Incorporating Environmental Impact in the Network Decisions at an Italian Distributor

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Introduction

Abstract

The following contribution aims at illustrating a practical network design decision incorporating both economic as well as environmental considerations. Product recovery will also be examined in this context, both with respect to that which is being done at present as well as deliberating several options for increased product recovery opportunities.

Keywords

Sustainable Operations, Economic and Ecological Factors, Product Recovery, Case Study

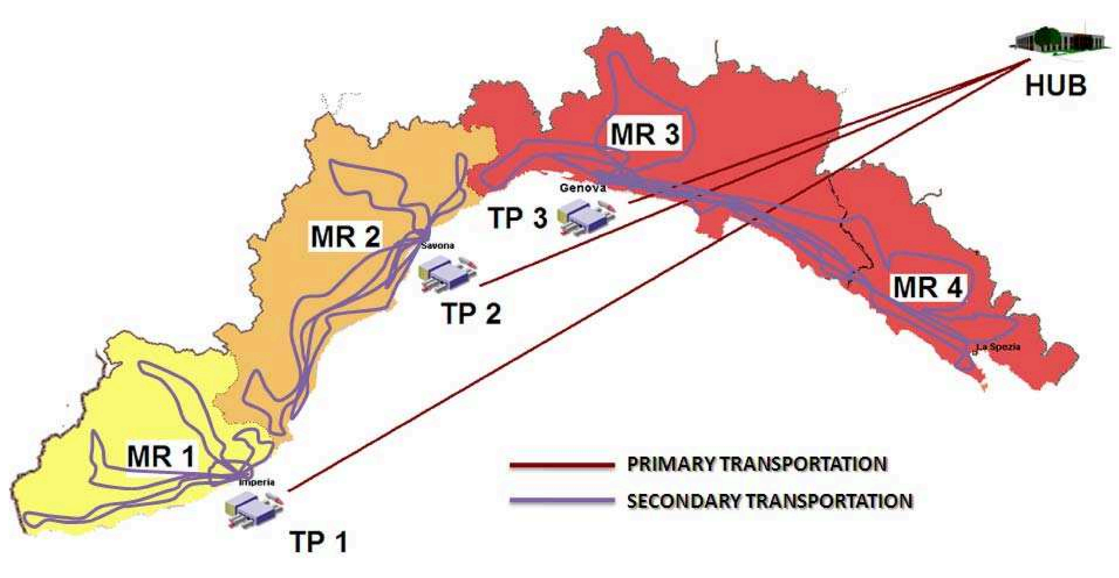
Case Study

The following case study is based on industrial contact to Porta a Porta (PAP), an Italian distributor of a diverse range of products. The company specializes in delivering products directly to customer's residences. Its customers are manufacturers selling products via catalogs, internet, or outside sales representatives.

In order to enable the distribution of the items, it has established a two-tier system consisting of:

- 1 *hub* located in Milan
- 50 *transit points*

The hub, which belongs directly to PAP, receives items shipped from manufacturers (OEMs). These shipments are then cross docked and shipped to transit points via full truck load shipments. The trucks are not directly owned by PAP but rather operate as independent contractors receiving a certain amount of money per kilometer. Transit points also operate independently, as do the vans which are used to deliver specific shipments to households. Households nationwide are divided into *market regions*, and each market region must be served by a transit point.



Illustrating the planning problem.

The figure above depicts the italian region of Liguria and will be used to illustrate the planning problem. The entire region to be covered is split into four distinct market regions (MR). As can be seen in the figure, the first two transit points serve the demand of their respective market regions while the third transit point must serve the demand of two market regions (MR3 and MR4). We distinguish between transportation modes as follows:

- Primary transportation: This refers to transportation between the hub and transit points on trucks. We can further differentiate between *forward* and *reverse* transport flows.
- Secondary transportation: This refers to transport from the transit points to the household, accomplished by vans. We can also discern here between forward and reverse flows.

Model

The **decisions** of this model are:

1. Where to open transit points (in which market regions)
2. Which transit points will serve each market region

The **objective function** contains fixed cost for setting up a transit point, primary transportation, and secondary transportation. In calculating the secondary transportation, we employ an an approximation found in [1] and [2]:

$$D = \frac{\alpha \cdot N}{\sqrt{N/A}}$$

where D denotes the distance, N the number of delivery destinations, and A the area. **Constraints** include capacity constraints on the primary and secondary transportation modes. The model is combinatorial in nature, and has a non-linear objective function (resulting from the approximation) making it extremely difficult to solve for practical-sized problems like those faced by PAP.

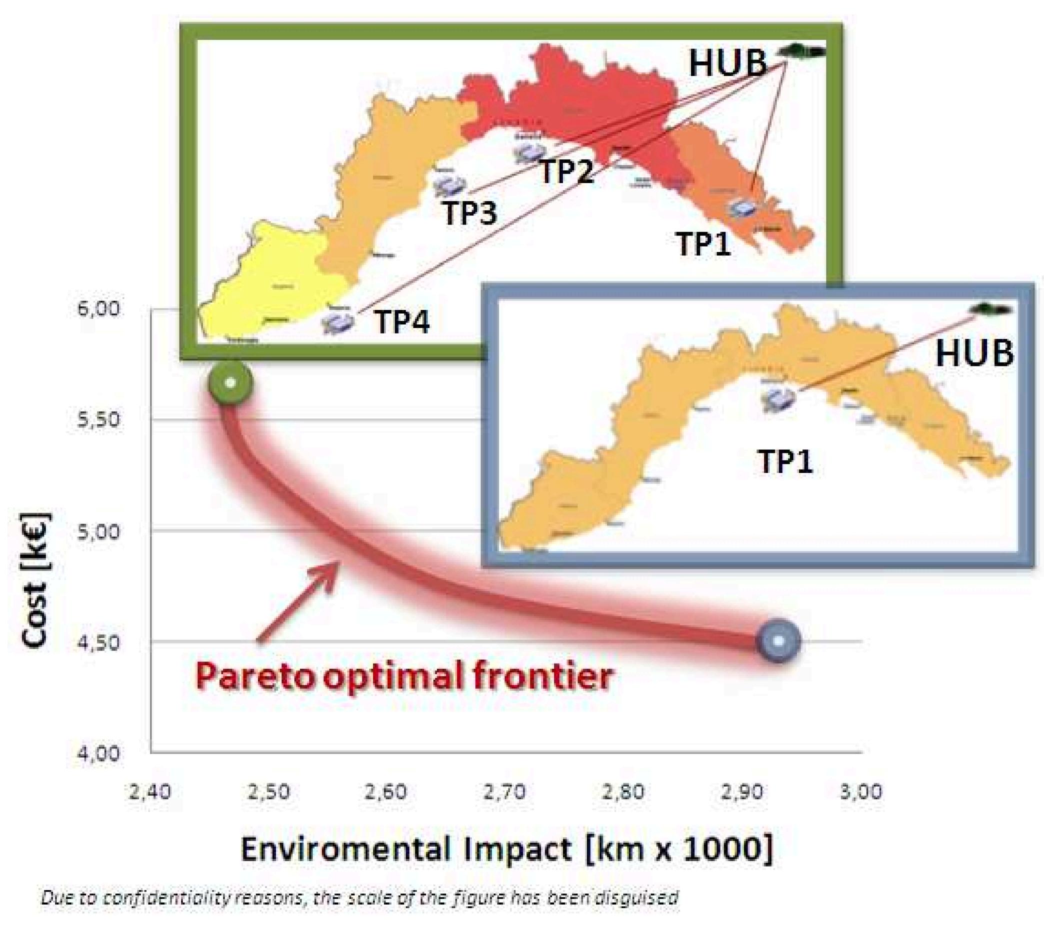
Sketch of Heuristic Solution Method

The heuristic we propose works in a greedy *drop* fashion. In a certain geographical region to be planned, we start by placing transit points in each market region. In each iteration, the transit point fulfilling the *least number of deliveries* is dropped and its market region is aggregated into the service area of a neighbor transit point. Specifically, all adjacent transit points are checked and the market region is added to the transit point which results in the largest cost reduction. In our experience, starting with all of the market regions as transit points results in the solution with the highest cost (economic measure) but the lowest number of kilometers travelled (the ecological measure). As points are dropped, the costs decrease while the number of kilometers increases. The result is a Pareto frontier similar to that observed in [4] and [5].

Illustrating the Heuristic

In order to illustrate the heuristic, we choose the italian region of Liguria.

1. In the first step, all market regions are designated as transit points, each serving only their own demand.
2. In the next step the market region with the lowest number of deliveries is aggregated with its neighbor, with
   - a decrease in costs
   - an increase in kilometers
3. Subsequent iterations likewise decrease costs while increasing kilometers travelled.
4. The final iteration aggregates all 4 market regions to one transit point, resulting in the lowest cost albeit with the highest kilometers travelled.



Due to confidentiality reasons, the scale of the figure has been disguised

On the basis of this **Pareto-efficient frontier**, management must strategically decide *how* environmentally friendly the firm wishes to be. While balancing competing objectives is inherently difficult, there is no cogent mechanism to resolve this conflict, and therefore this decision must be relegated to senior management.

Options for Product Recovery

At present PAP deals with what might be termed regret returns, returns which result from the customer refusing delivery of the product. This can mainly be attributed to the fact that customers order the items from sales channels such as catalogs and only pay for the items upon delivery. As such, product recovery is already occurring albeit on a very limited basis. These regret returns have already been incorporated into our analysis through data expressing the average percentage of shipments returned in each market region. Further analysis will attempt to include more sophisticated forms of product recovery, such as:

- *Spare parts returns*, where the customer orders a spare part and returns the broken spare part when the new one is delivered
- *Old product returns*, where the customer orders a new product (e.g. vacuum cleaner) and receives a discount contingent on returning the old vacuum cleaner when the new unit is delivered
- *Opportunity returns*, where in contrast to the return scenarios above, the customer has the opportunity to return a product unrelated to the product which has been delivered by PAP.

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