral agents are connected by a path of distance two. We call the directly connected agents as neighbors ($d = 1$), which can be denoted by $N_i(g) = \{j \in N \mid g_{ij} = 1\}$ for the agent i, and let $\varphi_i(g) = |N_i(g)|$ denote the number of neighbors of agent i on the network g. An agent i can propose and establish a link to any other agents in the group, and the linking choice of agent i can be captured by a vector $L = (l_1, l_2, ..., l_n)$, and $l_i \in L$, where $l_i = (l_{ij})_{j \in N} \in \{0, 1\}^n$, and $l_{ii} = 0$ since no

agent can establish a link with herself. If agent i establishes a link with agent j then $l_{ij} = 1$, and 0 otherwise. The value of a link is to offer strategic possibilities to the linked agents, which depends on the payoffs of the strategy. The agents can freely remove or add a new link to the others, we term $L \oplus ij$, if agent i propose a new link to j; otherwise $L \ominus ij$.

Another fundamental assumption is that the number of links for single agent is constrained (see, e.g., Ule 2008). The maximal number of links, which also indicates a local interaction, of agent i denoted by k_i. The set of actions of agent i can be captured by $J_i(k) = A_i \times L_i(k)$. Let (a_{-i}, l_{-i}) denote a profile of actions of agent i's opponents. The payoff function $\pi_i: J \to \mathbb{R}$, can be defined by

$$\pi_i(a, l) = \sum_{j \in L_i} v(a_i, a_j)$$

Therefore, the stage game can be defined by $\Gamma(k) = \langle N, J(k), \pi \rangle$ in the context of network game with linking constraints.

Definition 1
(Nash Equilibrium of Network Game)

The best response $(a_i^*, l_i^*) \in J_i(k)$ of each agent i to the profile of actions $(a_{-i}, l_{-i}) \in J_{-i}(k)$, if

$$\pi_i(a_i^*, l_i^*, a_{-i}, l_{-i}) \geq \pi_i(a_i', l_i', a_{-i}, l_{-i}) \qquad (1)$$

and

$$\pi_i(a_i^*, l_i^*, a_{-i}, l_{-i}) \geq \pi_i(a_i^*, l_i^* \oplus ji, a_{-i}, l_{-i}), \qquad (2)$$
$$\forall (a_i, l_i) \in J_i(k)$$

is the Nash equilibrium of game $\Gamma(k)$.

This definition here is similar to Ule's linking-proof equilibrium, so a detailed explanation can refer to Ule (2008: Chapter 4). The first condition is straightforward. The second condition ensures the linking choices have no effects on the payoff in Nash equilibrium. We can say that no agent has incentive to establish a new link given the actions of others, even though there is a possibility to propose a new link. In the equilibrium state, the network is stable and the payoffs of agents are optimal given the others' strategies and links.

In a PD game, the cooperative strategy is dominated by defection, so, in a one-shot perspective, the stable networks only can be defective. When cooperation can be locally attained under certain conditions (see segregation models of, e.g. Axelrod 1984/2006; Schelling 1969). When the network dilemma game is repeated for T-times, the interaction situation can be written as $\Gamma^T(k) = \langle N, J(k), \pi, \alpha, T \rangle$, in which we assume that there are three types of agents. The first type is one who always plays defective strategy (*AllD*) independent of the external conditions. The second type of agents is the modified *TFT* player. And the third type of agents is assumed to choose their strategies on the basis of the cooperation rate in the networks or the interacting neighborhoods, in which they are located, we term the strategy as $A(\alpha)$, and specify it, that is

$$\begin{cases} \text{if } \alpha^t \geq \alpha_i^*, \text{ then, } A(\alpha)^{t+1} = C \\ \text{if } \alpha^t \leq \alpha_i^*, \text{ then, } A(\alpha)^{t+1} = D, \end{cases}$$

where α_i^* is the threshold value of cooperation rate of agent i, which can be considered as the agent's risk attitude towards being defected against, for example, if one agent has relatively low threshold value, it means she or he is risk seeking of defection or has enough high discount factor.

At each round of the game, all agents will be informed of the cooperation level, therefore, the total payoff of agent i at the end of the repeated game can be determined by the history h^T, i.e. the cooperation rate α, the strategy taken and linkages, and given by

$$\Pi_i(h^T) = \sum_{t=1}^{T} \pi_i(a^t, l^t, \alpha^t)$$

Ule (2008) argues that the equilibrium concepts, for instance, Nash equilibrium and sub game perfect equilibrium, in conventional non-cooperative game theory can be applied in the network formation games with unilateral linking (Bala / Goyal 2000), but are not complete suitable for the network games with mutual linking. Therefore, we assume that an agent can propose

a link to another agent unilaterally without any agreements.

Definition 2
(Cooperation Rate Proof Perfect Equilibrium)

The strategy profiles (a^*, l^*, α^*) can be defined as cooperation rate-proof perfect equilibrium in game $\Gamma^T(k)$, if

$$\pi_{i,t}(a^*_{i,t}, l^*_{i,t}, a_{-i,t}, l_{-i,t} \mid \alpha^{t-1}) \geq \pi_{i,t}(a'_{i,t}, l'_{i,t}, a_{-i,t}, l_{-i,t} \mid \alpha^{t-1}) \qquad (3)$$

and

$$\pi_{i,t}(a^*_{i,t}, l^*_{i,t}, a_{-i,t}, l_{-i,t} \mid \alpha^{t-1}) \geq \pi_{i,t}(a^*_{i,t}, l^*_{i,t} \oplus ji, a_{-i,t}, l_{-i,t} \mid \alpha^{t-1}) \quad (4)$$

for $\forall (a_{i,t}, l_{i,t}) \in J_{i,t}(k)$.

This definition tells us the agents on networks can temporarily achieve an equilibrium state given the cooperation rate of last round. Hence, in order to have a stable network, it needs all agents have identical threshold value of cooperation rate, or the agents with same threshold value could stay together in clusters and some agents with the satisfied threshold value connect the clusters. The defective strategy, in the sense of the cooperation rate proof perfect equilibrium, still is the dominant strategy in this infinitely repeated game ($t \rightarrow \infty$ and $\rightarrow 0$). The cooperation strategy exists only if one agent plays cooperation in the previous stage ($t = T - 1$), because of the assumption of types of agents, the cooperative strategy will be played during the process of the game as the following shows:

1 When $T \rightarrow \infty$ and $\alpha \rightarrow 0$, all agents will keep playing strategy D.

2 When $t = T - 1$, and $\alpha > 0$, we will say at least one agent plays strategy C.

We suppose that the formation of network is defective and cooperation rate is equal to zero in such equilibrium, and in which all *TFT* players switch their strategy to D, and the $A(\alpha)$ players have left the network. With possibilities, a mixed stable network may appear as different agents with identical threshold value of cooperation rate are getting together within an enough short period.

3.2 LINKING DYNAMICS AND COOPERATION

In the network games, the agents can switch their networks and propose links based on their interacting neighbors' strategies in each round. Network g is an equilibrium network if there is a Nash equilibrium (α^*, l^*). In the context of Prisoners' Dilemma, the dominating strategy is defection, and the dominating relationship among agents is a defective relation, within the gaming framework of the single shot game setting. Theoretically, if all agents are well informed, cooperation can be achieved locally in a cooperation rate proof perfect equilibrium via the cooperative agents threaten of leaving network or excluding the non-cooperative links in a strict context of linkage constraints, but still the defective strategy is the only Nash equilibrium in the finitely repeated game. Any cooperative agent will stay in the network in repeated dilemma game as long as she or he can establish a cooperative link or there exists an appropri-ate cooperation rate as his expectation, alternatively, such cooperative agent can remove a link from a defective agent, and proposal a new link randomly; otherwise, he can choose to leave the network.

Trust always is investigated in the settings involving interactions of strangers; however, social and economic interactions occur not only between the networks of strangers, but also within families, friends, partners, clans and neighbors. In the context of economic transition, we suppose that there are plenty of opportunities and economic incentives for Chinese people to switch their social networks. When the agents, who frequently face defection on social networks, are prone to stay or go back to a network established based on family or kinship. In this case, such substitute options have negative effects on the social general trust level. In addition, it should be noticed that the agents leave the networks which are not based on the sense of family in the modeling processes.

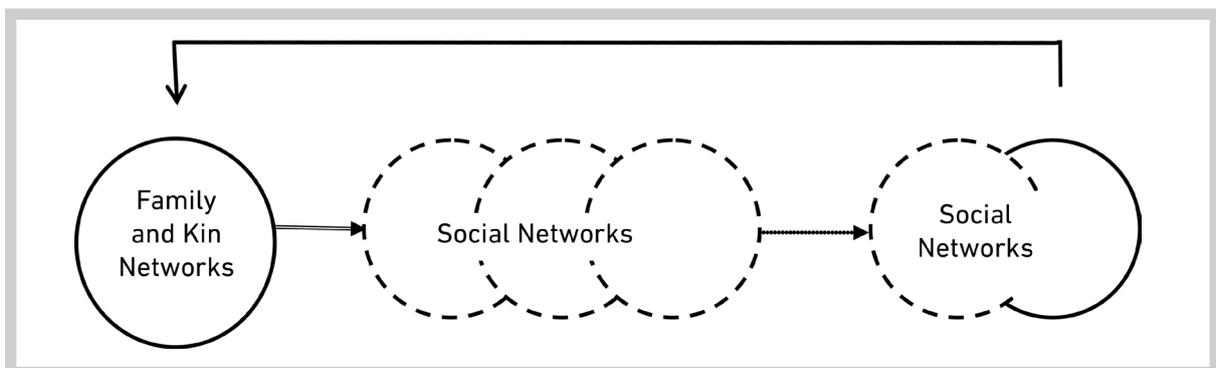*Fig. 1   Switch Dynamics among Networks*

Figure 1 shows the phenomena of switch dynamics among networks. During the initial periods of economic transition, many Chinese from impoverished regions experienced a process of leaving their hometowns and immigrating to the urban and prosperous coastal regions in pursuit of work. In the last few decades, they were the main force for urbanization and development in China. According to the latest Chinese government statistics, the current number of migrant workers is more than 260 million. However, a very critical issue is that the most migrant workers are not being treated equally as urbanite owing to the *Hukou* (Household registration) system) and its associated social welfares. For instance, the children of migrant workers have less access to qualified education and public services comparing to the local residence's children. Furthermore, the migrant workers are always governed discriminatively by the local city governments and in most situations where they are not respected and trusted. In addition,

we can say most of them are not integrated in the social networks of urbanites and do not trust the urbanites as well. Accompanied by the economic balance develop strategy that has been established, most migrant works prefer to stay their hometown for working, which leads to the lack of labor in the coastal regions. Such phenomenon definitely can be explained in many perspectives. In the present paper, we would argue that it is because of the migrant workers are segregated in cities and cannot trust the city networks at a relative high level, which forces them to come back to the kinship networks. This argument also has been put forward in, e.g., Banfield (1967), Whyte (1996), and Alesina / Ferrara (2002), who argued that family ties are stronger in backward societies were social trust is not well developed.
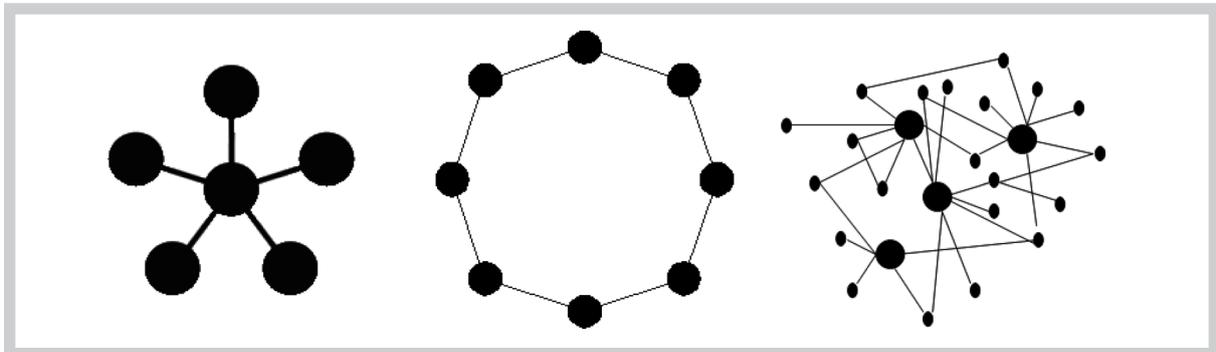
"Homing behavior" is an inherent ability of some specific animals to return towards their hometowns, and applied to many other non-animal phenomena due to their common features. Here we consider the homing behavior of migrant

workers as an evidence of switches among networks, thus, it is a substitute effect of "family & kinship" networks for the broader social networks, because in the face of societies, which are characterized by uncertainties, and weak formal institutions, people tend to rely on the closer personal relationships (Cook / Gerbasi 2009). Furthermore, such effects mean that the Chinese close family and kin structures have negative influence on the generalized trust in terms of the condition of the integration failure of social networks.

3.3 NETWORK STRUCTURES AND COOPERATION

Network structures, which have been investigated in numerous works, are evaluated by various measures, for instance, clustering coefficient, average distance, degree and information distribution. The present paper focuses on the graphic neighborhoods structure on different kinds of networks, such as star, circle and multi-center networks, see Fig. 2.

Fig. 2 Star, Circle and Multi-center Networks

In an interactive situation where agents face different topological structures based on the different networks. Now we consider a general network, the payoff function of each individual agent i is given by

$$\Pi_{i,t} = \sum \pi_{i,t}(a, l_{ij}),$$

which indicates that the overall payoff depends on the all links ($l_{i,j}$) the agents have at each round.

This function specifies a very simple mechanism of the decision making for the agents. Since the payoff is codetermined by the links that agents have, the strategic combination, and the types of agents, the network formation will have different impacts on the strategic behavior. A star network G_s is a most common network topology. In its general form, a star network consists of one central node, with which all peripheral agents are connecting.

Suppose that one agent is the central player of the star network plays, who acts as a conduit to convey information to other agents. Thus, all peripheral agents only may obtain the information of strategy of all other agents by transmitting to, and receiving from, the central agent. The neighbor of the central agent is $N_c(G_s) = n - 1$, and for the peripheral agents, it is $N_p(G_s) = 1$. The star topology has lower risk of network failure by connecting all of systems to a central agent if he is a cooperative node. It can be applied to many cooperation or reputation-based networks, for instance, business retail network, political system, etc. In other words, if the central agent always behaves defectively, the other peripheral agents can leave the network and then the network collapses immediately with high probabilities. For the detailed combination considering the different types of agents, see Tab. 1.

Tab. 1 Network Dynamics on the Star Networks

		Peripheral Agents (PA)		
		AllD	*TFT*	*A(α)*
Central Agents (CA)	*AllD*	Defective Networks	Defective Networks	If $\alpha^* = 0$ for part of PA, then, defective; otherwise, collapse
	TFT	Defective Networks	Defective Networks	Unstable Networks
	A(α)	If $\alpha^* = 0$ for the CA, then, defective; otherwise, collapse	Unstable Networks	Unstable Networks

Clearly, the combinations between the agents with *AllD* and *TFT* strategies will lead to defective networks, since there are too few opportunities for agents to come back the cooperative strategy. In the other five combinations, the situation becomes complicated. In case of an *AllD* central agent meet $A(\alpha)$ agents, the network will be easily collapsed unless some of the peripheral agents can stand for such defections. Similar to this case, when these agents interconvert their strategic attributions, the central agent also has to bear such defections for avoiding network collapse. When *TFT* agents meet, the network formation is dependent on how the PA behave. As long as one PA plays the defection strategy, the CA will switch his strategy to defection, and finally the whole network will become defective and stable. If $A(\alpha)$, whatever she or he is, CA or PA, meets *TFT* or her same genus, the networks will be unstable, since the heterogeneities of the threshold value of cooperation rate for agents.

In the process of transition, which companying with inequalities, social stratification, and such other centralization phenomena, the social structure can easily to be centralized. The strategic behavior of the central agent therefore will be very crucial to stable the social structure, and to the trust level of the whole society. In China, such centralized social structure is very common, for example, in the political and production organizations. If the central members, e.g. the top officials and managers, in those organizations behave defectively, or say, are untrustworthy, then the organizations are inevitably to be destroyed or to be full of distrust. In particular, such negative trend can diffuse badly under the forces of modern information communication technologies.

In the circle network G_c, each agent just connects with the immediate neighbors, for example $N_i(G_c) = 2$. If only some of the agents choose to defect, the network formation will be changed to a new circle or a line network, which depends on the strategies of the breaking nodes. For instance, if the breaking node is an *AllD* agent, he might choose to connect to others unilaterally, and a new circle will be formed; if the breaking node is an $A(\alpha)$ agent, he will sever the defective links or leave the network, then the circle net-

work become a line network. In this sense, the social ties become loose and trust level will decrease as the social interactions become rare.

In the multi-center network G_m, the situation becomes complicated. The number of neighbors of agent i is his direct links, $N_i(G_m) = \varphi_i(G)$, if the agents with many connections, who will meet the same opponents with lower probability, and lead to a lower cooperation rate in the whole network. However, a well-connected agent faces more complicated context for decision-making and acts as an adjusting actor for the whole network, but its influence depends on the types of agents. Consequently, we should consider the formation of networks, which is determined by the types of agents and the types of links. In the present paper, we assume that there are three types of agents (*AllD*, *TFT*, and *A(α)*), and the agents can establish links unilaterally. The formation of network will become various, if the different kinds of player randomly paired at the initial stage, and choose to maintain the link or paired randomly again, and suppose that there are adequate agents can join. Hence, as far as the definition of "cooperation rate proof perfect equilibrium" is satisfied, the network will be stable, otherwise, always is changing. Thus, the changing cooperation rate in the network reflects the dynamics of level of trust. In general, the level of trust is highly determined by the inner composition of different types of agents. For example, if the *AllD* agents were dominant, then the trust level would be low. As said above, during the transition, the defective behavior of most of agents actually is preventative, instead of trying to exploit others. Therefore, the proportion of *AllD* in population is temporarily increasing, as long as the social structure is flexible, or say, is multi-central in the terminology here; the generalized trust can be recovery.

3.4 SOCIAL DISTANCE AND COOPERATION

Social distance, which also is a significant aspect in Chinese transition, is crucial to under-

stand individual behavior and social collective outcomes. Social distance approach is an insightful method to study sociological phenomena, for instance, class structure and patterns of behavior (Akerlof 1997; Binzel / Fehr 2013). We can simply assume that the benefits of individuals depend on social distance, which can be measured by income, education, social status, or political and economic rights, or geographic distance. Generally, people are much easier to cooperate with the neighbors within certain radius; therefore, subsequently, agents propose links with others who are nearby, in terms of the reduction of transaction costs and the optimization of networks. Moreover, social distance affects the formation of the game, for instance, the transition of economic structures leads to a segregation of traditional family and clan network in China, which also can be described via the average distance between nodes of a network. A straightforward observation is that it is common for neighbors who live in the same apartment building for long time do not know each other in the big cities. Therefore, we can infer from the fact that they do not propose links even when the geographic distance is very close.

In the context of cooperation rate-proof perfect equilibrium, if the network g exists but is not stable, some agents will choose their strategy based on the cooperation rate of social networks. Apparently, in a network where the agents have long distance with the interacting partners, which means the clustering coefficient is low, and the cooperation cannot be sustained, since a network with low level of clustering, it is more difficult for the agents to generate common knowledge and transmit information, in addition, they will have higher risk to be defected. Hence, the negative effect of social distance on trust during Chinese economic transition is straightforward.

After the economic reform in China, many millions of people began to leave their familiarly networks and tried to integrate into the larger

networks. After the mobilization, agents from different networks (G_1 and G_2) had to interact with each other. Suppose the cooperation rate in these two networks was the same, say, α. Then we will have two possible interaction situations.

1 If agents integrate very well or a proper multicenter network is established (i.e. the interaction structure will not be changed after mobilization), and the different populations (N_1 and N_2) of agents as well as the cooperation agents (C_1 and C_2) are homogenous, and the interaction parameters, such as the interaction scope or social distance among agents, are not changed, then

$$\frac{C_1 + C_2}{N_1 + N_2} = \frac{C_1}{N_1} = \frac{C_2}{N_2} = \alpha .$$

In this case, the trust level of society will remain same as before.

2 In case the agents are forced into a larger anonymous and unstructured networks, if they cannot integrate very well, for example, some agents must interact with the agents who are "distant", for instance to get work. The distance between agents becomes larger comparing to that before immigration, and the meeting probability among the distanced agents will be smaller. We define the meeting probability according to the distance (d) between agents, $p_{ij} = 1 / d_{ij,t}(g)$. Let us assume a part β of cooperative agents must interact with the distanced agents, and the probability of them playing cooperation will equal to or, at least, positively relate to the meeting probability $1/d$. Then, the whole cooperative population will become

$$|C^*| = (1 - \beta)C + \frac{\beta}{d}C = C\left(1 - \frac{(1-d)\beta}{d}\right) .$$

Then, the cooperation rate $\alpha^* = \alpha \cdot (1 - (1-d)\beta/d)$ will decline. That is, the more people are involved and the more distanced the interactions, the lower the cooperation rate will become.

Now let us reformulate the payoff function considering the distance between interacting agents and the cost of interactions. It is given by

$$\Pi_{i,t} = \sum \frac{\pi_{i,t}(a,l)}{d_{ij,t}(g)} - \sum c_{ij,t}(g),$$

where $d_{ij,t}(g) \geq 1$ is the distance between agents i and j in networks at time t, and $c_{ij,t}(g) > 0$ is the cost for the agent i as interacting with j. Such function holds a fundamental structure of the connections model in Jackson / Wolinsky (1996). The payoff deteriorates and the cost increases in the distance of each other. This is represented by the factor of distance that lies between 1 and infinite. On the other hand, the factor $1 / d_{ij,t}(g)$ also indicates that the probability of meeting a distant agent is lower than that with the closer ones. Therefore it is costly to propose social links and interact with distanced agents.

In general, the challenges for agents are how to short the distances and reduce the cost of interactions in order to maximize the payoffs. At this moment, the only feasible way is to keep the network simply, and just to interact with the immediate neighbors. Thus, such situation we can define as a friendly environment and the trust level will be relative high. However, during the period of transition, such condition is difficult to be maintained. Economic transition will lead to an increase in the number of interactions. People will be more involved in social networks than before, and the distances between people inevitably enlarge. Ahn / Esarey (2008) argue that generalized trust cannot persist in a large society where people interact with strangers in a higher possibility in a dynamic model of generalized social trust. Nearly at the same time, Elsner / Heinrich (2009, 2011) investigate a dynamic of contingent trust from the perspective of interactive platform and arena size. They argue that the meso level is the proper level of emergence, diffusion and retention of cooperation behavior. A related argument is that of the effect of segmentation on cooperation of Bowles (2004) and Hédoin (2010), who argue that an increase in segmentation can raise the cooperation rate in the population.

Due to the economic transition and its impacts on the interactive distance, following the same payoff function, the payoffs of same strategies with same partners are very different before and after transition. In light of the increasing distance, the agents are forced to choose the defective strategy as a preventative measure, because of, first, exploiting the others, and second, meeting the same partners with relative lower probabilities. Hence, as the average distance between agents is enlarging, the average cooperative rate also is lowering and the social trust level is decreasing accordingly.

4 CONCLUSION

The contribution of this paper is to model some *dynamics of the general trust level*, based on the effects of *changes of the social network structures*, which, in turn, accompany *economic growth, development, and transition*; and to provide a general perspective for understanding the evolution of trust during social-economic transition.

We argued that the economic transition of China has led to those changes of interaction structures. A repeated prisoners' dilemma game approach on networks was used to explore the effects of *neighborhood structure, social distance*, and strategic types. A conception and definition of the cooperation rate proof perfect equilibrium was developed to reflect the trust level of certain networks (i.e. Chinese national perspective here) and to identify the formation process of stable social networks. Groups and agents with different threshold value of cooperation rate and strategy types would interact with each other and segregated in clusters, where there were different trust levels of networks.

We found that the *Chinese family network structure* over all had more negative than positive effects on the social trust, and could be considered a substitution for larger social networks. Further, the increase of *social distance* and of the general *scope of interaction* accompanying economic transition has led to a decrease of the level of informal cooperation. Finally, Different network structure influenced the level of cooperation differently. For instance, *multi-center networks*, a tiered social structure, tend to be more favorable for the general trust level. In contrast, the trust level in a more centralized network structure tends to be influenced the behavior of the central agents. As a centralization culture, if the central agents, e.g. the governments, big companies, famous figures, behave untrustworthily in China, the level trust of the society should come under pressure.

Regarding potential *policy implications*, we suggest that, on one hand, naturally it is important to *reestablish general trust*. On the other hand, governments should *construct more effective social network structures*, for example, allow free migration without the restrictions of household registration; and reduce social distance among people, e.g., reduce social and economic inequality and balance regional disparities; and *promote multiple network memberships* with spillovers of trust, instead of centralization. When the preventative motivation of people is further decreasing, under the conditions indicated, the trust level might nevertheless recover to the country's general trust. Again, overlapping and layered and built up from small local networks.

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