ABSTRACT

In this paper, we construct a new framework of optimal decision making in global supply chains with multiple production sites to multiple markets. Our analytical model provides global firms with allowable regions of cost parameters where offshoring is a profitable decision. In addition, our model discovers the existence of an interesting phenomenon-cross production in which the domestic market is fully satisfied by buying back the foreign production while all domestic production is exported to the foreign country. Finally, our findings provide national governments with strategies on how to increase tax revenue and/or create jobs by driving manufacturing back home.

KEYWORDS: Global supply chain, Transfer pricing, Offshore, Cross production

INTRODUCTION

Offshoring has attracted attentions of managers and researchers in recent years. Global firms might have pure or mixed manufacturing modes when they make decision on offshoring. Some global firms move all manufacturing oversea, such as Nike and Nokia, without possessing any domestic production; some other companies only partially offshore their manufacturing while keeping certain production locally, such as Toyota and Intel. On the market side, multiple markets are becoming more common and popular (Meixell and Gargeya, 2005, Hsu and Zhu, 2011). For example, iPhone/iPad prevails all over the world as soon as a new version is released. Retail prices might differ across countries, such as a relatively higher price in China than that in the States. Zara, the most profitable apparel company in Europe, offshores part of his production to China, especially the items with stable demand, to acquire the low manufacturing cost and the flexibility in changing order quantity (Ferdows et al, 2004). At the meantime, Zara produces its fashion items in its domestic plant located in Coruna. Such complicated mixed mode with multiple production sites for multiple markets challenges the decision-making in global supply chains.

Generally, the most critical factor that drives global firms to offshore fully or partially is the low production cost in foreign countries such as China, India and Indonesia (Vidal and Goetschalack, 2001). The gap between domestic taxes and international taxes is another basic factor (Hsu and Zhu, 2011). The U.S. government's business tax credits is the opposite way to attract global firms to move production back home - a strategy known as 'reshoring' (Davidson, 2010). It
exactly reveals the impact of international taxes on global supply chain decisions. Production costs and tax rates play important roles in global supply chain decisions, but this does not mean other factors, such as trade barriers and tariffs, transportation cost, uncertain lead times, local laws and nation's currency, can be ignored. Readers are referred to some recent review papers for extensive analysis on the effect of various issues on global supply chain decisions (Meixell and Gargeya, 2005; Goetschalckx et al., 2002; Perron, 2010; Schnabel, 2011).

When offshoring exists, it inevitably requires a bridge on shifting income when global firms transport products back to home country, even though some part of production will be left for foreign market. Such bridge is the transfer price (Abdallah 1989). The introduction of transfer prices ultimately changed the structure and policies on decision-making in global supply chains. As the tax accounting literature indicated, the differential national tax regimes motivate global firms to engage in income shifting and after-tax profit improvement via the role of transfer prices. For example, a global firm experiences a low unit production cost of $1 in her subsidiary in China and a retail price of $10 in American market. Let's assume that the corporate tax is .2 in China while .4 in America ignoring tariffs and any other tax related issues such as VAT. If the global firm sets a transfer price at $2, her total after-tax profit is ($2-$1)*.8+($10-$2)*.6=$5.6; however, if she sets the transfer price to be $9, her total after-tax profit increases to $7 leading to a 25% improvement. The simple example illustrated that when a global firm takes a low foreign production cost and low foreign tax rate as well, she will shift income from her foreign subsidiary and extract very high benefit if the transfer price can be arbitrarily high. To avoid such intentional income shifting, national governments install intra-firm transfer pricing regulations and principles from a tax perspective (OECD 1979; Halperin and Srinidhi, 1987). In general, there are three basic transfer pricing methods including comparable uncontrolled price method, cost plus method and resale price method. All other methods are classified into the fourth method. More detailed information can be found in Halperin and Srinidhi (1987).

In the past decade, researchers have showed their interests in the effect of transfer prices on global supply chain design and decision-making (Kouvelis, P. and G. Gutierrez, 1997; Vidal, C.J. and M. Goetschalckx, 2001; Shunko, 2007, 2010, Hsu, V. and K. Zhu, 2011, etc). Some of them dealt with multiple production sites and multiple markets (Kouvelis, P. and G. Gutierrez, 1997; Hsu, V. and K. Zhu, 2011; more researches can be found in the review paper by Meixell and Gargeya, 2005). However, transfer prices are not a decision variable in such complicated global supply chain structure. Shunko (2007, 2010) investigates the optimal transfer price in her models, but there is only a domestic market existing. The purpose of our paper is to explore the optimal global supply chain decisions on offshoring, distribution and transfer prices when the global firm faces two markets: the domestic market and foreign market. A general global supply chain structure is illustrated in Figure 1. In this paper, we restrict our model analysis in short selling seasons (e.g., fashion goods and computers) and two markets share the same time window in selling seasons. Other situations such as "style goods sold to two markets with nonoverlapping selling seasons" (Kouvelis, P. and G. Gutierrez, 1997) or "multiple selling opportunities in each market over different selling seasons" (Bisi, 2008) will be discussed in the future researches.
Our paper contributes to the supply chain literature by modeling the effect of transfer prices on global supply chain decision-making (mainly the decision of offshoring and distribution) in multiple markets. Our analysis provides managerial insights to global firms who are challenged to a network of international production and distribution, i.e., multiple production sites to multiple markets. Moreover, our model findings indirectly offer national governments with thoughts of how to establish tax credits or transfer price policies if ‘reshoring’ is one of their concerns.

The remainder of this paper is organized as follows: In Section 2, we review the related literature and state our paper's contribution. In Section 3, we establish the global supply chain model along with the analysis of optimal decision-making. Section 4 discusses relevant extensions to our model. We conclude the paper in Section 5 with managerial insights and further research.

LITERATURE REVIEW

This research is relevant to several streams of literature: transfer pricing models in global supply chain, tax strategies in global supply chain modeling, and global supply chain management with multiple markets. We review each stream separately and state our contribution accordingly. A numerous work in literature has focused on the role of transfer pricing in global supply chain where offshoring is considered as one of the competitive strategies of companies. Ernst&Young continued global transfer pricing survey in 2011 and observed that 74% of parent companies and 76% of subsidiaries believe that transfer pricing will be either "absolutely critical" or "very important" to their organizations over next two years (Ernst&Young, 2011). A number of researches on transfer pricing have been conducted from accounting perspective (Hirshleifer 1956, Horst 1972, Hoffman 2001). In operations management literature, however, the importance of the transfer pricing in global supply chain design has not been studied extensively; in most existing global supply chain models, transfer prices are not considered as an explicit decision but fixed and given (Meixell and Gargeya, 2005). Few researchers mentioned that transfer prices may significantly affect global firms' after-tax profit. They present mathematical models to optimize the global after-tax profit with decision variables including the transfer price, the transportation cost allocation, the flow of goods and others (Nieckels 1976, Cohen et al 1989, Arntzen et al 1995, Vidal and Goetschalckx 2001, Goetschalckx et al 2002, Perron et al 2010). Most of the models are formulated as bi-linear programming and solved exactly or heuristically. No general analytic framework has been developed on the global supply chain.
performance optimization with transfer pricing strategy. Our paper engages in proposing such analytic mechanism in global supply chains by paralleling to the framework of single-period newsvendor problems.

Empirical researches in accounting attribute offshoring decisions partly to tax savings that occur from the difference of tax rates (Mutti, 2003). De Mooij and Ederveen (2003) perform a summary study of empirical research on foreign direct investment responsiveness to tax rates and find that on the average 1% reduction in a country's tax rate leads to 3.3% increase in the country's foreign direct investment. This evidence suggests that low tax rate countries do attract more foreign companies. In operations management literature, however, the importance of taxation for offshoring has not been studied extensively. Usually the tax rates are fixed parameters in mathematic global supply chain models as we described in literature review of transfer pricing. A couple of newly work address the taxation strategy in global supply chains to pursue profit maximization. Bogataj and Bogataj (2011) consider free economic zones as a tool to hedge the fluctuation of logistics and skilled human resources. Their paper examines the level of tax burden reduction in the free economic zones of accession countries. Hus and Zhu (2011) study the impact of a set of China's export-oriented tax and tariffs rules on the global supply chain optimization in four major supply chain structures. The products are produced in China and sold in markets both inside and outside China. These few research tactically discuss the role of taxation but without the transfer price involved. Our work attempts to combine the taxation and transfer pricing strategy, and investigate how the tax rates in different circumstance influence the decision of transfer prices and then the optimal decision making in global supply chains.

There are rich literature on the global supply chain network design with the existence of both production facilities and markets in multiple countries (Cohen and Mallik, 1997; Kouvelis, P. and G. Gutierrez, 1997; Cohen and Huchzermeier, 1999, Meixell and Gargeya, 2005, Lu and Van Mieghem, 2009, Hus and Zhu 2011). As mentioned in the introduction, there is no paper explicitly treating transfer prices as decision variables. Wittendorff (2010) presents the arm’s length principle in transfer prices. He indicates that an arm’s length region might be available for transfer price. Therefore, a good transfer price needs to be carefully selected.

MODELS AND OPTIMAL DECISIONS

We begin by discussing some model assumptions and transfer price policies. Market demand in both countries is uncertain but unrelated. The retail prices both in domestic market and foreign market are exogenous. This is normal in most of traditional newsvendor models and global supply chain management models as well (Cachon, 2003; Hsu and Zhu, 2011). Our models can be easily extended to price-sensitive random demand models when some appropriate assumptions are available. Readers are recommended to read the review paper (Petruzzi and Dada, 1999) for the construction of price-sensitive demand models.

As mentioned in previous sections, the transfer price has to follow those polices established by the government. When the foreign tax benefit exists, the global company has the motivation to set up a transfer price as high as possible, to avoid the high tax in the domestic country. In our model, according to the arm’s length principle, we assume a upper limit for transfer prices, i.e., the transfer price cannot exceed such limit (Wittendorff, 2010). On the other hand, a reasonable transfer price should not be lower than the foreign production cost. In summary, the transfer price must satisfy $c_f \leq T \leq U_T$, where $c_f$ stands for the foreign production cost and $U_T$ is the upper limit of the transfer price. Based on the assumption of exogenous retail price $P$, we assume $P \geq U_T$ in a normal market. When a transfer exists, transportation costs cannot be neglected, as well as the cost of tariffs.
Both domestic market and foreign market will be considered in this model. The decision variables include the offshoring proportion, the percentage of production shipping back to the domestic country if offshoring exists, or the percentage of production exporting to the foreign country if the domestic production is applied, the transfer prices which could be in both sides, and production quantity in both countries.

Some notations to be used in the models are listed as follows.

c\(_D\) : Unit production cost in the domestic country;
c\(_F\) : Unit production cost in the foreign country;
t\(_D\) : Tax rate in the domestic country;
t\(_F\) : Tax rate in the foreign country;
T\(_D\) : Transfer price from the foreign country to the domestic country;
T\(_DD\) : The upper limit of the transfer price T\(_D\);
T\(_F\) : Transfer price from the domestic country to the foreign country;
T\(_FF\) : The upper limit of the transfer price T\(_F\);
TT\(_D\) : Transportation cost and tariffs related if products shipped to the domestic country;
TT\(_F\) : Transportation cost and tariffs related if products shipped to the foreign country;
\(\lambda\) : Proportion of production moved to the foreign country;
Q : Total production in both production sites;
k\(_D\) : Percentage of products shipped to the domestic country from the foreign country;
k\(_F\) : Percentage of products shipped to the foreign country from the domestic country;
P\(_D\) : Retail price in the domestic market;
P\(_F\) : Retail price in the foreign market;
d\(_D\) : Demand in the domestic country, a random variable with pdf \(\phi_D\) and cdf \(\Phi_D\);
d\(_F\) : Demand in the foreign country, a random variable with pdf \(\phi_F\) and cdf \(\Phi_F\);

Given demand uncertainty in both markets, the global firm's objective is to maximize her global after-tax profits with respect to the decision variables including offshoring, production quantity, distribution and transfer price. We formulate the global firm's strategy as

\[
\max_{\lambda,k_F,k_D,Q,D_F,T_F} \pi_{\text{global}} \quad \text{s.t.} \quad \begin{align*}
c_F &\leq T_D \leq P_D \\
c_D &\leq T_F \leq P_F \\
0 &\leq \lambda \leq 1 \\
0 &\leq k_D \leq 1 \\
0 &\leq k_F \leq 1 \\
\text{if } \lambda = 0, k_D = 0 \\
\text{if } \lambda = 1, k_F = 0
\end{align*}
\] (1)

where
\[ \pi_{\text{global}} = (1-t_D) \left\{ P_D \cdot E \left[ \min \{d_D, k_D \lambda Q + (1-k_F)(1-\lambda)Q\} \right] \right. \\
- \left. (T_D + TT_D)k_D \lambda Q + T_F k_F (1-\lambda)Q - c_D (1-\lambda)Q \right\} \\
+ (1-t_F) \left\{ P_F \cdot E \left[ \min \{d_F, k_F (1-\lambda)Q + (1-k_D)\lambda Q\} \right] \\
+ T_D k_D \lambda Q - (T_F + TT_F)k_F (1-\lambda)Q - c_F \lambda Q \right\} \]

Let \(Q_D = k_D \lambda Q + (1-k_F)(1-\lambda)Q\), \(Q_F = k_F (1-\lambda)Q + (1-k_D)\lambda Q\)

\[M_D = (T_D + TT_D)k_D \lambda Q - T_F k_F (1-\lambda)Q\] and \(M_F = (T_F + TT_F)k_F (1-\lambda)Q - T_D k_D \lambda Q\)

By introducing the symbols \(Q_D\), \(Q_F\), \(M_D\) and \(M_F\), we can simplify \(\pi_{\text{global}}\) as follows,

\[\pi_{\text{global}} = (1-t_D) \left\{ P_D \cdot (Q_D - \int_0^{Q_D} (Q_D - x)\phi_D(x)dx) - M_D - c_D (1-\lambda)Q \right\} \\
+ (1-t_F) \left\{ P_F \cdot (Q_F - \int_0^{Q_F} (Q_F - y)\phi_F(y)dy) - M_F - c_F \lambda Q \right\} \]

\(Q_D\) is the total supply in the domestic market, combined with the imported portion from the foreign company if there is an offshoring and the leftover after exporting to the foreign market if the domestic company holds some production; while \(Q_F\) is total supply in the foreign market in similar matter. As expressed in the constraints of the programming, there is no import occurring without offshoring, i.e., \(\lambda = 0\); Similarly, there is no export occurring with a complete offshoring, i.e., \(\lambda = 1\).

\(M_D\) can be considered as the total transfer costs to the domestic market including the transportation cost and tariffs related whenever import and/or export happen, and \(M_F\) has the similar meaning. There are two points worth of notifying here. One is that both \(M_D\) and \(M_F\) can be any value on the real axis. If \(M_D\) or \(M_F\) is negative, it is taken as a transfer value received from transferring the production out of the country.

The second point is that a dual transfer is possible in the global supply chain. The dual transfer means the domestic company imports from the foreign company, and at the same time, it exports some to the foreign company. It is contradictory at the first glance, since the transportation cost and tariffs are incurred whenever there is an export or import, then it won't be optimal to let such unavoidable cost happen twice. However, if we take the transfer price \(T_D\) and \(T_F\) into consideration, a dual transfer becomes possible in some ways. By satisfying the transfer price policy, one company might utilize a proper transfer price to transfer the low production cost advantage or low tax rate advantage from the other country.

We illustrate such situation by a simple example. Suppose in the domestic country, the tax rate \(t_D = 0.5\) and the production cost \(c_D = 2\); in the foreign country, the tax rate \(t_F = 0.2\) and the production cost \(c_F = 2.2\). According to the arm's length principle, we assume the upper limit of transfer price \(T_D\) is 5. Let's look into the questions on two sides. On the one side, the domestic company's profit is \((1-0.5) \cdot (P_D - 2) = 0.5 P_D - 1\) if she produces the unit herself and then sells it
to the domestic market, whereas her profit increases to 
\[
0.5P_d + 0.3T_d - 1.76 = 0.5P_d - 0.26
\]
if she offshores the production to the foreign country and then transfers back at the highest transfer price \( T_d = 5 \). It states that offshoring benefits the domestic side.

At the meantime, on the other side, the foreign company’s profit is
\[
(1 - 0.2) * (P_F - 2.2) = 0.8P_F - 1.76
\]
if he uses his own production to satisfy the foreign market. Let’s see how his profit will change if the domestic company exports the unit to the foreign market. Considering the foreign tax rate is lower than the domestic tax rate, to avoid the profit consumed in the domestic country, it is reasonable to set up a transfer price as low as possible, i.e. \( T_F = 2 \). Therefore, the foreign company’s profit changes to
\[
(1 - 0.2) * (P_F - 2) + (1 - 0.5) * (2 - 2) = 0.8P_F - 1.6
\]
Once again, the foreign company benefits from transferring.

In summary, the domestic company and foreign company produce one unit respectively. The domestic unit is then exported to the foreign country, while the foreign unit is bought back by the domestic company. We name it cross production for any further description (Figure 2).

Figure 2: Cross Production

![Cross Production Diagram](image)

But this simple example ignores one important issue which is the transportation cost and tariffs. From the analysis above, the domestic company gains 0.74 per unit from cross production, while the foreign company obtains 0.16 per unit from cross production. As long as any corresponding transportation cost and tariffs exceed the improved profit, cross production is not a good choice. That’s why the cross production is not normal in real business.

In this paper, besides transfer prices, we emphasize the analysis of the effect of production costs and tax rates on global supply chain decision making. In the following, we illustrate in different scenarios the optimal solutions of offshoring portion \( \lambda \), transfer prices \( T_D, T_F \), and shipping back portions \( k_D, k_F \).

**Theorem 1:** If \( t_D > t_F \), the optimal solutions of the model (Eq. 1) are as follows:

(1) if \( c_F \leq \min \left \{ c_D + TT_F, c_F, \text{threshold} \right \} \), \( \lambda^* = 1 \), \( T_D^* = T_DU \), \( k_F^* = 0 \), \( k_D^* = \frac{Q_{FF}^*}{Q_{FF}^* + Q_{FD}^*} \). All productions are foreign.

(2) if \( c_F \geq \max \left \{ c_D + TT_F, c_F, \text{threshold} \right \} \), \( \lambda^* = 0 \), \( T_F^* = c_D \), \( k_F^* = \frac{Q_{DF}^*}{Q_{DF}^* + Q_{DD}^*} \), \( k_D^* = 0 \). All productions are domestic.
(3) if \( c_D + TT_F \geq \tilde{c}_{F,\text{threshold}} \) and \( \tilde{c}_{F,\text{threshold}} < c_F < c_D + TT_F \),
\[ \lambda^* = \frac{Q_{FF}}{Q_{FF}^* + Q_{DD}^*} \], \( k_D^* = k_F^* = 0 \). No transfer occurs in either side.

(4) if \( c_D + TT_F < \tilde{c}_{F,\text{threshold}} \) and \( c_D + TT_F < c_F < \tilde{c}_{F,\text{threshold}} \),
\[ \lambda^* = \frac{Q_{DF}^*}{Q_{DF}^* + Q_{FD}^*}, \ T^*_D = T^*_{DU}, \ T_F = c_D, \]
\( k_D^* = k_F^* = 1 \). Cross production occurs.

where \( \tilde{c}_{F,\text{threshold}} = \frac{(1-t_D)c_D + (t_D - t_F)T_{DU} - (1-t_D)TT_D}{1-t_F} \), \( Q_{DD}^* = \Phi_D^{-1}(1 - \frac{c_D}{P_D}) \), \( Q_{DF}^* = \Phi_F^{-1}(1 - \frac{c_F}{P_F}) \),
\[ Q_{DF}^* = \Phi_D^{-1}(1 - \frac{c_D + TT_F}{P_F}), \ Q_{FD}^* = \Phi_F^{-1}(1 - \frac{(T_{DU} + TT_D) - (T_{DU} - c_F)(1-t_F)}{(1-t_D)}) \]

**Proof.** See Appendix.

Theorem 1 summarizes the global firm’s optimal decisions provided the foreign country holds a lower tax rate which is normal in many developing countries, such as China, where they offer a low tax rate to encourage foreign investments. Provided the tax benefit in the foreign country, the global firm has the motivation to offshore their production as long as the foreign production costs are relatively low, and international transportation cost and tariffs are affordable as well. \( \tilde{c}_{F,\text{threshold}} \) provides a threshold of the opportunity offshoring cost incorporated with tax rates, transportation cost, tariffs, and the allowable region of the transfer price. As long as the foreign production cost \( c_F \) is higher than such threshold, the global firm has no incentive to offshore the production which will be used to satisfy the domestic market. A further look at the formula of the threshold \( \tilde{c}_{F,\text{threshold}} \) leads to the following corollary.

**Corollary 1:** If \( t_D > t_F \), the global firm is more likely to benefit from offshoring the domestic production when

1. The upper limit of the transfer price \( T_D \) becomes larger; or
2. The domestic production \( c_D \) becomes higher; or
3. The difference between two tax rates becomes larger.

**Proof:** All results can be simply derived from the equation of
\[ \tilde{c}_{F,\text{threshold}} = \frac{(1-t_D)c_D + (t_D - t_F)T_{DU} - (1-t_D)TT_D}{1-t_F}, \] where \( T_{DU} \) is the upper limit of the transfer price \( T_D \).

Theoretically, if there is no limit on the transfer price, offshoring always is a better choice. To restrict the global firm from avoiding normal taxation, the domestic government, such as U.S.A., establishes transfer price policies indicated in the introduction section. A higher domestic production cost certainly increases the chance of offshoring. The threshold \( \tilde{c}_{F,\text{threshold}} \) not only provides the global firm a measure on offshoring decision, but also helps the government on the policies of taxation. Nowadays, the voice of “bringing manufacturing home” is rising in some developed countries. \( \tilde{c}_{F,\text{threshold}} \) provides those governments a quantitative view point.

Furthermore, \( c_D + TT_F \) can be considered as the adjusted unit production cost in the domestic country and then the unit is shipped to satisfy the foreign market. When the foreign production cost is smaller than the domestic production cost, it's better to manufacture in the foreign country and then directly sell them to the foreign market.
Part (3) in the Theorem 1 indicates a situation where the global firm offshores part of the production to the foreign country and then completely uses them to supply the foreign market, and produces the remaining part in the domestic country and then sells them to the domestic market. This acts like two independent companies if we ignore the effect the transfer price. Such situation is restricted ensured by the assumption that two market demands are unrelated.

Part (4) in the Theorem 1 describes an interesting phenomena stated before. To be specific, when the cost parameters satisfy \( c_D + TT_D < c_F < \tilde{c}_{D,\text{threshold}} \), import is better off than independent production for both companies. That is to say, the amount manufactured in the domestic country will be entirely transferred to the foreign country, while what is produced in the foreign country will be fully shipped back to the domestic country. That’s the cross production. This situation ensures the domestic company takes the advantage of the low foreign tax rate and the foreign company utilizes the low domestic production cost.

Considering the domestic side is symmetric to the foreign side, the optimal solutions in the situation \( t_D \leq t_F \) are similar to Theorem 1. We simply summarize them in Theorem 2.

Theorem 2: If \( t_D \leq t_F \), the optimal solutions of the model (Eq. 1) are as follows:

1. if \( c_D \leq \min \{ c_F + TT_D, \tilde{c}_{D,\text{threshold}} \} \), \( \lambda^* = 0 \), \( T_F^* = T_F^{\text{FU}} \), \( k_F^* = \frac{Q_F^*}{Q_D^* + Q_{DD}^*} \), \( k_D^* = 0 \). All productions are domestic.

2. if \( c_D \geq \max \{ c_F + TT_D, \tilde{c}_{D,\text{threshold}} \} \), \( \lambda^* = 1 \), \( T_D^* = c_F \), \( k_F^* = 0 \), \( k_D^* = \frac{Q_F^*}{Q_F^* + Q_{FD}^*} \). All productions are foreign.

3. if \( c_F + TT_D \geq \tilde{c}_{D,\text{threshold}} \) and \( \tilde{c}_{D,\text{threshold}} < c_D < c_F + TT_D \), \( \lambda^* = \frac{Q_F^*}{Q_F^* + Q_{FD}^*} \), \( k_F^* = k_D^* = 0 \). no transfer occurs in either side.

4. if \( c_F + TT_D < \tilde{c}_{D,\text{threshold}} \) and \( c_F + TT_D < c_D < \tilde{c}_{D,\text{threshold}} \), \( \lambda^* = \frac{Q_D^*}{Q_D^* + Q_{FD}^*} \), \( T_D^* = c_F \), \( T_F^* = T_F^{\text{FU}} \), \( k_D^* = k_F^* = 1 \). Cross production occurs.

where

\[
\tilde{c}_{D,\text{threshold}} = \frac{(1 - t_F)c_D + (t_F - t_D)T_F^{\text{FU}} - (1 - t_F)TT_F}{1 - t_D},
\]

\[
\hat{Q}_{FD}^* = \Phi^{-1}_D(1 - \frac{c_F + TT_D}{P_D}), \quad \hat{Q}_{DF}^* = \Phi^{-1}_F(1 - \frac{(T_F^{\text{FU}} + TT_F) - (T_F^{\text{FU}} - c_D)(1 - t_D) / (1 - t_F)}{P_F})
\]

Proof. Considering the proof structure is similar to that in Theorem 1, the proof is omitted. 

Even there is no tax benefit in the foreign country; the global firm still has motivation to offshore as long as the domestic production cost is higher than the critical value. For example, the results in part (2) in the Theorem 2 show that if the production cost is not less than \( c_F + TT_D \) and exceeds the threshold \( \tilde{c}_{D,\text{threshold}} \), the global firm will entirely offshore the production.

Actually, as long as \( c_D > c_F + TT_D \), the global firm will offshore the production part which will be supplied to the domestic market. The critical point leading to such decision is the global firm
sets up the optimal transfer price to the domestic country as $T_D^* = c_F$. Such lowest transfer price protects the firm from high taxation applied in the foreign country.

Furthermore, the threshold $\tilde{c}_{D,\text{threshold}}$ reveals when it is better to hold the production and export to the foreign market. In fact, a large upper limit $T_{FU}$ of the transfer price $T_f$ increases the odds of export. Similar to the statement in Corollary 1, we have

**Corollary 2**: If $t_D \leq t_F$, the global firm is more likely to benefit from offshoring when

1. The upper limit of the transfer price $T_f$ becomes smaller; or
2. The foreign production $c_F$ becomes smaller; or
3. The difference between two tax rates becomes smaller.

In conclusion, on the one side, the global firm can use the gap between tax rates and production costs in each country, and utilize the allowable region of the transfer prices as well to maximize his total profits on the global supply chain. On the other side, it is possible for the domestic or even foreign government to manipulate the transfer price policies to keep the manufacturing and then improve the employment rate in her or his society.

**DISCUSSION**

Under the assumption of the independent market demand in two countries, we analyzed the global firm’s decision when she exposes to different situations of tax rates, production costs, transfer price restriction, transportation costs and tariffs. There are two points we would like to discuss further in this section.

First, we haven’t considered the salvage value and market leftover in the previous analysis. Since the market demand is random in each market, it is inevitable that the company might undersupply or oversupply the market. For example, the global firm overestimates the domestic demand, while at the meantime, she underestimates the foreign demand. Theoretically, under such situation it may bring the global firm more profit if she exports the leftover in the domestic market to the foreign market as long as the fast transportation cost and tariffs can be counteracted by the revenue in the foreign market. One critical issue here is the “fast” transportation. When the product has a short selling season, to use the inventory leftover, fast international transportation is required. As we all know well, air shipping has a much higher cost than the freight shipping. To take into account the salvage value and market leftover, we only need simply modify the previous programming model by incorporating the fast transportation cost.

Second, the market demand in each country is related in some content. Nowadays Customers are immersed in internet news and information. The market’s response reaction has become globally, especially the foreign market demand is relatively influenced by the domestic demand. IPhone/iPad selling market is a good example for this. The foreign customers access to domestic customers’ reviews, have the knowledge of the price differentiation in two markets.

The feature of relative market demand highly increases the difficulty of solving programming model. Unfortunately, the analytical structure applied in the proof presented in the Appendix isn’t proper anymore. More complicated and advanced analytical tools and even simulation technique will assist the global firm to achieve her best solution under this situation.

**CONCLUDING REMARKS**

In this paper, we construct a new framework of optimal decision making in global supply chains with multiple production sites to multiple markets. This study contributes to the global supply chain theory in the following ways:
chain management literature by originally formulating a general analytical framework of global supply chain decision making problem in multiple markets with considering the transfer price as a decision variable in the global firm's global after-tax profits. Our results provide the following managerial implications for global firms and national governments as well. When the international tax benefit exists (the foreign tax rate is lower than the domestic tax rate), global firms have opportunities to benefit from offshoring fully or partially as long as the foreign production cost is lower than a threshold. Such threshold is determined by the domestic production cost, the gap between two national tax rates, transportation and tariffs, and the upper limit of the transfer price. A relative high domestic production cost and/or high transfer price motivate the global firm to offshore so that she can gain the production cost advantage and/or tax benefit. On the other hand, even the global firm is unable to seek a low tax rate in the foreign country, she still has the chance to move her production overseas and gain more profit from that. In fact, when the foreign production and business cost factors are not optimistic (another threshold can be referred here) to support the foreign market demand, it is preferable to export the domestic production to satisfy the foreign market. In addition, if transformation and tariff costs are relatively low, it is possible that the global firm has two production sites at the same time, and the domestic market is fully satisfied by importing the foreign production while all domestic production is exported to the foreign country. Such interesting phenomenon is named cross production in this paper. Finally, our findings of the impact of the transfer price and cost thresholds provide strategies to national governments on increasing tax revenue and creating jobs by driving manufacturing back home. There are a number of ways to extend this research. Our model currently assumes two overlapping markets with short selling season. The effect of transfer pricing can be studied in non-overlapping markets (e.g., a primary market and a secondary market) or the multiple markets over different selling seasons. In those cases, the inventory level should be carefully analyzed. Another possible extension would be to consider the mixed supply modes, i.e., the demand could be satisfied from local/foreign production and/or third party sources. The cost charged by the third party source could be higher than the local/foreign production cost but providing a prompt replenishment. This issue is very important especially for seasonal products. Last but not the least, global supply chain integration can be investigated by incorporating multiple markets' selling effort and creating supply chain contracts and schemes as well.

APPENDIX

Theorem 1. Proof.
Given the assumption that demands are independent in two markets, we can consider the domestic-side profit and foreign-side profit separately. On the domestic side, the profit can be computed as follows,

\[
\pi_D = (1-t_D) \left\{ P_D \cdot E[d_D, Q_{DD} + Q_{FD}] - (T_D + TT_D)Q_{FD} - c_D Q_{DD} \right\} + (1-t_F)(T_D - c_F)Q_{FD} \quad (A1)
\]

where \( Q_{DD} \) stands for the amount produced in the domestic company and used for the domestic market, i.e., \( D \to D \), while \( Q_{FD} \) is the amount produced in the foreign company and then shipped back to the domestic market, i.e., \( F \to D \). \( \pi_D \) only considers the total profit in the domestic market. By applying for the probability density function of the domestic demand \( d_D \), we have

\[
\pi_D = (1-t_D) \left\{ P_D \cdot ((Q_{DD} + Q_{FD}) - \int_0^{Q_{DD} + Q_{FD}} (Q_{DD} + Q_{FD} - x) \phi_D(x)dx) - (T_D + TT_D)Q_{FD} - c_D Q_{DD} \right\} + (1-t_F)(T_D - c_F)Q_{FD} \quad (A2)
\]
The attribute of the optimal transfer price \( T_D \) can be achieved by taking the first derivative of the profit function \( \pi_D \) with respect to \( T_D \), \( \frac{\partial \pi_D}{\partial T_D} = (t_D - t_F)Q_{FD} \). When there is transfer existing, i.e., \( Q_{FD} > 0 \), the profit increases as \( T_D \) increases if \( DF_{tt} > 0 \). Therefore, the highest available transfer price, \( T_{DU} \), in this case, is optimal.

Notice that \( DDQ \) is independent from \( FDQ \), we can take the first derivative \( \frac{\partial \pi}{\partial DD} \) and \( \frac{\partial \pi}{\partial FD} \),

\[
\frac{\partial \pi_D}{\partial Q_{FD}} = (1-t_D) \left\{ P_D \cdot (1-\Phi_D(Q_{DD} + Q_{FD})) - (T_D + TT_D) \right\} + (1-t_F)(T_D - c_F) \quad (A3)
\]

\[
\frac{\partial \pi_D}{\partial Q_{DD}} = (1-t_D) \left\{ P_D \cdot (1-\Phi_D(Q_{DD} + Q_{FD})) - c_D \right\} \quad (A4)
\]

By comparing Equation (A3) and (A4), we can see \( \frac{\partial \pi}{\partial Q_{FD}} > \frac{\partial \pi}{\partial Q_{DD}} \) if model parameters satisfy the following inequality,

\[
-(1-t_D)(T_{DU} + TT_D) + (1-t_F)(T_{DU} - c_F) > -(1-t_D)c_D 
\]

or

\[
c_F < \frac{(1-t_D)c_D + (t_D - t_F)T_{DU} - (1-t_D)TT_D}{1-t_F} \quad (A5)
\]

In other words, for the domestic market, offshoring is always a better choice than local production. Thus the optimal \( Q_{DD}^* = 0 \), and

\[
Q_{FD}^* = \Phi_D^{-1}(1 - \frac{(T_{DU} + TT_D) - (T_{DU} - c_F)(1-t_F)}{P_D})
\]

can be computed by setting Equation (A3) to be 0 and substituting \( T_D \) with \( T_{DU} \).

Similarly, under the situation \( c_F \geq \frac{(1-t_D)c_D + (t_D - t_F)T_{DU} - (1-t_D)TT_D}{1-t_F} \), we can conclude that \( Q_{FD}^* = 0 \). And the optimal production \( Q_{DD}^* = \Phi_D^{-1}(1 - \frac{c_D}{P_D}) \) can be achieved from Equation (A4).

The domestic analysis ends here.

On the foreign side, the profit can be computed as follows,

\[
\pi_F = (1-t_F) \left\{ P_F \cdot E[d_F \cdot Q_{DF} + Q_{FF}] - (T_F + TT_F)Q_{DF} - c_FQ_{FF} \right\} + (1-t_D)(T_F - c_D)Q_{DF} \quad (A6)
\]

where \( Q_{DF} \) stands for the amount produced in the foreign company and used for the foreign market, i.e., \( F \rightarrow F \), while \( Q_{DF} \) is the amount produced in the domestic company and then shipped back to the foreign market, i.e., \( D \rightarrow F \). Note that Equation (A6) shares the same structure of Equation (A), therefore the model analysis is similar to what we have done for the domestic side except the optimal transfer price \( T_F^* \) is offshoring occurs. To the foreign company, \( t_D > t_F \) means that he can take advantage of tax benefit if he produces there, not like the reverse situation on the domestic side. Or if he exports from the domestic company, he would like to set up a transfer price as low as possible, i.e., \( T_F = c_D \).

Then equations (A3) and (A4) should be changed to
\[
\frac{\partial \pi_F}{\partial Q_{DF}} = (1-t_F) \left\{ P_F \cdot (1-\Phi_F (Q_{FF}+Q_{DF})) - (c_D + TT_F) \right\}
\]
(A7)

\[
\frac{\partial \pi_F}{\partial Q_{FF}} = (1-t_F) \left\{ P_F \cdot (1-\Phi_F (Q_{FF}+Q_{FF})) - c_F \right\}
\]
(A8)

It's easy to tell if \( c_F < c_D + TT_F \), \( Q_{DF}^* = 0 \) and \( Q_{FF}^* = \Phi_F^*(1-\frac{c_F}{P_F}) \). All other results in Theorem (1) can be simply derived.

#

REFERENCES


