ABSTRACT

of the dissertation titled

BILEVEL PROGRAMMING BASED MODELING FOR PRICING DECISIONS IN OFFSHORE MANUFACTURING CONTRACTS INVOLVING GREEN TAX

Submitted by

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In business parlance, *outsourcing* means contracting out a portion of the business activity to an external (foreign or domestic) party rather than doing it in-house. Outsourcing helps firms to reduce costs, increasing flexibility, access to advanced technology or expertise, focusing more on core competencies; whereas, *offshoring* refers to the relocation of jobs and production to a foreign country. The relocated jobs and production could be at a foreign office of the same multinational company or at a separate company located abroad. In contrast, the term 'outsourcing' does not necessarily imply that jobs and production are relocated to another country. Exorbitant taxes, high energy costs, excessive government regulations and mandates, along with high production and labor costs motivate firms in developed countries to offshore the production to developing countries. Sometimes a firm goes for *offshore outsourcing*, i.e., outsource a business function to a firm in another country.

Though, offshore manufacturing is one of the main reasons for the economic development of the developing countries, economic development has come with a heavy price in the form of environmental pollution caused due to the *Green House Gas* (GHG) emission coming out from manufacturing activities. CO_2 along with other GHGs is considered to be a global pollutant in nature. It not only destroys the country's atmosphere where it is released, but, ignores man-made boundaries to affect other countries' atmosphere also. During rapid industrialization, between 1750 and 1950, manufacturing units of developed countries emitted a huge amount of GHGs in the atmosphere which is causing the global warming and climate change related damages to the entire world in this 21^{st} century.

Hence, the governments and policy planners worldwide are really worried and so the *United Nations Framework Convention for Climate Change* (UNFCCC), an international environmental treaty has been negotiated at the Earth Summit in Rio de Janeiro from 3 to 14 June 1992, and then has entered into force on 21 March 1994. Today, it has a near-universal membership. The 195 countries that have ratified the Convention are called *Parties to the Convention*. They have unanimously signed an accord to bring down GHG emission to a tolerable limit by 2030. GHGs are global pollutants and, therefore, *green taxes* are now being levied on the manufactured products to tackle global pollution due to GHG emissions. Green taxes are basically excise taxes levied on production of goods which damage the environment by emitting GHGs. The purpose of these taxes is to discourage economic activities with minimal

cost in order to reduce and control environmentally damaging discharges. In the concept of green tax, pollution is considered as a cost of production. Therefore, levying such tax reflects the true cost of production which internalizes all externalities of production activities. Unfortunately, there is hardly any systematic quantification of such damage costs happening in the world, which can get added to the production cost. Quantification of environmental externalities is not an easy task, but some attempts have been made in Europe, US and also in Japan in these lines. But still today, barring a few experimental activities, levying a green tax on a regular basis is yet to get a formal acceptance from the national governments world over.

Combining offshore manufacturing with controlling GHG emissions is relatively new in the international climate negotiation. Given the example of China, where more than 70% of Chinese manufacturing is getting exported out of the country and consumed by non-Chinese countries, the legitimacy of China's contribution to global GHG emissions is questionable. Given the argument that China is producing for someone else and not for themselves, a new border tax adjustment has been created. This furthers the debate on the requirement of additional taxes on imported commodities based on the embedded carbon footprint in each unit of product. Developed countries are bound to reduce their emissions onshore. But they can meet part of their targets in the developing world by offshoring their manufacturing activities. This leads to the debate of controlling GHG emissions in offshore manufacturing. Hence, the motivation for designing effective offshore manufacturing contracts based on the transfer price keeping in mind, green tax. The contracts must result in optimal after-tax profits for two firms: a firm in a developed country which sells a single product in its market, and another firm in a developing country which manufactures the product with a lower manufacturing cost. Generally, offshoring contracts deal with transfer price as the contracts are supply-side contracts between a firm and its supplier(s). Thus, emphasize is given on designing an offshoring contract based on the transfer price. Therefore, this dissertation focuses on designing offshore manufacturing contracts considering green tax.

This dissertation titled "Bilevel Programming Based Modeling for Pricing Decisions in Offshore Manufacturing Contracts Involving Green Tax" is aimed to address the following problems:

1. How long term offshore manufacturing contracts can be designed based on transfer price considering green tax between a single manufacturer and a single retailer?
2. How short term offshore manufacturing contracts can be designed considering green tax based not only on transfer price, but on the ordered quantity depending on the consumer demand between a single manufacturer and a single retailer?
3. How an offshore manufacturing contract based on transfer price and shipment quantity can be designed involving green tax between a single manufacturer and a single retailer when the manufacture is also involved in
    a. retailing the product in her domestic market as the sole franchise seller for the retailer?
    b. production and selling a local brand in her domestic market as a competitor of the retailer?
4. How ordering quantities can be allocated between two manufacturers supplying a single retailer in case of offshore manufacturing considering green tax?

The problem of offshore manufacturing contract design consists of an interactive hierarchical decision making process where the two firms are located in different countries and are owned by separate bodies. Hence, the firm owners can control their costing independently but they cannot take their pricing decisions independently; rather they influence each other in setting the prices (the transfer price as well as the retail price) of the product by involving in a *Stackelberg Game*. Actually, the price setting is sequential; based on the market power, either the manufacturer or the seller can act as the Stackelberg leader while the others follow suit. If the manufacturer acts as the leader, she first offers a per unit transfer price, which will maximize its net profit after paying green tax to its Government. Then the seller, as the follower, sets the per unit retail price after anticipating the consumer demand, which will maximize its net profit after paying the import duty to its Government. Whereas, when the seller acts as the leader, she must first set the per unit retail price and decide on the quantity to be ordered after anticipating the consumer demand, and then the manufacturer in its turn must set a per unit transfer price.

As explained above, the problem of offshore manufacturing contract design consists of interactive hierarchical decision making. As *Bilevel Programming* (BLP) is a nested optimization technique for solving decentralized planning problems involving hierarchical decision-making in

which the upper level decision maker (called the leader/superior/top planner) influences the lower level decision maker (called the follower/inferior/bottom planner), BLP has been applied to design effective offshore manufacturing contracts based on the transfer price considering green tax. Not much work has been done so far in designing offshore manufacturing contract using bilevel programming. BLP based contract models are solved to yield the optimal transfer price, the optimal quantity and the optimal retail price which must result in optimal after tax profits for both the manufacturer and the seller. Green taxes in developing as well as developed countries have been taken as the parameters of the contract. Other parameters being the manufacturing costs in developing and developed countries, export duty in developing and import duty in developed countries and the shipping cost from developing country to developed country. The factory's capacity has been assumed to be capable of producing the quantity ordered. The seller neither can set the retail price more than a maximum retail price applicable to the market nor can order a quantity more than the production and shipping capacity of the manufacturer.

This dissertation is based on the following published and working research papers:

1. Singh S., N. Haldar, and A. Bhattacharya. 2016. "Offshore Manufacturing Contract Design Based On Transfer Price Considering Green Tax: A Bilevel Programming Approach." *International Journal of Production Research,* DOI: 10.1080/00207543.2016.1144940.
2. Haldar N., S. Singh, and A. Awasthi. "Offshore Manufacturing Contract under Green Tax considering Retail Competition due to Local Brand Introduction." (Under review)
3. Haldar N., and S. Singh. "A bilevel programming model for designing a joint offshore manufacturing and franchise contract considering green tax." (Under review)
4. Haldar N., and S. Singh. "Multi-Supplier Offshore Manufacturing Contract Based On Transfer Price Considering Green Tax: A Multi-Leader & Multi-Follower Bilevel Programming Approach" (Working Paper)

The dissertation consists of eight chapters. The first chapter describes the background and the motivation for the work. This chapter also introduces the methodology for designing the contracts and presents the structure of the dissertation. Chapter 2 presents relevant theoretical results and applications of Bilevel Programming. The chapter ends with describing the proposed solution techniques in detail. Chapter 3 and 4 present BLP modeling approaches to design short-

term and long-term offshore manufacturing contracts respectively. Chapter 3 presents two separate contracts for two different power structures. Chapter 4 assumes price leadership of the manufacturer and presents a long-term contract with some special cases. Both chapters give an experimental study where a US firm offshores its manufacturing activity to a Chinese manufacturer and compares the results obtained for different power structure and cases. All the contract designs in Chapters 3 and 4 assume that there is no demand and hence no market in the developing country. The fifth and the sixth chapters deal with the existence of local market in the developing country (e.g., China in the experiment) for the product. Chapter 5 assumes that the offshore manufacturer acts as the sole franchise seller for the firm in the developed country (e.g., US in the experiment) in the developing country whereas Chapter 6 considers the situation when seller has made FDI in the developing country to set her own retail outlet. But, Chapter 6 further discusses the complexity of introducing a local brand in the market of the developing country by the offshore manufacturer and hence the seller facing a retail completion in the local market. Chapter 7 discusses the case of a single retailer sourcing from two manufacturers in two different developing countries. Here, no market has been assumed in either of the developing countries. An experimental study is done where a US firm sourcing from two offshore manufacturers – one in China and the other in Mexico. Hence, Chapter 7 basically discusses the supplier allocation problem. For this chapter Bi-leader and Bi-follower BLP models have been proposed with the novel solution techniques. Finally, in Chapter 8, the overall contributions of the dissertation have been summarized in the conclusion and the limitations have also been pointed out along with the possible directions for the future research.