Abstract

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The Effect of Economies of Scale and Transportation Cost on Supply Chain

One of the industries that have undergone a radical change is the chemical industry. During the last decade, many companies of this industry have established global production sites and used these sites to fulfill global demands. Bayer, for instance, plans to invest 1.8 billion USD into a Toluylen-Diisocyanat (TDI) production site in Shanghai by 2009, doubling the production capacity of this site to 300,000 tons per year. The output of this plant is used to fulfill worldwide demands. Similar investments have been made by many other companies. BASF expanded the capacity of its plants in Nanjing, Ludwigshafen, Antwerp, and Pasir Gudang throughout the years 2002-2006 and opened a new plant in Pudong in 2006. SABIC, the Saudi Basic Industries Corporation, a leading manufacturer of chemicals, fertilizers, plastics, and metals, expanded its global network by acquiring, amongst others, the petrochemicals business of the Dutch group DSM, Huntsman's UK petrochemical activities, and GE Plastics' US-based activities. In 2006, SABIC shipped over 8.6 million metric tons of chemicals and gases to more than 90 ports in over 35 countries around the world with nearly 500 vessels. To match global demand with global supply, chemical companies use global supply chains. Typically, products are produced at a few plants and are shipped to regional tank farms, where they are stored. Customer demand is then fulfilled from these regional tank farms. In most situations, the tanks are owned by a tank farm operator that rents the tanks to chemical companies. When designing a supply chain, companies must make a number of decisions. They must decide on the product mix and production quantities at the production sites, on the locations of the tank farms and tank capacities to use, and on the frequency of deliveries between plants. These supply chain design decisions are medium to long -term decisions and are typically made annually bi-annually. The cost structure of chemical supply chains exhibits several important economies of scale that have to be considered when designing the supply chain. The most important ones are economies of scale in transportation quantities and economies of scale in tank capacities. The freight rate between Europe and South America, for instance, decreased from about 400 USD/m3 to 200 USD/m3 when the transportation volume increases from 1,000 m3 to 10,000 m3. The costs of tank rentals exhibit similar economies of scale. The rental cost of a typical 500 m3 tank, for instance, is 54 USD/m3/year, whereas the cost of a 2,000 m3 tank is only 24 USD/m3/year. Previous research has addressed some of the issues that are relevant when designing supply chains. However, there is no approach that considers all of the main characteristics: design of product mixes, transportation routes, transportation frequencies, storage locations, and storage sizes, taking into account non-linearities in transportation and storage costs. Since the decisions are highly dependent, they must be made simultaneously to obtain an efficient supply chain design and cannot be made independently. The sixteen countries with the greatest production of chemicals accounted for 80 per cent of all world production according to the OECD's Global Outlook 2010. These countries were the United States, Japan, Germany, China, France, the United Kingdom, Italy, South Korea, Brazil, Belgium/Luxembourg, Spain, the Netherlands, Taiwan, Switzerland and Russia. It can be seen that a large proportion of these countries are Member States of the EU. Annual growth in the world chemical industry was 4.6 per cent over the period 2002-2010, which can be compared with growth for industry in general of 4.8 per cent. Growth rates in various parts of the world over the same period were EU 1.7, NAFTA 2.2, Latin America 4.5 and ASEAN 8.1 per cent (CEDFIC 2010b). Asia outside Japan increased its market share from 18 per cent to 30 per cent during the period 1997-2010, a surprisingly rapid rate of growth over this ten-year period. The chemical and petrochemical sector combined represents 12% of total industrial

production and is valued at marginally over US$2bn, accounting for about 3% of total Egyptian gross domestic product (GDP) in 2010. The chemical industry in Egypt has been facilitated in its development by the country’s strong oil industry sector and abundant availability of minerals which is able to provide raw materials, feed stocks and manufacturing infrastructure.