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## Design of international assembly systems and their supply chains under NAFTA

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### Abstract

The purpose of this paper is to provide a decision support aid for the strategic design of an assembly system in the international business environment created by NAFTA. The strategic design problem is to prescribe a set of facilities, including their locations, technologies, and capacities, as well as strategic aspects of the supply chain, selecting suppliers; locating distribution centers; planning transportation modes; and allocating target levels (i.e., amounts) for production, assembly, and distribution. The objective is to maximize after-tax profits. This paper presents a mixed integer programming model that represents the complexities of the international design problem as well as relevant enterprise-wide decisions in the US–Mexico business environment under NAFTA. It deals with a broad set of design issues (e.g., bill-of-material restrictions, international financial considerations, and material flow through the entire supply chain) using effective modeling devices (e.g., linearizing non-linearities that arise in modeling transfer prices and allocating transportation charges). Examples demonstrate how managers might use the model as a decision support aid.

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*Keywords:* Designing international assembly systems; Designing international supply chains; Strategic planning under NAFTA; Modeling international business considerations; Mixed integer programming

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## 1. Introduction

Global competition is increasing the need for enterprises to internationalize, using the production sharing strategy to locate operations in countries that offer comparative advantages. Trade allows countries to allocate natural, labor, and capital resources more efficiently, resulting in productivity increases and economic gains that improve income and living standards. According to a *Wall Street Journal* editorial (Editorial, 2004) “The point of free trade isn’t to create jobs per se but to allow resources to find their most efficient use and re-deploy workers to better paying jobs. Manufacturing networks incorporating the comparative advantages of all three NAFTA members have made North America an attractive investment for global capital”. In particular, the North American Free Trade Agreement (NAFTA) (The NAFTA Secretariat) has encouraged US-based companies to locate assembly operations in Mexico. No widely accepted tools provide decision support for the strategic design of an assembly system in this international environment. The purpose of this paper is to address this need.

The strategic design problem is to prescribe a set of facilities, including their locations, technologies, and capacities, as well as strategic aspects of the supply chain, selecting suppliers; locating distribution centers; planning transportation modes; and allocating target levels (i.e., amounts) for production, assembly, and distribution. Strategic decisions design the system and its capacity for a relatively long horizon (e.g., 2–10 years) with the objective of maximizing after-tax profits. The *objectives* of this paper are a model that represents the complexities of the international design problem, integrating relevant enterprise-wide decisions in the US–Mexico business environment under NAFTA, and examples that demonstrate how managers might use the model as a decision support aid.

Initiated in 1993, NAFTA (The NAFTA Secretariat) furthered relationships between the US and Mexico, the world’s 1st and 10th largest economies. Trade between the US and Mexico jumped 74% from 1994 to 1999 to over \$41 billion (Brezosky, 2003). The 1250-mile Texas–Mexico border fosters close socio-economic ties. The Texas Border Region (TBR) comprises four counties (Cisneros, 2001) with six cities, each of which has a “sister city” across the border. Both Texas and Mexico BRs participate extensively in production sharing under NAFTA. With low levels of education and worker skill, and high levels of unemployment and immigration, the TBR has historically been economically challenged (Yücel, 2001); “There are few places in the United States as desperate for economic development as the impoverished communities of the Rio Grande valley” (Pinkerton, 2001). Trade with Mexico promises new economic opportunities in the TBR.

Before NAFTA, much of the trade between the US and Mexico was conducted under the Maquiladora Program (MP), which began in 1965. Comprised of low-cost, labor-intensive assembly plants that employed only unskilled labor (Vargas, 1998a,b, 2000), it has allowed US companies to assemble products that are priced competitively in the world marketplace. Maquiladora import parts from the US, assemble them, and return end products to the US where distribution centers (DCs) typically offer better insurance coverage, protection against pilferage, and hedging against changes in exchange rates. Shipments into Mexico incur no tariffs, and the US shipper pays duties only on the value added in Mexico, stimulating job growth in the Maquiladora but discouraging use of suppliers in Mexico. Second-generation operations, which involve higher levels of technology using modern management techniques (e.g., just-in-time (JIT)), began in the 1980s. More recently, third-generation operations (Buitelaar and Perez, 2000) have involved

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