ELSEVIER

Journal of Economic Behavior & Organization
Vol. 64 (2007) 448–469

JOURNAL OF
Economic Behavior
& Organization

www.elsevier.com/locate/econbase

From production networks to geographical economics

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Received 2 September 2005; received in revised form 6 May 2006; accepted 30 June 2006
Available online 7 July 2007

Abstract

Although standard economics textbooks are seldom interested in production networks, modern economies are more and more based upon supplier/customer interactions. One can consider entire sectors of the economy as generalised supply chains. We will take this view in the present paper and study under which conditions local failures to produce or simply to deliver can result in avalanches of shortage and bankruptcies and in localisation of the economic activity. We will show that a large class of models exhibit scale free distributions of production and wealth among firms and that regions of high production are localised.

JEL classification: D85; L14; L22; O18

Keywords: Networks; Supply; Credit chains; Geographical economics

1. Networks of firms

Firms are not simply independent agents competing for customers on markets. Their activity involves many interactions, some of which involve a degree of cooperation. Interactions among firms might include

- information exchange (Davis and Greve, 1996; Battiston et al., 2003a,b),
- loans (Stiglitz and Greenwald, 2003 chapter 7; Delli Gatti et al., 2005)

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0167-2681/$ – see front matter
doi:10.1016/j.jebo.2006.06.018

- common endeavours (Powell et al., 1996)
- partial ownership (Kogut and Walker, 2001; Battiston et al., 2007a)
- and of course economic transactions allowing production (Bak et al., 1993; Battiston et al., 2007b, and the present paper).

Economic activity can be seen as occurring on an economic network ("the economic web"): firms are represented by vertices and their interactions by edges. The edges are most often asymmetric (think for instance of provider/customer interactions). The availability of empirical data has provoked research on the structure of these networks; many papers discuss their "small world properties" and frequently report scale free distribution of the connections among firms.

The long term interest of economic network research is rather the dynamics creating or occurring on these nets: how are connections evolving, what are the fluxes of information, decisions (Battiston et al., 2003a,b), economic transactions, and so on, but dynamic studies lag behind statistical approaches because of conceptual difficulties and because time series of individual transactions are harder to obtain than time aggregated statistics.

Business to business connections are a recent hot topic, especially on the Internet; the practice is probably as old as long distance trade (say antiquity), and its importance was been recognised early by 19th century economists. Even the role of linkages in favouring economic development, a central topic of the present paper, is already discussed in, for example Marshall (1890).

The connections among different industries and countries have received a lot of attention since the pioneering work of Leontieff (1966). These previous approaches concerned aggregated exchanges and are in the domain of macro-economics. The units of models that we present here are individual firms, and we want to establish how their exchanges shape time and spatial properties of the global economy.

Our problematics is largely inspired from earlier efforts by Bak et al. (1993), Stiglitz and Greenwald (2003) and Delli Gatti et al. (2005), to determine the role of local random events on the distribution of production and wealth dynamics.

In Bak et al. (1993) for instance, production networks are defined by edges that represent supplier/customer connections among firms engaged in batch production activity. The authors describe the distribution of production avalanches triggered by random independent demand events at the output boundary of the production network.

The papers by Stiglitz and Greenwald and Delli Gatti et al. are about the consequences of firms' failures to pay their debts in a network where edges represent inter-firm loans. Bad debt might propagate in such loan-connected networks, resulting in avalanches of bankruptcies and in scale free distribution of wealth among firms.

These papers are not based on any empirical description of the network structure, but assume a very simple interaction structure: star structure in the case of Stiglitz and Greenwald and Delli Gatti et al., periodic lattice in Bak et al.

The simplifications introduced in the present paper are largely inspired from Bak et al., Stiglitz and Greenwald and Delli Gatti et al.

We start from a very simple lattice structure, and we study the consequences of simple local processes of orders/production (with or without local failure)/delivery/profit/investment on the global dynamics: evolution of global production and wealth in connection to their distribution and spatial patterns. However, it is worth emphasising from the beginning that while the structure of our production network is inspired by Bak et al., the dynamics of supply and demand differ completely from that work, and in particular, our model does not include the mechanisms that lead to the so-called "self-organized criticality."