Network Design for an Electronics Manufacturer

Introduction

T-Nova Global Electronics (TGE) is a multinational electronics and computer hardware company selling high-tech electronic devices mainly in European markets. Currently, TGE outsources to contract manufacturers. These manufacturers receive components and raw materials from suppliers and oversee the assembly, quality control, testing, and packaging of the final products. The company receives the final products first at cross-dock facilities located in airports and ports, then ships to distribution centres which are used as central hubs for inventory storage. Afterwards, the products from the distribution centres are distributed to retailers, including larger retail chains (e.g., Mediamarkt) and smaller local retailers. End customers, comprising individual consumers, businesses, educational institutions, and government organizations, purchase their products through these retailers. The company strives to provide reliable products, exceptional customer service, and after-sales support to ensure customer satisfaction.

Despite these efforts, TGE's management is unsure whether the current operations are being managed efficiently. One of the main challenges facing the company is aligning its economic and environmental objectives. The company wants to minimize operational costs, but also to pay attention to carbon emissions. To understand the situation and make good decisions, therefore, the management seeks to conduct a thorough analysis of the current and prospective supply chain network design scenarios, considering operational and carbon emissions costs.

Supply Chain Details

The current product flow and transportation mode of TGE is visualized as follows:

Fig 1.: The current product flow

TGE's supply chain includes **three** manufacturing facilities situated in Asia. After the products are manufactured, they are routed to **six** strategically positioned cross-dock facilities at European airports and ports. The network incorporates **four** distribution centres (DCs) that serve as central hubs for inventory storage and management. These facilities collectively cater to the demands of end customers through **fifty** retailers. Furthermore, all products are shipped via air freight for expedited delivery.

Data

All relevant data is available in the Excel files and accompanying supplementary materials. The data attributes and guidance for the necessary calculations are described as follows:

ATTRIBUTE	OWNER	DESCRIPTION
SOURCING COST (€)	Manufacturer (source)	Unit sourcing costs across various manufacturers
HANDLING COST (€)	Cross-Deck & Distribution Centres	Cost of handling each unit upon receipt/storage in respective locations
DEMAND (UNIT)	Retailer	Retailers' demand
VARIABLE COST (€)	New Production (Optional Source)	Unit variable cost (per product) for each newly opened facility
OPENING COST (€)	New Production (Optional Source)	Fixed opening cost for each newly established facility
OPERATIONAL COST (€)	New Production (Optional Source)	Operational expenses for newly established facilities (optional source) per year
OVERALL CAPACITY (UNIT)	New Production Facilities (Optional Source) & DCs	Maximum available capacity per year at each New Production facility and DC
LATITUDE & LONGITUDE	All Locations (Nodes)	The distance between nodes should be calculated using latitude and longitude coordinates.
TRANSPORTATION COST/KG-KM (€)	Air – 0.0105 Sea – 0.0013 Road – 0.0054	The estimated average transportation costs for electronic products per kilogram-kilometre.
CO_2-EMISSIONS FACTORS (gCO_2/TONNE-KM)	Air – 971 Sea – 27 Road – 76	Average emissions factors by transportation modes

Requirements

As part of your role in providing analytical support to TGE's management, you are required to develop a transshipment model that encompasses location and transportation mode decisions to facilitate the analysis of the situation. The following scenarios will guide you in making informed decisions and recommendations.

Scenario 1: To expedite time-to-market, TGE currently utilizes **air freight** for product shipments (Fig. 1). Your task is to formulate an efficient distribution plan, incorporating relevant data and input parameters, to address the transshipment challenge. This plan should outline the allocation of products from sources to cross-docks, cross-docks to distribution centres, and distribution centres to retailers.

Scenario 2: To enhance resilience against supply chain disruptions, management wishes to establish new production facilities (*Optional Source*), close to demand points in Europe. There are **ten** potential locations for establishing a new production facility. Consequently, the product flow within TGE's supply chain is reconfigured as follows:

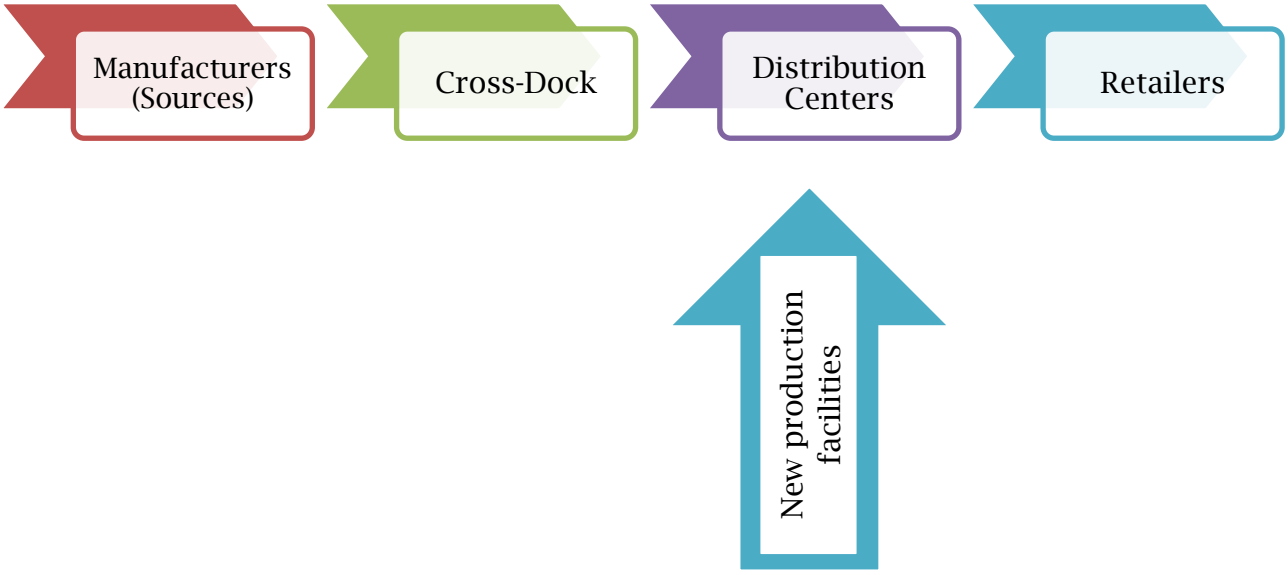

Fig 2.: The product flow with new production facilities

However, apart from variable production costs, these locations are associated with significant opening and operating costs, but they are expected to reduce transportation costs. Therefore, by considering location decisions your task is to reformulate the transhipment problem developed in Scenario 1 and to investigate the feasibility of opening a production facility.

Scenario 3: Recognizing that air freight is both expensive and environmentally unsustainable, TGE is proactively investigating alternative strategies to minimize costs and reduce its carbon footprint. Consequently, the management seeks to understand the impact of adopting an alternative transportation mode, encompassing sea freight and road in addition to air freight (Fig.3). It's important to note that the road transportation option is not available for the movement of goods from manufacturers to cross-docks; the only available options are air and sea freight.

Although the cost factor plays a key role in the decision-making, the speed of the chosen transportation mode is also crucial for the company. TGE has analysed historical data and discovered that different transportation modes are associated with different additional costs per unit distance, primarily attributable to variations in their transport speed. These additional costs encompass expenses incurred due to stockouts, backorders, lost sales, penalty costs, and other factors. Internally, TGE refers to this category of cost as "*slowness cost* (π)," and it is estimated for each transportation mode as follows:

- $\pi_{air} = 0.00065 \text{ €}\, unit/km$
- $\pi_{sea} = 0.0525 \text{ €}\ unit/km$
- $\pi_{road} = 0.00270\ \text{€}\, unit/km$

And now, TGE's management wishes to exert more effort into abating its carbon emissions. Please provide suggestions to TGE to make a trade-off between reducing its emissions compared to the current plans (Scenario 1 & 2) and the change in optimising its allocation plan with a primary focus on minimizing the cost

associated with carbon emissions. What is the effect of this new consideration on the allocation plan?

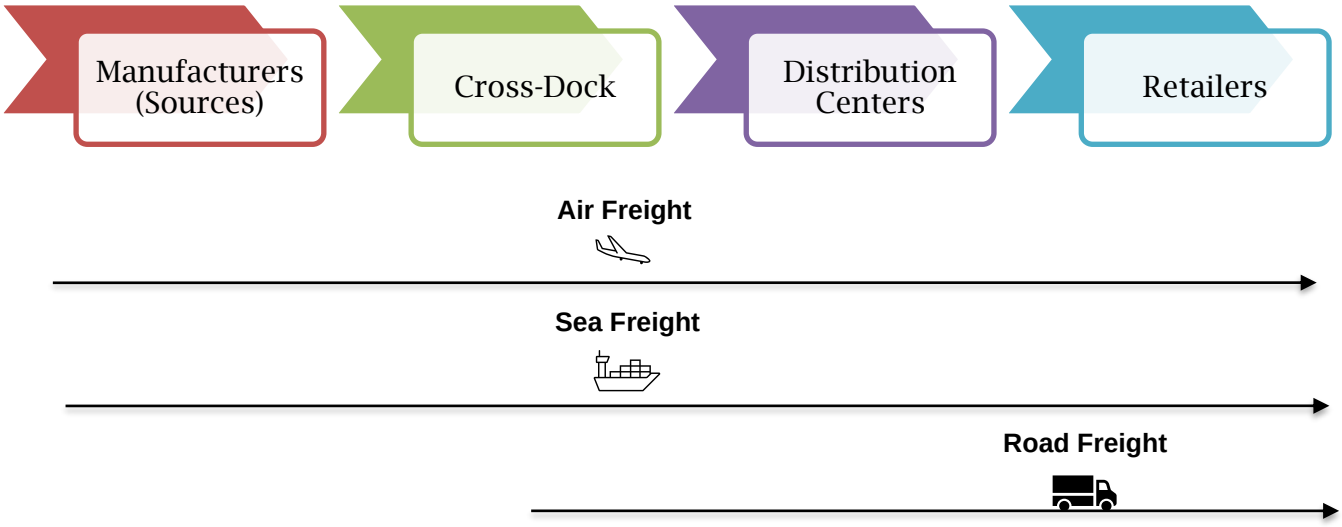

Fig 3.: The product flow and alternative transportation modes