Analysis of the Physical Internet vs. supply chains

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1 Motivation

Supply chains intensely use means of transport and storage facilities to deliver goods all around the world. However they are still mainly dedicated, poorly interconnected and this fragmentation is responsible for a lack of consolidation and thus efficiency. To cope with challenging emissions targets, an improvement by an order of magnitude in supply networks is sought rather than continuous improvement or a giant leap in vehicle technologies [1].

This is the purpose of the Physical Internet a slightly new way to look at the consolidation problem at the global design level and related issues in logistics [2-4]. This approach claims to universally interconnect logistics services as the Internet did with computer networks [5]. Physical Internet no longer deals with goods but with smart containers. The use of a set of smart and secured containers with modular dimensions and standardized interfaces for handling and communication enables a new supply network organization. Instead of dedicated, fragmented and overlapped supply networks, interconnecting different existing networks can develop a global meshed network.

If from a logical point of view, this concept should improve efficiency by merging flows a demonstration of its potential has been carried out in term of transportation efficiency [6] and has to be carried out on several aspects such as emissions reduction or inventory required for a given service level. We show in this paper that this topology of logistic networks has a major performance impact and that it can be significantly improved if the actual organization of flows is substituted by an organization founded on the universal interconnectivity of logistic networks.

2 Methodology

Contemporary logistics networks are marginally challenged in term of organizations in the assessment and the improvement of their performance in supply chains. Contrary as the goal sough here is to search for a contrasted solution the performance is not assessed by a detailed optimization model but rather by an analytical model based on previous work done in the field of continuous approximation [7] and shortest path in networks [6] over a given region.

The analytical approach as described in [8] allows us to describe a set of supply chains as a stylized set of flows and inventories over an area. Assumptions are made here to make the model easy to understand and discover the levelers. For example, the demand at retailers' level is represented by a density function over a geographical area. For the sake of the comparison the demand and the plants localization remains the same for the classical supply chains and for the Physical Internet network.

On one side the classical supply chains are modeled from plant to warehouse to distribution centers and to retailers. On the other side the design of the physical Internet is modeled from plant to the network hubs and to the retailers. For these two types of supply networks the flow required to satisfy the demand, the transportation needs, the storage needs and the environmental footprint are determined over different configurations of areas.

3 Results

In this paper, we show through the examination of the original works on the Physical Internet that it offers a better alternative to the current logistics organization and away to generalize logistics pooling. Through a fundamental analytical model, we have put in evidence four levels of evaluation and potential gains: transportation intensity, transportation efficiency, supply chain inventory for a given service level and environmental footprint on a generic network. For each of these four levels, the Physical Internet organization has revealed to be a significantly dominating solution under fair costs assumptions.

The uncovered potential of the Physical Internet makes it possible to save up to 40% in logistics-generated CO2 emission while still relying heavily on truck transportation means as currently done. If we switch to less polluting means, the improvements could be even more spectacular but depends of the production mode.

It is however important to place our work in its intended exploratory context. It thus includes a number of simplifying assumptions that translate into potential future research avenues. A first perspective consists of extending our work to more realistically configured geographical spaces and to real data so as to study the robustness of our early results and to highlight the stakes at national and international levels with import and export of goods and different costs structures. A second perspective is to introduce dynamic analysis to study stability and the behavior of such new supply networks under various perturbations or disruptions.

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