Insourcing vs. outsourcing under economical and environmental considerations

Narjes Kandil[1], Olga Battaïa[2], Ramzi Hammami[3]

[1] Institut Supérieur de l'Aéronautique et de l'Espace, Toulouse, France
Narjes.KANDIL@isae-supaero.fr
[2] Kedge Business School, Bordeaux, France
olga.battaia@kedgebs.com
[3] Rennes School of Business, Rennes, France
hammami.ramzi@gmail.com

Mots-clés : *optimisation, green supply chain, operational research*

1 Introduction

With the increasing environmental awareness, the greeness of the product is becoming an essential aspect in the current context. As governments around the world are implementing regulations in order to reduce the alarming effect of globalization on the environment, we develop analytical models to study the sourcing strategy of a firm under a carbon tax. We take into consideration carbon emissions from the production process as well as transport. The firm faces a price and carbon emission sensitive demand. Our goal is to find the impact of a carbon regulation on the strategic decisions of a firm.

2 Assumptions and Mathematical Formulation

We consider a profit maximizing firm that can either produce the product in-house and have a vertically integrated supply chain (SC) or outsource the semi-finished good to a supplier in a foreign country and have a decentralized SC. The objective is to find out which SC structure is more beneficial to the firm.
Taking into consideration the environmental legislations that are being set in many countries, we assume that the firm faces a carbon tax t per unit of carbon emitted. Furthermore, the firm chooses to invest K to reduce its emissions from an initial level x_0 to x_p per unit of product. The firm has to set x_p at the beginning of the planning horizon. In the case of insourcing, the firm chooses to manufacture the product in-house with a cost c and an amount x of carbon emitted during the production process per unit of product. We assume that the production zone is so close to demand zone that transpotation emissions can be neglected.. We can then write the firm's profit as in Table 1 where $A - \alpha p - \beta x$ is the demand,A being the market potential and α and β the customers sensitivity to price and emissions.
In the case of outsourcing, the firm will benefit from a lower production cost but the transport of goods will induce a higher environmental penalty. In this case, $x = x_p + x_t$ where x_t is the emission level related to transport. We consider three different sourcing contracts and maximize both the firm and the supplier's profits. We try to find the firm's optimal profit margin m and emissions level x_p that she would impose on the supplier. On the other hand, the supplier sets his optimal wholesale price ω.
Similar works can be found in the literature. For example, Meng et al. [1] study the make - or - buy decision under environmental legislations, and study the impact of the tax on the

firm's sourcing strategy and overall carbon emissions. The main differences between their work and ours is that the authors here consider an exogenous price while it is a decision variable in our model. Besides, we do not consider the government's behaviour but rather consider an exogenous tax. And there is no sustainability investment while we are assuming that the firm will invest to reduce its emissions in our case.
Singh et al. [2] assume a green tax on the net revenue of the firm to study the income of different manufacturing contracts. They use a bilevel programming approach to determine the optimal transfer price, retail price and the optimal profits of both the supplier and the manufacturer.Although this paper is more about managing the sourcing structures than the make-or-buy decisions, it is one of the few works that considers a tax on carbon emissions in the supply chain.

In the table below we write the profit functions for different scenarios.

Sourcing strategy	Profit functions
Insourcing	$\Pi(p,x) = (p - c - tx)(A - \alpha p - \beta x) - K(x_0 - x)^2$
Cost sharing contract	$\Pi_r(m,x_p) = (m - tx)(A - \alpha m - \alpha\omega - \beta x) - \phi K(x_0 - x_p)^2$
	$\Pi_m(\omega) = (\omega - c)(A - \alpha m - \alpha\omega - \beta x) - (\phi - 1)K(x_0 - x)^2$
Revenue sharing contract	$\Pi_m(\omega) = ((1-\Phi)(m+\omega) + \omega - c)(A - \alpha m - \alpha\omega - \beta x_p - \beta x_t) - K(x_0 - x_p)^2$
	$\Pi_r(m,x_p) = [\Phi(m+\omega) - \omega - tx_p - tx_t](A - \alpha m - \alpha\omega - \beta x_p - \beta x_t)$

TAB. 1 – Profit functions for different sourcing cases

In case of outsourcing, we will seek to maximize both the retailer and the manufacturer's profit functions, e.g Π_r and Π_m respectively. The coordination contracts considered here are commonly used in the literature. Under a cost sharing contract, both parties agree upon a portion of the costs to share. In our case, we assume that the environmental investment is shared. Under the revenue sharing contract, the retailer gives a portion of his revenues to the manufacturer in exchange for a reduced wholesale price.

3 Conclusion et perspectives

We are using backward induction to derive the analytical expressions of the optimal decision variables and are using Scipy L-BFGS-B solver to compare the numerical results with our analytical findings. This represents a simple model that we thought of to try to consolidate between Production and Operations Management and Theory of the firm community to see how would an environmental regulation such as a carbon tax would affect the sourcing strategy and the pricing decision of a firm.
With our results, we seek to find the best localisation, sustainability investment and selling price for a firm facing a price and emission sensitive demand. In case of outsourcing, we are interested in the supply chain coordination by comparing the outcomes of different sourcing contracts to see what would be more beneficial to both the manufacturer and the supplier.
As future directions of our research, we want to improve this model by incorporating uncertainty in demand and also in environmental cost as it would be closer to real life cases where the price of carbon is unknow or changes from one year to another.

Références

[1] Meng, X., Yao, Z., Nie, J., Zhao, Y. *Make or buy ? It is the question : A study in the presence of carbon tax.* International Journal of Production Economics, 2017.

[2] Sanjeet Singh, Nivedita Haldar & Anindya Bhattacharya Offshore manufacturing contract design based on transfer price considering green tax : a bi-level programming approach International Journal of Production Research, 2016.