Chapter 43

PRICE DISCOVERY AND ALLOCATION IN CHAINS AND NETWORKS OF MARKETS

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The experiments reported in this chapter explore the interaction of networks of markets. The issue is whether, and how long, "chains" of markets separated in time, space and participants might behave. The setting can be interpreted in two different ways. One is a system of vertical markets in which tiers of intermediate goods are produced as inputs for the next, higher level on the way to a final consumption good. Another, and perhaps more graphic, interpretation is geographic, in which suppliers are located at one location and consumers are at a different location. They are connected by a series of "short" transportation hauls that must be undertaken by different transporters. No transporter can undertake a "long haul" from seller to consumer. Markets exist at the beginning and end of each short haul. That is, the first transporters/middlemen buy from sellers and transport to the first drop-off for sale there. At the first drop-off a different set of transporters/middlemen purchase the units in an open market and transport it to the second drop-off where a new set of transporters/middlemen have the capacity to negotiate, purchase and haul to the third drop-off, and so on.[1]

The structure of interdependence clearly creates a type of fragility in the system. Each link of the chain is crucial to the success of the whole. The system cannot work if it fails at any point. Two basic results appear in the data.

First, the markets do equilibrate to the general competitive equilibrium. The overall system efficiency is high.

Second, long chains of markets with vertical interdependencies exhibit a "backwards" process of convergence toward the competitive equilibrium. The time flow of economic activities through such systems when the system is near equilibrium is a "lump" that moves through the chain as opposed to a continuous, equal flow.

The nature of the observations is contained in Figure 1. A total of three experiments were conducted, and all of them exhibited the same qualitative properties.

The model is summarized in Figure 2. The classical equilibrium model of a network of markets making up a supply route holds that the prices between two markets should

[1] Interactive markets populated by randomly behaving robots in the first and only other study of the framework developed here, see Bosch-Domenech and Sunder (2000). Their remarkable conclusion was that the competitive equilibrium could be attained in the market even without the levels of rationality assumed by the competitive model. There are some differences when humans are the agents, which seem related to the speed with which the robots can interact. Aspects of the convergence structure reported here are also seen by Bosch-Domenech and Sunder (2000), but for the most part the human convergence process has properties not seen in the robots.

Handbook of Experimental Economics Results, Volume 1

DOI: 10.1016/S1574-0722(07)00043-1

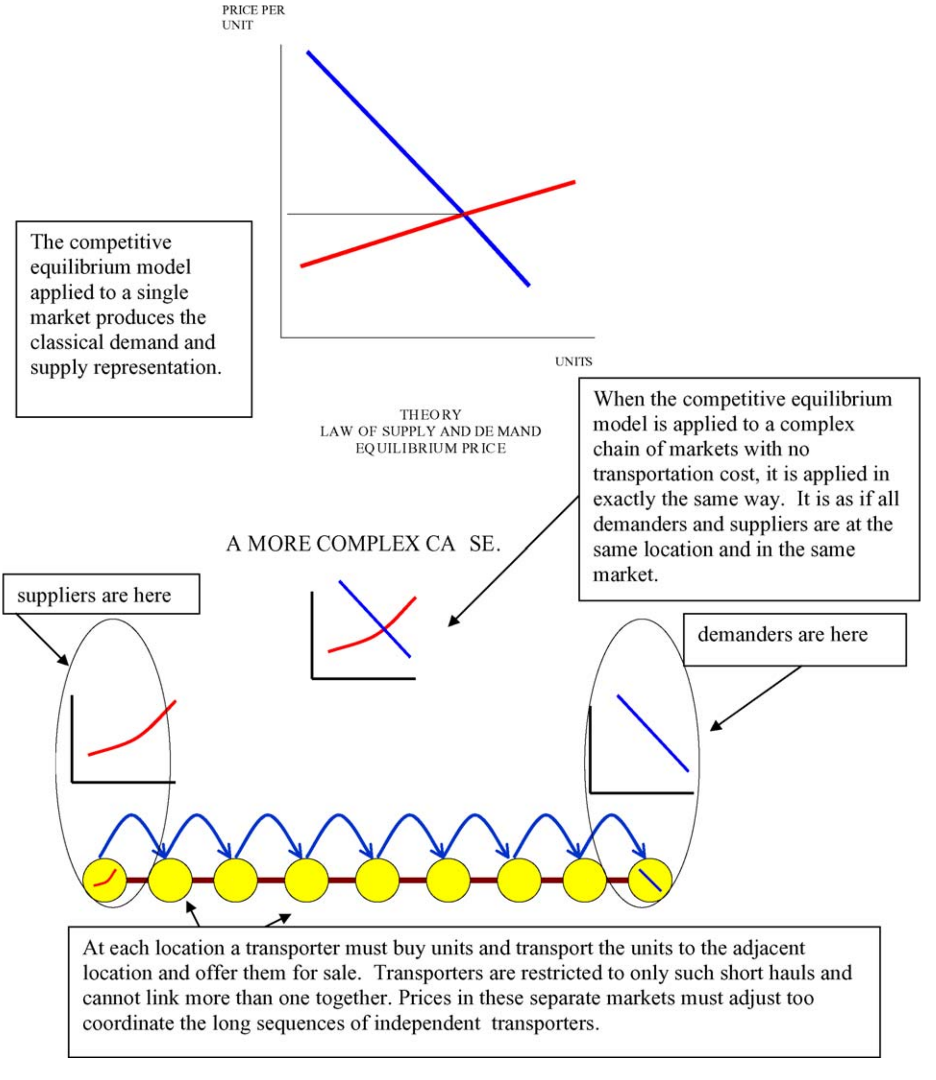

Figure 1. Prices and resource flows in chain-like networks of markets.

differ only by the transportation cost. So, if transportation costs are zero, then the prices at the source should equal prices at the sink. If there is a transport cost, then the price gradients will be as shown. Aggregate flow is constant across locations according to the equilibrium model.

The dynamics of price formation in networks is illustrated in Figure 3. As can be seen, two separate dynamics are at work. Markets near the source open first, followed

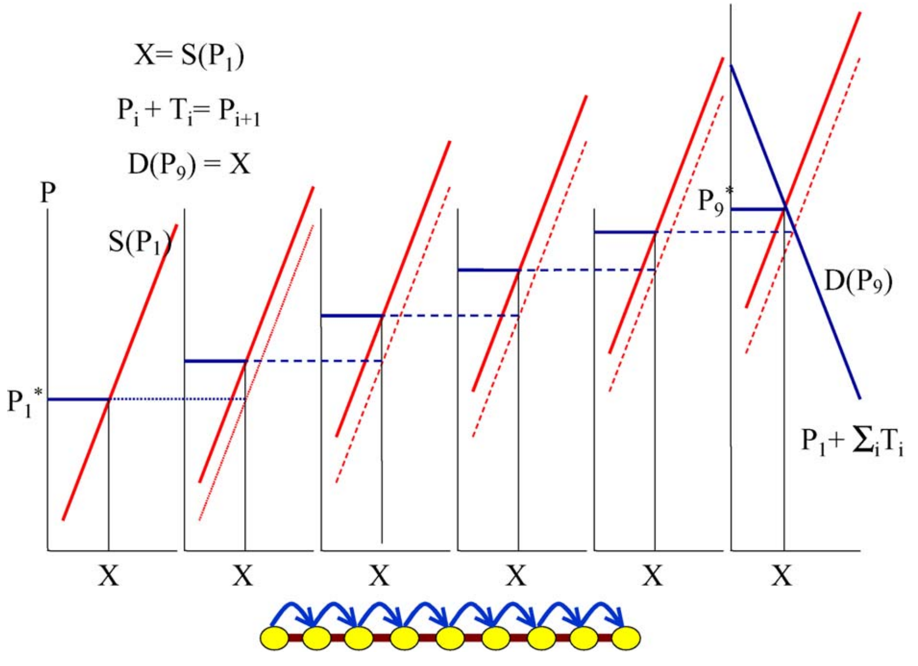

Figure 2. The competitive model applied to the chain of markets.

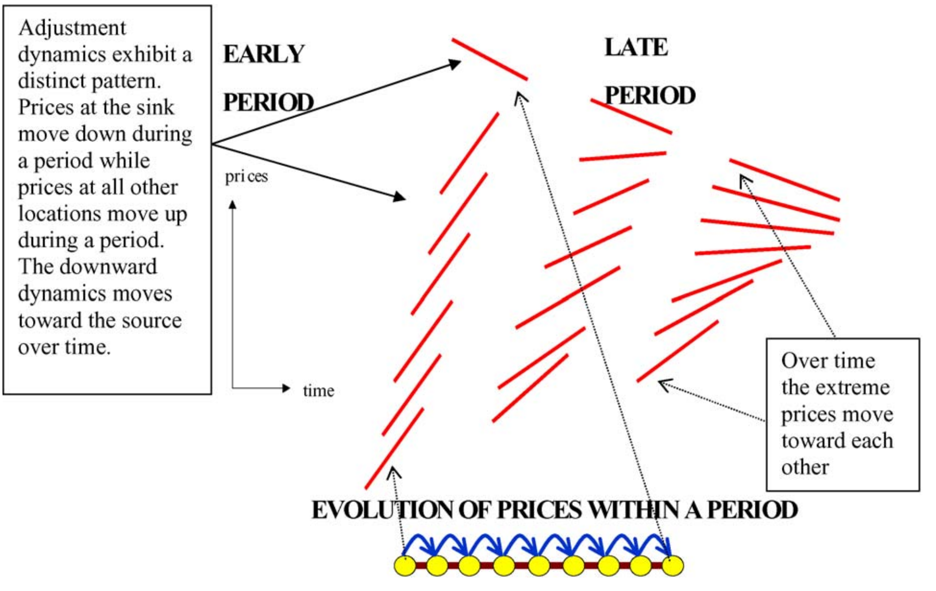

Figure 3.

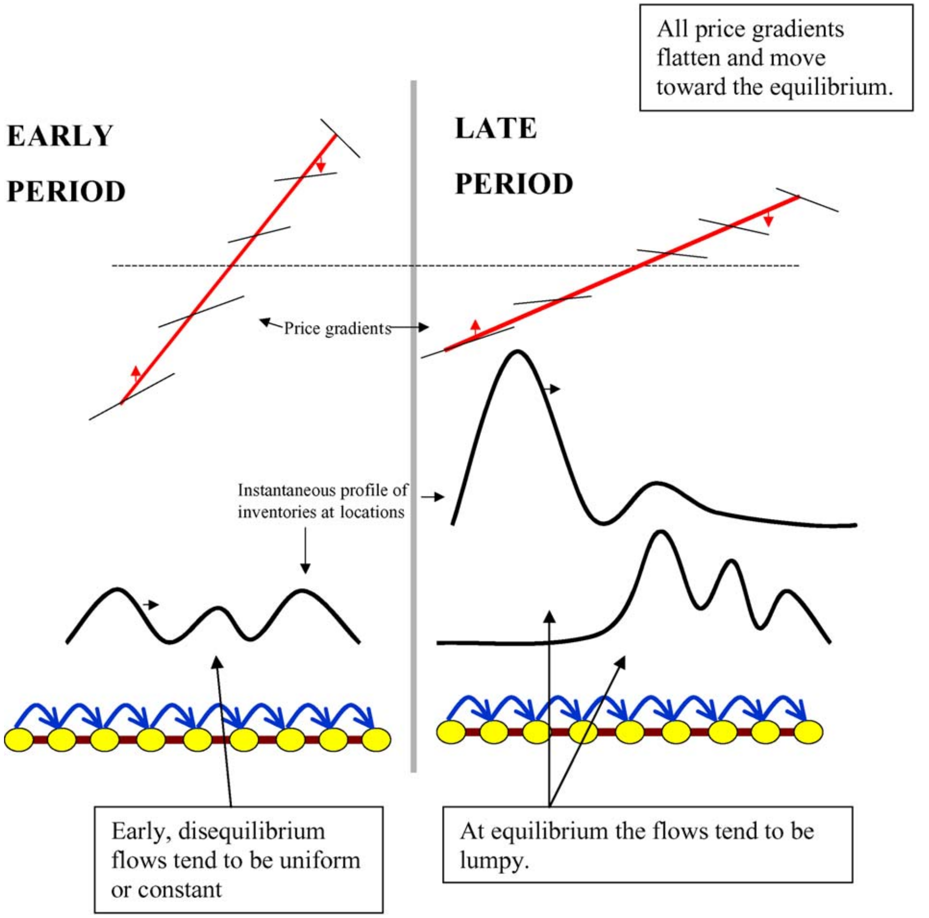

Figure 4. The structure of flow equilibration in relation to price equilibration in a networked chain of markets.

by the markets in the order of the chain. Within a market and within a period the price formation is as shown. The other dynamics operate across periods. The tendency is for prices across periods to equalize towards the competitive equilibrium.

While the prices tend to equalize as the system moves to an equilibrium, the flows have the opposite property (as is illustrated in Figure 4). Flows start rather constant over time but become lumpy as the system equilibrates. That is, all activity is concentrated in one location until all activity moves to the next location. This dynamic reflects the problems and cost minimization features of coordinated activities.

The relationship between prices and inventory location from an experiment that is illustrated in Figure 5. In the top panel, the average prices are shown for each location during period 3 and period 7. The price gradient across location becomes flatter over

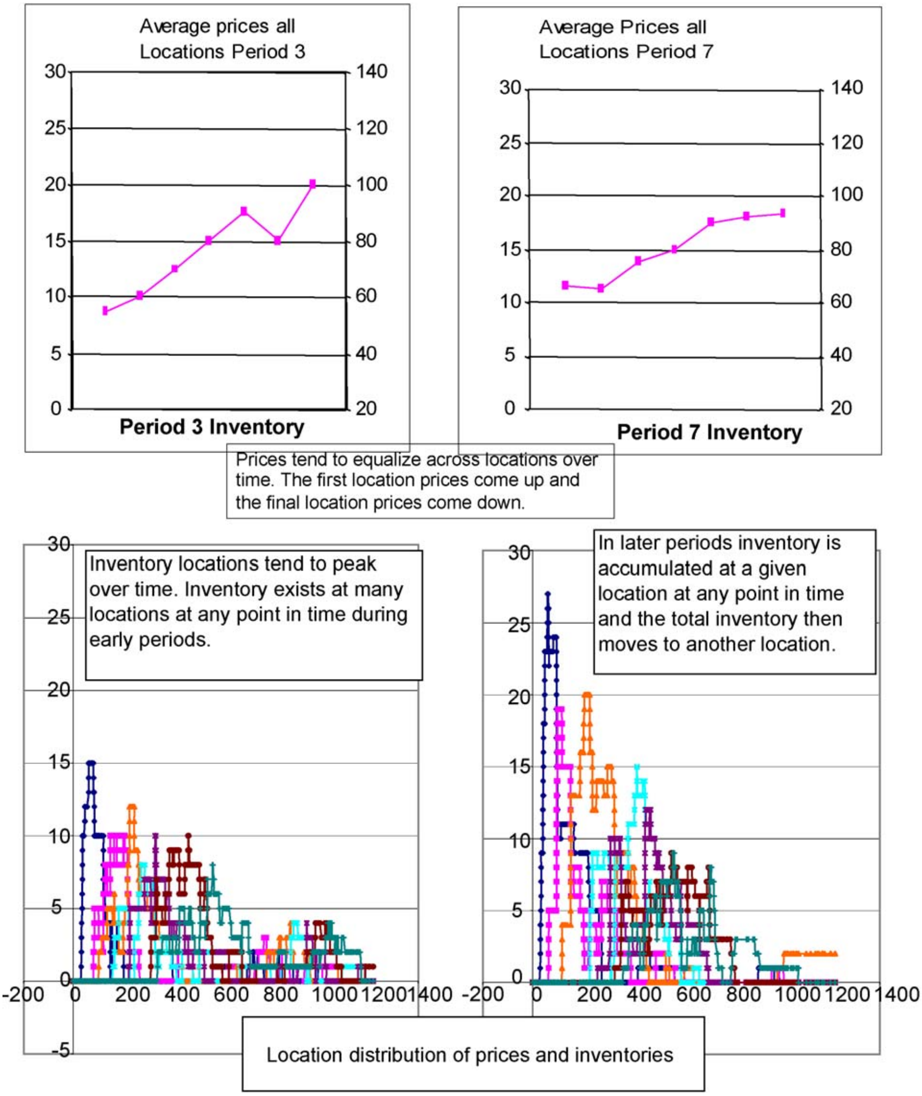

Figure 5. Location distribution of prices and inventories.

time. The bottom panel shows the location of inventory as a function of time (the horizontal axis). The quantity of inventory that exists at the particular location at the instant of time is shown. As can be seen inventory location in the disequilibrium period tends to be scattered in all locations, in a sense it is a constant flow through the system. In later periods the inventory accumulates at a location and then moves all at once. Thus, as the system approaches equilibrium, the flow is lumpy, reflecting the conservation of resources and coordination of agents required to move the units.

Reference

Bosch-Domenech, Antoni, Sunder, Shyam (2000). "Tracking the invisible hand: Convergence of double auctions to competitive equilibrium". Computational Economics 16, 257–284.