In many industries it is common to see multi-stage supply chains, in which different companies occupy different stages of the chain. The number of firms at any level of a supply chain can vary quite substantially. Supply chains also exhibit considerable structural variation across industries. Basic goods and commodity products are often purchased by several distinct sectors – for example, steel is purchased by the automotive industry as well as by the construction industry – and goods can also be sold in more than one geographically distinct marketplace.

Supply chains of this type display a “distributive structure.” These distributive chains, which generalize the serial chains of Corbett and Karmarkar (2001), are the focus of this paper. Firms are grouped into sectors where all firms within a sector are identical. Each sector procures inputs from an upstream sector and produces a product that is distributed to (potentially) many downstream sectors. The resulting system can be pictured as a multi-echelon arborescent network in which each node represents a sector. Each sector is supplied by a unique upstream sector, but may be a supplier to more than one node. Examples of this type of structure abound. Personal computer manufacturers like Gateway and Hewlett Packard buy microprocessors from upstream firms such as Intel or AMD and distribute their computers through large retailers like Best Buy or Target and many other small retailers targeting local markets. These chip manufacturers, besides supplying personal computer manufacturing companies, also supply server manufacturers like IBM and Sun Microsystems, and other electronic device producers like PDA and cell phone manufacturers.
The figure exemplifies a distributive supply chain – each node represents a group of firms in competition. Sector 1 is a group of manufacturers who compete to sell goods to sectors 2 through 4. Sectors 2 and 3 distribute these goods to their respective markets, but the goods that flow through sector 4 are distributed to a third tier of sectors before reaching consumer markets.

![Figure 1: Distributive Network Example](image)

This model also allows us to examine the impact of cost structure on entry and competition. As in Corbett and Karmarkar (2001) we model post-entry competition using the Successive Cournot framework. We provide explicit expressions for equilibrium prices, quantities and firm-level profits. We construct network transformation methods that can compress networks to simpler forms, or expand them to particular (binary branching) forms. By using these transformation methods, we are able to analyze the impact of cost and demand parameters without having to deal with the complexity of the network structure. Importantly, we are also able to study the effect the entry in any sector in the network on any other sector. These effects are in some cases quite non-intuitive.

Our analysis permits us to address a wide range of questions about supply chains with distributive structures:

- What is the relationship between prices and quantities across the supply chain? how are these quantities affected by the structure of the supply chain, and by the number of entrants?
- What is the nature of competitive interactions between different layers or tiers of the
What is the effect of changing demands in one downstream market on channels supplying other markets?

What is the nature of the horizontal interactions that occur in these structures, as distinct from purely vertical interactions? For example, how does change of numbers of firms in one distributive channel affect the profitability in another?

We assume that firms in each sector compete in the Cournot sense, and competition in the network follows the Successive Cournot framework (as in Machlup and Taber (1960), Greenhut and Ohta (1979), Abiru(1988), Tyagi (1999) etc.). That is to say, each firm in a sector chooses a production quantity to maximize its profit given the price it pays to procure goods from upstream. Additionally, the firms consider a demand curve that relates the aggregate production within the sector to the price that they will receive from downstream buyers. For the bottom-most sectors, this demand curve is just consumer demand which we assume to be linear. For other sectors, demand curves are established recursively. Within this context, we use two criteria to determine the equilibrium. For every sector: (1) Given the demand curve faced by a sector and the resource price charged by the upstream sector, no firm in that sector has an incentive to unilaterally deviate from its production quantity. (2) The aggregate quantity produced in every sector is balanced with the aggregate quantity of the resource required (i.e. markets clear). For arbitrarily complex distributive supply chains, we establish that equilibrium prices, production quantities, and profits derive from solving a system of linear equations that encapsulates the network structure together with each node’s production/distribution costs, degree of competition (i.e., number of firms), and derived demand function.

From this system of equations, we extract several structural properties of distributive supply chains and numerous comparative statics. We discuss the implications of our analyses for these questions in detail. One of our most counter-intuitive findings (under our assumptions on costs and demands) is related to the effects on firm-level profits from downstream entry. Conventional wisdom and earlier studies in the literature state that increase of number of firms in a market generally causes the total output of that market to increase, the consumer price to decrease, and each incumbent’s profit to decrease (Seade 1980a). These results are
indeed obtained in the serial and assembly cases (considered in Carr and Karmarkar (2005)), under assumptions similar to those of this paper. However, we find that for the distributive case, with the consideration of vertical and horizontal interactions, firm-level profit for incumbents could increase rather than decrease when more firms enter the market. This result is due to the combined effect of competition and resource price changes. On the one hand, increased competition causes incumbent’s profit to reduce. On the other hand, a decrease in the (upstream) resource price can occur due to horizontal interactions, and this can cause incumbent profits to increase. If the effect of resource price decrease outweighs the effect of competition, the net profit for each incumbent can increase rather than decrease. This result is perhaps the most unusual finding of this study, and is discussed at length.