Omega 58 (2016) 111–127

Contents lists available at ScienceDirect

Omega

journal homepage: www.elsevier.com/locate/omega

Correct accounting for duty drawbacks with outward and inward processing in global production networks ☆

Marius Häntsch [a], Arnd Huchzermeier [b]

[a] Daimler AG – Production Strategy Locations, Mercedesstraße 138, 70327 Stuttgart, Germany
[b] WHU – Otto Beisheim School of Management, Burgplatz 2, 56179 Vallendar, Germany

ARTICLE INFO

Article history:
Received 20 March 2014
Accepted 15 April 2015
Available online 28 April 2015

Keywords:
Duty drawbacks
Production networks
Automotive
Strategic planning

ABSTRACT

We develop a new model for the correct accounting of customs duties levied on a product. We examine inward and outward processing – that is, processed components can be either imported or produced in a foreign country – in the strategic planning of a global production network. This complex modeling problem is structured with path variables, and the duty drawbacks can be simultaneously and correctly entered for n production stages in m market regions (with corresponding duty regions) for all products with a maximum n-level bill of materials. We present a case study from the automotive industry to examine whether or not the possibility of future duty rate changes or free trade agreements, such as one between the United States and the European Union, could affect the design of a production network and hence should be considered in strategic planning. We show that correctly accounting for duty drawbacks can lead to changes in the global footprint of production. We also demonstrate that intercontinental trade barriers (in the form of duties) diminish working capital and entail longer delivery routes. Eliminating these political trade barriers could increase the returns to capital while reducing both delivery lead times and environmental costs.

1. Introduction

The production networks in many industries have become more internationally linked than ever. Especially in the automotive industry, global added-value activities are critical for success – as we can see with such market leaders as VW, Toyota, BMW, and Mercedes-Benz. Yet the establishment of production networks involves more than following market developments; relationships, restrictions, and promotions in international trade play a key role in selecting future production locations [26]. For many industrialized nations and emerging markets, the automotive industry is an important one. It symbolizes the highest technological progress of a nation's economy, and its high job multiplier (7.5 per job; [23]) creates steady employment in automotive manufacturing. Trade restrictions, such as high duties on vehicles or trade agreements with selected partners, help governments to enhance the appeal of their own production location and flow of goods. For instance, China has high import duties on finished vehicles even though upstream products can usually be imported with much lower duties; moreover, if upstream products are re-exported then duties may be waived or refunded in order to ensure the international competitiveness of local companies. There are also lower duties upon re-import of goods that were further processed by "extended workbenches" in other countries as part of an intermediate process. Western European original equipment manufacturers (OEMs) use such a cost advantage (e.g., from Eastern Europe) to improve their global competitiveness [21]. The latter measures can significantly affect the appeal of production locations and so, in general, should be considered in the strategic planning of such networks. Duty drawbacks are rarely addressed by optimization models found in the literature. We know of no other research publications about the proper accounting of duty drawbacks for globally produced products, as when their components are (repeatedly) manufactured or assembled in foreign countries.

Section 2 reviews the literature on accounting for duty drawbacks in optimization models. In the next section we discuss the relevant fundamentals of duties and duty drawbacks. In Section 4 we develop a new model that performs that accounting in full. A case study is presented in Section 5, where the effects of a free trade agreement between the United States and Europe are analyzed and we present results of a study on the ideal production footprint. In Section 6 we summarize the results, discuss some managerial insights, and suggest future avenues of research.

2. Survey of the literature

In this section we review previous optimization models for global supply chains that incorporate duties and duty drawbacks.

☆This manuscript was processed by Associate Editor Kuhn.

E-mail addresses: marius.haentsch@daimler.com (M. Häntsch), arnd.huchzermeier@whu.edu (A. Huchzermeier).

http://dx.doi.org/10.1016/j.omega.2015.04.007
0305-0483/

The optimization model of Henrich [12] has been further developed over the years with an emphasis on the automotive industry. This model has been updated by Fleischmann et al. [8] to include investment decisions and has been given more flexibility by Kauder and Meyr [18] – for example, by chaining plants (see also [17]). Despite mentioning the importance of duty drawbacks, Kauder and Meyr omit this factor from their model (as do Fleischmann et al.) and thus account only for duties on imported end products in sales regions.

A fundamental work on optimizing the supply chain network is that of Huchzermeier and Cohen [15], which is based on Huchzermeier's [14] dissertation. These authors have developed a stochastic, dynamic model that accounts for real options in the strategic planning of global supply chain networks. The model maximizes global profit after taxes, and their theory offers a way to evaluate the risks and opportunities of flexible production networks. With respect to international factors, no duty drawbacks are accounted for in the duties – see the models of Pomper [28], Cohen and Lee [6], and Canel and Das [4]. We remark that Huchzermeier's dissertation explicitly accounts for duty drawbacks (by way of aggregation) but does not track the flow of goods. This limitation makes it impossible to account correctly for inward and outward processing if (as discussed in Section 3) intermediate components are further processed in a foreign country. In the case of multi-sourcing options, one cannot easily identify the duty region from which a product's respective upstream product comes. That being said, in practice a component's origin must be clearly marked.

Kouvelis et al. [20] present a relatively simple, multi-period, mixed integer linear programming (MILP) model for choosing locations in a global production network. Investment decisions are accounted for as in Bhutta et al. [3]. The Kouvelis et al. model is distinguished by permitting investments only in the first period; hence that model accounts only for a two-stage production network. Exogenous factors include incentives, tax breaks, and duties. As in the models of Jacob [16] and Goh et al. [10], the customs payments in the Kouvelis model occur irrespective of the destination country. That simplification should be critically examined because, in fact, the duty rates on products differ by destination and region of origin. These models also overlook duty drawbacks.

Bhutta et al. [3] have developed a MILP model for location decisions of multinational companies. When determining the ideal production footprint, this model accounts not only for investments and capacity but also for such exogenous factors such as exchange rates and customs duties. The model is demonstrated and validated with the help of multiple scenarios – in which capacity is assumed to be unlimited – and highly simplified case studies. Bhutta et al. do account for customs but their model does not include duty drawbacks. The model of Chakravarty [5] looks at the static design of supply chain networks. That model accounts for investment decisions and variable costs; it also includes such global parameters as local taxes, exchange rates, and customs duties. Sales prices are not specifically addressed either in this model or in the Bhutta et al. [3] model, and customs owed are simply added to the unit costs. Häntsch and Huchzermeier [11] take a similar approach, assessing the risks in strategic network planning by way of a model that includes customs in the relevant transport costs.

Summaries of different models for planning supply chain networks can be found in Aikens [1], Vidal and Goetschalckx [31], Erengüç et al. [7], Goetschalckx and Fleischmann [9], Papageorgiou [27], and Melo et al. [24]. Aikens presents, as do Goetschalckx and Fleischmann, one of the first overviews of fundamental location decision models. In their detailed review, Vidal and Goetschalckx classify the various models in terms of the factors for which they account. Erengüç et al. analyze possible planning approaches for operational, tactical, and strategic supply chain planning; Goetschalckx and Fleischmann focus on the strategic level. Melo et al. give a broad and detailed review of facility location models in the context of supply chain management. Although that review considers duties, it merely conflates duties, exchange rates, and some other financial aspects as “internal factors”; thus, duties are mentioned only as an aside.

In short, only a few authors account for duty drawbacks in their models. One explanation for this reluctance is that correctly calculating the route of materials or upstream products requires one to trace them in full from the source to the end customer. Tracing a path increases the complexity of a model's formulation and practically assures a longer run time for the optimization model.

We will use the example that follows to establish the relevance of duty drawbacks (see Fig. 1). We will demonstrate how the models that account for duties – but not for duty drawbacks – can result in significant discrepancies when calculating netduties. A cost calculation that fails to account for duty drawbacks results in customs duties of €200 for the import of the powertrain to a

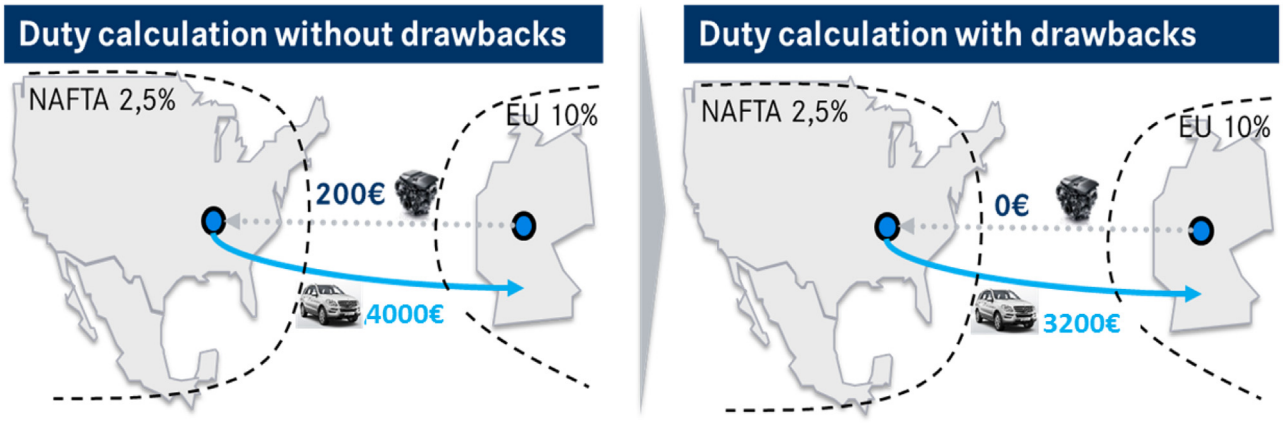

Fig. 1. Correct customs calculation based on static tariff values.