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Determining intra-company transfer pricing for multinational corporations

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ABSTRACT

Although significant attention has been paid to transfer pricing — the pricing of intermediate products sold between different divisions within one company — the focus has been limited to tax minimization within regulatory boundaries. This paper presents a comprehensive model that aims to determine the optimal transfer price for a multinational corporation (MNC) to maximize the entire organization's profit. The model considers the situation in which intermediate products are sold from the MNC's selling divisions to buying divisions; the buying divisions further process these intermediate products to produce final products; the final products are then sold in both selling-divisions and buying-divisions across the MNC's global locations. In contrast to the existing literature, our innovative model incorporates elements such as international transportation costs, holding costs, taxes, tariffs (including the introduction of a second tariff), and exchange rates. This paper also provides managerial insights about the impact of setting transfer prices in different currencies on the variance of each division's profit given exchange rate uncertainty.

1. Introduction

Transfer pricing refers to the pricing of an intermediate product or service that is transferred between two divisions within a multinational Corporation (MNC). Because this transfer price has a direct impact on the revenue of the MNC's selling divisions and the costs of buying divisions, it is also usually seen as a tool for allocating an MNC's total profit. For this reason, transfer pricing can be misused for tax avoidance by companies that intentionally lower profits in divisions located in high-tax countries and increase profits in divisions located in low-tax or tax-haven countries (Wiederhold, 2013). This is particularly true in North America, where corporate taxes are usually higher than in countries like Ireland, Luxembourg, or Switzerland, for example.

More than 60% of world trade takes place within multinational corporations, the importance of transfer pricing becomes clear. Currently, more than 60 government tax authorities enforce transfer price rules. Most of them adopt "arm's length principles." Article 9 of the Organization for Economic Co-operation and Development (OECD, 2003) Model Tax Convention defines arm's length principles as such:

> *"where conditions are made or imposed between the two enterprises in their commercial or financial relations which differ from those which would be made between independent enterprises, then any profits which would, but for those conditions, have accrued to one of the enterprises, but, by reason of those conditions, have not so accrued, may be included in the profits of that enterprise and taxed accordingly."*

To put this definition in less technical phases, the arm's length principle basically states that a transfer price should be the same as if the two companies involved were indeed two independents, not part of the same corporate structure.

In current taxation practices, several methods are used to determine transfer prices that are compliant with arm's length principles according to the OECD guideline. These include, from a transaction perspective, the comparable uncontrolled price, the cost-plus method and the resale price method; from a profitability perspective, these taxation practices include the comparable profits method, the transactional net margin method, and the profit split method. These methods are typically used to justify the fairness of the transfer price in order to mitigate the risk of later tax adjustments and potential fines.

By Ernst and Young (2007), more than 90% of the companies surveyed, indicated that transfer pricing is an important international taxation issue that they face, and 31% indicated that transfer pricing would be absolutely critical for them over the next few years. Presently, when companies try to determine transfer prices, their goal is to minimize taxes and avoid authorities raising red

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flags on them, but they often neglect to consider maximizing profitability by accounting for tariffs as well as production, transportation, and warehouse costs.

In May 2013, the U.S. Congress investigated a case at Apple Inc. that revealed an average tax loss of $10 billion per year resulting from several tax avoidance schemes, including setting up divisions in lower-tax countries and manipulating the transfer prices of its digital products. This led to the re-attempt to close loopholes in tax law and regulations known as “check the box” and “look through” that let some offshore units be disregarded for tax purposes, sheltering substantial profits from taxation. Although the re-attempt turned out to be unsuccessful, it raised attention on transfer pricing from the public and government authorities. Other countries are toughening their stance on tax avoidance as well. During the 2013 G-20 meeting in Russia, 20 countries committed to sharing taxation information by the end of 2015. In addition, the U.K. and China announced policies to further scrutinize offshore profit shifting in September and December 2014, respectively.

The message is clear: a new transfer pricing strategy is needed, and tax minimization will no longer be the focus. This need for change motivated us to develop a model that returns the optimal transfer prices with the goal of maximizing an MNC's overall profits rather than simply minimizing its taxes. Our model will allow companies to pay their fair share of taxes while maintaining a healthy gross margin.

Although not fully recognized and implemented by MNCs, profit maximization models have been explored in scholarly literature dating back to 1956. In comparison to models and proposals discussed in the existing body of literature, our model introduces more practical cost elements to better reflect actual business operations. These cost elements include the “second tariff,” which, to the authors' knowledge, has not been previously examined in profit maximization stream of literature. The model is significant also because it incorporates all the practical cost elements including manufacturing costs, international transportation costs, holding costs, taxes, tariffs and exchange rates, whether or not they have been mentioned in literature. Furthermore, the solution approach of our model is simplified to meet the limitations of the computing capability and software capital investment of actual businesses. Specifically, with this new model of determining transfer pricing, we aim to answer the following research questions:

- How does a MNC determine optimal transfer pricing when considering practical cost elements such as operations costs, taxes, tariffs, and second tariffs?
- How does the selection of the transfer pricing currency affect the risk of each division? What managerial insights does the model offer to division managers on currency selection?
- Does this model's optimal solution echo that of existing models? If so, how?
- How does optimal transfer pricing change with varying economic parameters and cost elements?

Our general model shows that the consideration of realistic cost elements impacts the optimal solution to a fair extent, compared with existing models such as Kassicieh's (1981). A sensitivity analysis of this model's parameters suggests that MNC division managers need to closely monitor the tax-rate fluctuations of the selling/buying countries, and adjust the transfer price accordingly. To our surprise, our model suggests that setting the transfer price in the selling division's currency will benefit not only the selling division but also the buying division if all final products are sold back to the selling-division country. If all final products are sold in the buying division country, however, division managers have incentive to select their own local currency.

Next is a review of the closely related literature.

Hirshleifer (1956) studied optimal transfer pricing and output level aimed at overall profit maximization using the marginal price determination theory with consideration of net marginal revenue. He discovered that the market price is the correct transfer price only when the commodity being transferred is produced in a competitive market, that is, no single producer considers itself large enough to influence price by its own output decision; additionally, if the market is imperfectly competitive, or where no market for the transferred commodity exists, the correct procedure is to transfer the commodity at marginal cost or at some price between marginal cost and market price in the most general case. His research set the foundation for future research on transfer price setting based on profit-maximizing strategy and drew significant academic attention to this topic. Taxes were not considered in Hirshleifer's and subsequent marginal price determination theories, however.

Fifteen years later, Horst (1971) explored a profit-maximizing strategy for a monopolistic firm selling to two national markets. His model considered variable production costs, taxes, and tariffs, but transportation and holding costs were not considered. In addition, no solution approach is considered.

In the 1980s and 90s, this research stream expanded to studies with behavioral and managerial perspectives. Eccles (1985) concluded that when determining transfer prices, the objective should be to find prices that achieve global corporate goals and ensure that performance measures are fair for all of the firm's subsidiaries. O'Connor (1997) asserted that the reason for having different transfer prices stems from the conflict between the global corporation's general goals and its subsidiaries' specialized, internal goals. Vaysman (1998) demonstrates that the firm can design managerial compensation schemes and bargaining infrastructures so that the negotiated transfer pricing structure enables it to reach the upper bound on reasonably obtainable profits.

The topic of transfer pricing started to grow in popularity in the operations research academic community in the late 1990s when transfer pricing became an integral mechanism of global supply chain optimization. Vaysman (1996) presented a model that maximizes expected firm-wide profits from a utility perspective. He discovered that when division managers were not able to communicate their private information to the firm's top management, a managerial compensation system employing cost-based transfer pricing allowed the firm to earn strictly higher expected profits than if the firm's top management made all decisions based on division managers' reports. His model does not consider taxation and tariffs, however. Fandel and Stammen (2004), Lakhal (2006), Vila et al. (2006), and Perron et al. (2010) discussed the issue of transfer pricing in their global supply chain models; however, in each of these papers at least one cost element is overlooked; in contrast our model incorporates all cost elements – manufacturing costs, international transportation costs, holding costs, taxes, tariffs and exchange rates. In addition, solving these models requires significant computing power, which most companies do not possess.

Around the same time, researchers began to closely examine the methods used in everyday accounting practices. Harris and Sansing (1998) considered the comparable uncontrolled pricing method and showed that it tends to allocate a disproportionately high level of income to the firm's manufacturing division. Baldenius and Reichelstein (2006) investigated the market-based pricing method and the corresponding discounts of internal price where the selling divisions have both external and internal markets. They found that internal discounts are not sufficient to improve overall corporate profits, and that fully efficient outcomes of discounts can only be attained when production capacity is constrained or the external market is substantially larger than the internal one. Hiemann and Reichelstein (2012) explored cost-based and market-based methods from an integrated management and taxation perspective and discovered that the optimal internal transfer prices should be chosen below the arm's length price. Huh and Park (2013) considered the cost-plus method and the resale-price method and compared supply chain profits under these two methods. The analysis shows that the cost-plus method tends to allocate a higher percentage of profit to buying divisions, whereas the resale-price method tends to achieve a higher firm-wide profit under the Newsvendor Framework. These findings on these methods' constraints and limitations support our belief that a model is needed that better captures the reality to assist transfer pricing decisions.

In this paper, a bilinear programming model, often called a generalized geometric programming model, is developed to determine the optimal transfer prices and quantities to be transferred between divisions. This model's objective is to maximize the expected value of an MNC's total profits. The programming is solved using Matlab R2012a. Corporate and divisional profit variances are discussed in Section 3. This variance is caused by exchange rate uncertainty and occurs when transfer prices are set in different divisional currencies. Managerial insights on currency determination are also given for risk-averse division managers.

This paper contributes to the existing body of knowledge by providing a comprehensive model that determines transfer pricing considering both operational and accounting perspectives; it introduces the second tariff, which is widely used in practice but is overlooked in the existing literature; and it includes transportation and holding costs for both the selling and buying divisions, which are not considered in many related articles. More importantly, this paper provides a solution approach that can realistically be adopted by actual MNCs. Furthermore, this paper offers managerial insights on the choice of currencies for transfer prices considering the impact of exchange-rate uncertainty on profit variances.

2. Problem description and basic model

The goal of our model is to determine the optimal transfer prices and the quantities of goods to be transferred to maximize the expected value of an MNC's total profit. This model assumes that (1) the MNC is risk neutral, which explains why expected profits are used in our main model rather than utility; (2) division managers can be risk averse, which leads to the discussion in Section 3, which closely examines divisional profit variances. Of note is that division managers are assumed to have the authority to choose the currency in which the transfer prices are set, but the value of transfer prices is determined by headquarters.

Our basic model has one selling division and one buying division. The cost allocation and physical flow of goods are shown in Figs. 1 and 2, respectively. The selling division in the home country produces intermediate products that are sold overseas to the buying division. The selling division is responsible for the cost of manufacturing, holding, and transportation of intermediate products. Assuming that there is no free trade zone in either country, when the buying division purchases the intermediate products, it will have to pay the “first” tariff to its local tax authority. It then further processes the intermediate products (these costs are called manufacturing costs in the model), pays the holding costs, and then sells the final products both locally and in the selling-division country. We assume that units sold locally are shipped at retailers' or consumers' expense; the buying division pays for the international transportation for units sold in the selling-division country, but further distribution within the selling-division country is covered by retailers or consumers.

At this point we introduce the concept of the “second tariff.” As noted earlier, this is the first model that considers a second tariff based on a thorough literature review, although it is a common practice. Second tariff refers to the tariffs collected by the selling-division country's tax authority when finished goods are shipped back to the selling division to sell. The tariffs are based on the value added to the product, which in this case is the retail price of the final product in the selling-division country minus the transfer price of the intermediate product, minus the per unit manufacturing cost equivalent in the selling-division country's currency. This second tariff is paid by headquarters.

In this paper, except for in Section 3, transfer prices are always set in the currency of the selling division and all costs incurred are based on each division's local currency. By incorporating the operational and accounting details, we provide a transfer-pricing decision model that has important practical value for MNCs that operate globally.

2.1. Formulation of the basic model

In this model, the transfer prices and quantities transferred between the selling and buying divisions are the decision variables. The objective function is to maximize the MNC's total expected profit.

The following notations are used:

Indices

i	Selling-division index
j	Buying-division index

Variables

p_{ij}	Transfer price that selling division i charges buying division j, a decision to be made by MNC headquarters
q_{ij}	Quantity transferred from selling division i to buying division j, a decision to be made by the headquarters
π_i,π_j	Net after-tax profit of selling division i/buying division j, in local currency
T_2	Second tariff costs

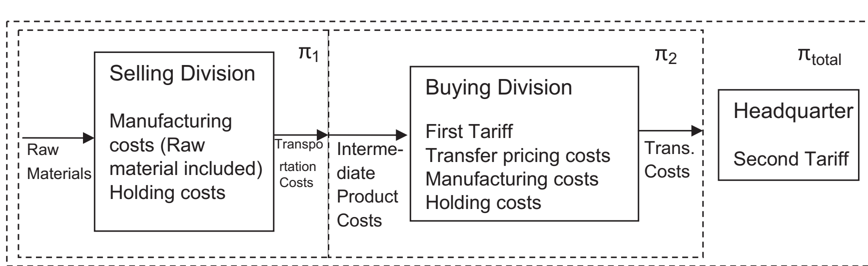

Fig. 1. Basic model cost allocation.

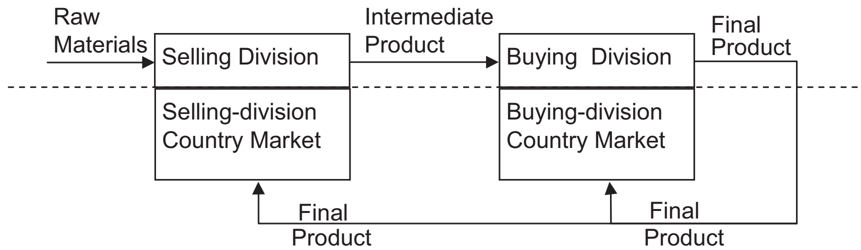

Fig. 2. Physical flow of goods.

Parameters

F_i^M, F_j^M	Fixed manufacturing cost at selling division i/at buying division j
V_i^M, V_j^M	Variable manufacturing cost at selling division i/at buying division j
K_i^M, K_j^M	Manufacturing capacity at selling division i/ at buying division $j$for the period
$F_{ij}^T(F_{ji}^T)$	Fixed transportation cost traveling from division i to division $j$per load, vice versa
$V_{ij}^T(V_{ji}^T)$	Variable transportation cost of good transported from division i to division j, vice versa
$K_{ij}^T(K_{ji}^T)$	Capacity of transportation traveling from division i to division j, vice versa
h_i, h_j	Holding cost rate per unit per time period at selling division i/at buying division j
t_i, t_j	Tax rate in country i/country j
k_i, k_j	Tariff rate in country i/country$j$, assuming there is no free trade zone in buying division countries.
$e_{ij}(e_{ji})$	Exchange rate that converts currency i to currency j, and vice versa
β_{ij}	The percentage of final products manufactured at buying division $j$that are shipped back to country i to sell; 1-$\beta_{jj}$is the percentage that is sold locally
α	Product conversion rate (e.g., $\alpha = 0.5$if two units of intermediate products are needed for one unit of final products)
M_i, M_j	Selling prices of final products in country i/in country j, in local currency
A_i, A_j	Minimum profit requirement of selling division i/buying division j

For the basic model, we assume that division 1 is the selling division and division 2 is the buying division. Based on most actual cases and for simplicity, we assume the MNC's headquarters is located in country 1 and the total profit of the company is calculated in currency 1. However, it is worth mentioning that since we are looking at the expected value of the total profit, this assumption can be easily changed to country 2 and currency 2 without affecting the result. Both π_1 and π_2 are in local currency, and $T_2$is in the same currency as the total profit, in this case in currency 1.

The revenue of the selling division is derived from sales of the intermediate products. The variable manufacturing and transportation costs are assumed to be linear in our models. In terms of shipping and warehousing, we adopt the strategy in which production rate is assumed to be consistent and units are shipped as soon as the inventory level reaches the point of a full transportation load. Therefore, the fixed transportation cost is based on the full-load cost and number of loads; the number of loads is dependent on the number of units to be shipped and the full load capacity of transportation. There could be cases where the last load is not full, but the fixed transportation cost still applies in this case. That is why we used a ceiling function to calculate the number of loads. In terms of holding costs, we do not consider the holding cost for inventory in-transit. Under our shipping and warehousing strategy, with negligible variance, the average inventory level should be half of the transportation capacity per load. The holding duration should equal the time to produce the amount of units to fill one full load. Lastly, we consider the tax factor by multiplying$1-t_1$to getπ_1, the net after-tax profit of division 1 (the selling division).

The same principles of transportation and holding costs apply to division 2 (the buying division), but only for the units that are sent back to country 1 to be sold. Here we assume the locally sold units are purchased as soon as they are produced, with shipping at retailers' or customers' expense. Other costs include the straight purchase cost of intermediate products plus tariff. The revenue of the buying division comes from two sources: local sales and country 1 sales (converted to currency 2 – the local currency of the buying division). After incorporating the tax-rate factor, we arrive at the net after-tax profit for buying division 2:π_2.

Based on the description above, the model is expressed as:

Maximize $E(\pi_{total}) = E(\pi_1 + \pi_2 e_{21} - T_2)$ where

$$\pi_1 = \left[p_{12}q_{12} - \left(F_1^M + V_1^M q_{12}\right) - \left(\lceil q_{12}/K_{12}^T \rceil F_{12}^T + V_{12}^T q_{12}\right) - h_1\left(K_{12}^T/2\right)\left(q_{12}/K_1^M\right)\right](1-t_1); \tag{1}$$

$$\pi_2 = \left[\beta_{12}\alpha q_{12}M_1 e_{12} + \beta_{22}\alpha q_{12}M_2 - (1+k_2)p_{12}q_{12}e_{12} - \left(F_2^M + V_2^M \alpha q_{12}\right) - \left(\lceil \beta_{12}\alpha q_{12}/K_{21}^T \rceil F_{21}^T + V_{21}^T \beta_{12}\alpha q_{12}\right) - h_2\left(K_{21}^T/2\right)\left(\beta_{12}\alpha q_{12}/K_2^M\right)\right](1-t_2); \tag{2}$$

$$T_2 = k_1(\beta_{12}\alpha q_{12})\left[M_1 - p_{12} - \frac{F_2^M + V_2^M \alpha q_{12}}{\alpha q_{12}} * e_{21}\right]. \tag{3}$$

In Appendix, we show that $E(\pi_{total})$ is not well-behaved. To solve the problem, we must do an extensive numerical search given the parameter values. In terms of constraints of the model, we refer to the article from Business International Corporation (1965), in which its author sets seven essential requirements for a transfer pricing system to work: (1) the producing unit should make a fair profit; (2) the purchasing unit should be able to market competitively priced products; (3) top management should be able to compare the performance of the various producing and purchasing units; (4) purchasing and producing units should be satisfied with the transfer pricing system so that top management would not spend too much time in mediation to settle disputes; (5) the transfer prices should be acceptable to tax authorities; (6) the transfer prices should be acceptable to customs officials;

and (7) control via transfer pricing should be exercised over foreign subsidiaries so that the subsidiaries would be able to meet their profit requirements.

Competition and performance measurement are beyond the scope of this paper. With the guidance of the above requirements, we consider the following constraints:

Minimum profit requirements (Participation constraints)

$$E(\pi_1) \geq A_1; \tag{4}$$

$$E(\pi_2) \geq A_2; \tag{5}$$

Production capacity constraints

$$q_{12} \leq K_1^M; \tag{6}$$

$$\alpha q_{12} \leq K_2^M; \tag{7}$$

Assuming all the units produced can be sold

$$\beta_{12} + \beta_{22} = 1. \tag{8}$$

In terms of requirement (5) set by Business International Corporation, some existing models set lower bounds and upper bounds for the transfer prices. In fact, there is no suggested range for companies to follow, especially for those with no comparable market prices. According to Horst (1971): "A firm would probably not try to declare the value of its exports to be less than their marginal cost of production or greater than their market price in the exporting country. But any value the firm wished to declare within these broad limits would probably go unchallenged" (p.1061). In this case, the minimum profit requirements provide stronger constraints than the bounds Horst suggests. Therefore, the formulation of the basic model is complete.

In the next section, we take a closer look at how the decision to set transfer prices in different currencies can impact the variance of divisional profits with exchange rate uncertainty. Following this, the article presents a solution approach to the generalized model and a sensitivity analysis of some key economic parameters.

3. Exchange-rate uncertainty and effects

Currency risk usually complicates the design of transfer pricing strategies. Prior studies have examined resource allocation decisions for MNCs under exchange rate uncertainty (Batra and Hadar, 1979; Itagaki, 1981, 1982, 1987; Yahya-Zadeh, 1998); however, the research objectives in these studies focus primarily on a profit-sharing scheme design. In this section, we discuss the impact that setting transfer prices in different currencies can have on divisional profit variances under exchange-rate uncertainty.

Two scenarios are considered: setting the transfer prices (1) in the selling-division currency, and (2) in the buying-division currency. We then compare the divisional profit variances as a measurement for risks under both scenarios. Risk measures are particularly helpful if division managers are risk averse. Mentioning risks may lead some readers to think of utility; however, as outlined earlier in the paper, it is assumed that the value of transfer prices is determined by the MNC's risk-neutral top management in the headquarters. This discussion is solely focused on divisional profit, and variances are discussed only if division managers are risk averse. Furthermore, utility maximization is usually more suitable for individuals rather than a business entity, and in practice it is not easy to assign an appropriate risk coefficient to a manager and to convince the board of shareholders that this utility maximization objective function is aligned with the company's risk level.

3.1. Scenario 1: setting transfer prices in selling-division currency

The formulae for this scenario are the same as in the basic model.

Noting the variance of e_{ij} as$\mathrm{var}(e_{ij})$, the variance of the two divisional profits can be expressed as:

$$\mathrm{var}(\pi_1) = 0; \tag{9}$$

$$\mathrm{var}(\pi_2) = \left[\beta_{12}\alpha q_{12} M_1 - (1+k_2) p_{12} q_{12}\right]^2 (1-t_2)^2 \mathrm{var}(e_{12}); \tag{10}$$

In Scenario 1, the transfer price is set in the selling-division (division 1) currency. This means that all transactions in division 1 are transacted in its local currency. As a result, division 1's profit is not affected by the currency exchange rate, making it deterministic in this scenario.

3.2. Scenario 2: setting transfer prices in buying-division currency

The only change in this scenario is that the transfer prices are now given in the buying-division currency, so in the expressions for selling-division profit and total profit, terms associated with transfer prices are multiplied by the exchange rate e_{21}; and in the expression for the buying-division profit (division 2), the prices are not multiplied by e_{12}.

$$\pi_1 = \Big[p_{12} q_{12} e_{21} - \left(F_1^M + V_1^M q_{12}\right) - \left(\lceil q_{12}/K_{12}^T \rceil F_{12}^T + V_{12}^T q_{12}\right) - h_1\left(K_{12}^T/2\right)\left(q_{12}/K_1^M\right)\Big](1-t_1); \tag{11}$$

$$\pi_2 = \Big[\beta_{12}\alpha q_{12} M_1 e_{12} + \beta_{22}\alpha q_{12} M_2 - (1+k_2) p_{12} q_{12} - \left(F_2^M + V_2^M \alpha q_{12}\right) - \left(\lceil \beta_{12}\alpha q_{12}/K_{21}^T \rceil F_{21}^T + V_{21}^T \beta_{12}\alpha q_{12}\right) - h_2\left(K_{21}^T/2\right)\left(\beta_{12}\alpha q_{12}/K_2^M\right)\Big](1-t_2); \tag{12}$$

So the variances of the two profits are

$$\mathrm{var}(\pi_1) = \left[p_{12} q_{12} (1-t_1)\right]^2 \mathrm{var}(e_{21}); \tag{13}$$

$$\mathrm{var}(\pi_2) = \left[\beta_{12}\alpha q_{12} M_1 (1-t_2)\right]^2 \mathrm{var}(e_{12}); \tag{14}$$

3.3. Comparison of the profit variances

The variances calculated above are summarized in Table 1.

From Scenario 1 to Scenario 2, the profit variance of the selling division clearly increases, from zero to a positive amount.

The movement of profit variance for the buying division is varied under the following conditions:

Table 1
Profit variances under both scenarios.

Profit variances	Scenario 1	Scenario 2	Movement
$\mathrm{var}(\pi_1)$	0	$\left[p_{12}q_{12}(1-t_1)\right]^2 \mathrm{var}(e_{21})$	Increased
$\mathrm{var}(\pi_2)$	$\left[\beta_{12}\alpha q_{12} M_1 (1-t_2) - (1+k_2)(1-t_2) p_{12} q_{12}\right]^2 \mathrm{var}(e_{12})$	$\left[\beta_{12}\alpha q_{12} M_1 (1-t_2)\right]^2 \mathrm{var}(e_{12})$	Increased/constant/decreased

Table 2
Conditions for movement of buying-division profit variance.

Movement	Condition
Increased	$\beta_{12}\alpha M_1 > \frac{1}{2}(1+k_2)p_{12}$
Constant	$\beta_{12}\alpha M_1 = \frac{1}{2}(1+k_2)p_{12}$
Decreased	$\beta_{12}\alpha M_1 < \frac{1}{2}(1+k_2)p_{12}$

Table 3
Profit variances under both scenarios for special case 1.

Profit variances	Scenario 1	Scenario 2	Movement
$\mathrm{var}(\pi_1)$	0	$[p_{12}q_{12}(1-t_1)]^2\mathrm{var}(e_{21})$	Increased
$\mathrm{var}(\pi_2)$	$[(1+k_2)(1-t_2)p_{12}q_{12}]^2\mathrm{var}(e_{12})$	0	Decreased

Multiplying both sides of the expression byq_{12}, we can see that the left-hand side is the home country's finished-product sales revenue, and the right hand side is half of the raw material cost for the buying division. So the buying-division profit variance will increase, stay constant, or decrease if the home country sales revenue is greater than, equal to, or less than half of the raw material costs for the buying division.

In the following, we compare the profit variances under both scenarios in two special cases.

3.3.1. Special case 1: $\beta_{12}=0$

In this case, all the final products are sold locally in the buying-division country.

The profit variance of the buying division decreases when the transfer price is set in its local currency. Here, we come to our first theorem.

Theorem 1. *If all final products are sold locally in the buying-division country, setting the transfer price in the buying-division's currency will raise the profit risk of the selling division but will lower that of the buying division.*

Proof: based on Table 3. □

The theorem indicates that if both division managers are risk averse; they will both prefer the transfer price in their local currency. In other words, conflict will arise due to currency difference. In practice, the decision is usually based on each party's bargaining power.

3.3.2. Special case 2: $\beta_{12}=1$

$\beta_{12}=1$ indicates all the final products are sold in the home country.

In this case, the profit variance of the buying division is increased because (1) the selling price must exceed the raw material costs, thus $\alpha M_1 \geq p_{12}$; and since $1+k_2<2$, it falls into the first category of Table 2. In other words, for special case 2, the buying division's profit variance increases even when the transfer price is set in its local currency. This leads to Theorem 2:

Theorem 2. *If all the final products are sold in the home country, setting the transfer price in the buying-division's currency will raise both the selling and buying divisions' profit risks.*

Proof: based on Table 4. □

Theorem 2 shows division managers that when all final products are sold in the selling-division country, both parties enjoy lower profit risks if they set the transfer price in the selling-division's currency.

4. Generalized model

The basic model can be expanded to multiple selling and buying divisions. In this generalized model, transfer prices are given in selling-division-currency *i* and the headquarters measures the total profit in a standardized currency indexed as*s*. A realistic assumption is that finished goods produced in one buying division, say division *j*, will be sold to all selling division countries' markets and division *j*'s local market, but not other buying division countries' markets.

Maximize $E(\pi_{total}) = E(\sum_i \pi_i e_{is}) + E(\sum_j \pi_j e_{js}) - E(T_2)$
s.t.

$$\pi_i = \left[\sum_j p_{ij}q_{ij} - \left(F_i^M + V_i^M \sum_j q_{ij}\right) - \left(\sum_j \lceil q_{ij}/K_{ij}^T \rceil F_{ij}^T + \sum_j V_{ij}^T q_{ij}\right)\right.$$
$$\left. - \sum_j h_i\left(K_{ij}^T/2\right)\left(q_{ij}/K_i^M\right)\right](1-t_i); \tag{15}$$

$$\pi_j = \left\{\sum_i \beta_{ij}(\alpha\sum_i q_{ij})M_i e_{ij} + \beta_{jj}(\alpha\sum_i q_{ij})M_j - (1+k_j)\sum_i p_{ij}q_{ij}e_{ij}\right.$$
$$- \left(F_j^M + V_j^M \alpha \sum_i q_{ij}\right) - \left(\sum_i \lceil \beta_{ij}(\alpha\sum_i q_{ij})/K_{ji}^T \rceil F_{ji}^T\right.$$
$$\left.\left. + \sum_i V_{ji}^T \beta_{ij}(\alpha\sum_i q_{ij})\right) - \sum_i h_j\left(K_{ji}^T/2\right)\left[\beta_{ij}(\alpha\sum_i q_{ij})/K_j^M\right]\right\}(1-t_j); \tag{16}$$

$$T_2 = \sum_i k_i \sum_j \beta_{ij}(\alpha\sum_i q_{ij})\left\{M_i - p_{ij} - \frac{F_j^M + V_j^M(\alpha\sum_i q_{ij})}{\alpha\sum_i q_{ij}} * e_{ji}\right\}e_{is}; \tag{17}$$

$$E(\pi_i) \geq A_i \ \text{ for } \ \forall i,j \tag{18}$$

$$E(\pi_j) \geq A_j \ \text{ for } \ \forall i,j; \tag{19}$$

$$\sum_j q_{ij} \leq K_i^M \ \text{ for } \ \forall i,j \tag{20}$$

$$\alpha\sum_i q_{ij} \leq K_j^M \ \text{ for } \ \forall i,j; \tag{21}$$

$$\sum_i \beta_{ij} + \beta_{jj} = 1. \tag{22}$$

4.1. Comparative numerical example

Kassicieh (1981) conducted similar research, but did not consider manufacturing capacity, transportation costs, holding costs, and second tariffs in the model. To show the significance of including these elements in the model, we used the same numerical example given in Kassicieh's study and compared the results.

Kassicieh's numerical example included two selling divisions and two buying divisions located across four countries. The parameters in Kassicieh are given in USD. To fairly illustrate the effect of including the cost elements mentioned above, additional parameters are also given directly in USD or converted to USD. In Kassicieh's model, a risk parameterR_i is assigned to each country, but since the risk rate is always used along with the tax rate in the

Table 4
Profit variances under both scenarios for special case 2.

Profit variances	Scenario 1	Scenario 2	Movement
$\mathrm{var}(\pi_1)$	0	$[p_{12}q_{12}(1-t_1)]^2\mathrm{var}(e_{21})$	Increased
$\mathrm{var}(\pi_2)$	$[\alpha q_{12}M_1(1-t_2) - (1+k_2)(1-t_2)p_{12}q_{12}]^2\mathrm{var}(e_{12})$	$[\alpha q_{12}M_1(1-t_2)]^2\mathrm{var}(e_{12})$	Increased

Table 5
Numerical example parameters.

Country	Manufacturing costs			Transportation costs*		
	Capacity (units)*	Fixed ($)*	Variable ($)	Capacity (units)	Fixed ($)	Variable ($)
EEC ($i=1$)	1000	4000	$80	10000 units	$2000	$1/unit
Brazil ($i=2$)	800	8000	$65			
US ($j=1$)	2000	3000	$20			
Mid East ($j=2$)	1600	2500	$25			

Country	Holding costs (/unit/period)*	Tax rate (equivalent)	Tariff rate	Selling price($)	Min. profit ($)(converted)
EEC($i=1$)	$0.15	40.6%	10%	150*	(1188)
Brazil($i=2$)	$0.12	31.75%	20%	160*	(682.5)
US ($j=1$)	$0.04	50%	12%	120	(7.100)
Mid East($j=2$)	$0.07	16.75%	5%	200	(4703.625)

EEC stands for European Economic Community.

* Parameters that are not in Kassicieh's model; values are given by authors..

Table 6
Values of Beta*.

Country ($\alpha=1$)	EEC ($i=1$)	Brazil ($i=2$)	US ($j=1$)	Mid East ($j=2$)	Sum
US ($j=1$)	40%	40%	20%		100%
Mid East($j=2$)	50%	35%		15%	100%

form of $(1-t_i)(1-R_i)$, we will use the value of this expression for that of $(1-t_i)$in our model.

The values of all the parameters used are shown in Tables 5 and 6. The values of the parameters with asterisks are given by us and the rest of the values are either given or converted from Kassicieh. Transportation parameters are assumed identical among the four countries in this example.

Fixed manufacturing costs are given by us in this table even though they are mentioned in Kassicieh's model because Kassicieh's numbers indicate the final values of the expression, involving minimum required profits, fixed manufacturing costs, tax rates, and tariff rates. The tax and tariff rates are known, but the model does not specify the exact value for minimum profits or fixed manufacturing costs, so we assigned reasonable fixed manufacturing costs and used Kassicieh's expression to obtain the value of the corresponding minimum profit.

Also worth mentioning is that in Kassicieh's model, divisions are required only to break even; it is assumed that divisions are supported by profits from other corporate products. So we can treat the additional profits in Kassicieh's model as the negative minimum profit requirement. Thus the number for external profits in Kassicieh is converted one step further to be negative and become the “minimum profit requirement” in our model.

To better explain the value of betas in Table 6, we provide the following example: in Row 2, Col. 1, 50% means that 50% of the finished goods produced in the Middle East are shipped to the European Economic Community (EEC) to sell.

Table 7
Results comparison of two models.

Variables	*Kassicieh's*	Our model	Difference
p_{11}	120.00	120.00	0%
p_{12}	53.51	93.42	75%
p_{21}	120.00	116.58	−3%
p_{22}	108.87	131.04	20%
q_{11}	122.89	200.00	63%
q_{12}	110.1	33.00	−70%
q_{21}	77.1	0.00	−100%
q_{22}	62.89	140.00	123%
π_{total}	16592.55	9478.3	−43%

This problem is solved using the built-in “fmincon” function in Matlab R2012a. Matlab has four built-in options for running the function: interior-point, sqp, active-set, and trust-region-reflective. The trust-region-reflective option is set at default and Matlab automatically switches to a different option if it is best for the problem. The option used for our programming is interior-point, which is usually used for large-scale programming as it handles large, sparse problems, satisfies bounds at all iterations, and can recover from NaN or Inf results.

The results are shown in Table 7.

It is clear that the differences are significant except for p_{11} andp_{21}: the transfer price from EEC to the Middle East increases by 75%, and the transfer quantity decreases by 70%; a major volume shift occurred for products from the EEC – our model suggests that more of them should be sold to the US instead of the Middle East. More dramatically, our model suggests Brazil should sell all its products to the Middle East rather than to the US. These result differences lend us evidence that incorporating parameters like manufacturing capacity, transportation costs, holding costs, and second tariffs does make a difference.

Although the total profit in our model is lower, perhaps giving readers the impression that our model is less favorable, the authors point out that we arrived at this total profit amount because we

Table 8
Base values of parameters ($=CAD$).

Country	Manufacturing costs			Transportation costs		
	Capacity	Fixed	Variable	Capacity	Fixed	Variable
Canada(div. 1)	30,000 units	$60,000	$400	10,000 units	$10,000	$0.5
China (div. 2)	50,000 units	¥200,000	¥300	10,000 units	¥65,000	¥3.25

Country	Holding costs (/unit/period)	Tax rate	Tariff rate	Selling price	Min. profit	Beta
Canada(div. 1)	$4.5	25%	4%	$1300	$100,000	0.5
						Alpha
China (div. 2)	¥20	20%	8%	¥10,000	¥500,000	1

Table 9
Three shipment size levels.

Level	Capacity	Fixed cost	Variable cost
1	5000	$6000	$1.2
2[a]	10,000	$10,000	$0.5
3	20,000	$17,000	$0.3

[a] Base value for transportation selection.

included more cost elements such as fixed manufacturing costs, transportation and holding costs and second tariffs, etc. Because Kassicieh did not consider these elements, the expenses are not taken off the bottom line. Because our model considers these additional cost elements, it is more realistic and holistic. It takes more variables into account, which leads to better optimization. This will allow managers to make more well-informed decisions.

To sum up, the large differences between these results show the significance of these additional elements – manufacturing capacity and fixed costs, transportation and holding costs, and second tariff costs – which appear in our model.

5. Sensitivity analysis of controllable and regulatory parameters

In this section, we present several numerical tests on the sensitivity of each controllable or regulatory parameter in the basic model, using Matlab R2012a. Controllable parameters are those that the company can control without causing additional R&D costs, for example, choice of shipment size. Regulatory parameters are those related to tax authorities, such as tax and tariff rates.

We first use a set of base values for all parameters and run the corresponding optimal solution. Then, we change, one at a time, each controllable or regulatory parameter around the base value to see its effect on the optimal solution.

5.1. Solution for base example

The values of the parameters used in this example are shown in Table 8.

The transportation parameters are assumed identical in both divisions. The exchange rate used is $1 = ¥6.5. Thus, even though the numbers look different, the dollar value of the cost rates is the same.

Local optimal solutions given by Matlab are: $p = \$409$, $q = 30,000$units, and total profit $\pi_{total} = \$21,904,000$. We can see that the transfer price is just slightly above the variable manufacturing cost of the selling division.

Table 10
Results under different selling-division-country tax rates.

t_h	5%	15%	25%[a]	35%	45%	55%
p($)	***1266***	***1266***	409	409	410	412
π_{total} (*10^7)	2.4658	2.2071	2.1904	2.1886	2.1863	2.1829

[a] Base value for the selling-division-country's tax rate.

5.2. Choice of shipment size

Now we run the model using three levels of shipment size: please see Table 9.

Minimal change occurred in p among the three levels, 1–3; the profits are $21,885,000, $21,921,000, and $21,888,000 respectively. At this scale, the change in profit under these three shipment sizes is insignificant and without an apparent trend. Our recommendation for companies is to consider other practical factors, such as the reliability of the transportation carrier and operations KPIs such as lead time, damage incidents, and equipment availability.

5.3. The selling-division-country tax rate

In this sensitivity analysis, the selling-division-country's tax ratet_h is adjusted from 5% to 55%[1] in increments of 10% (Table 10; Fig. 3–4).

As we increase the selling-division-country's tax rate, the transfer price drops dramatically from $1266 (close to the selling price), to $409 (just slightly above the raw material costs); then the slope starts to trend flat. The large drop can be explained by legal tax avoidance. Raising the transfer price will increase the selling division's profits and decrease that of the buying division. When the selling-division-country's tax rate is lower than that of the buying-division country, or 20%, the MNC as a whole will benefit by keeping the profits of the selling division high and keeping the buying division's profits low. After 25%, the price goes up slowly to maintain the minimum profit requirement for the selling division.

The total profit drops significantly, as one would expect; however, the curve is relatively flat except for the front end, where the tax rate greatly increases but the transfer price remains the same, resulting in a sharp drop in total profits.

Based on these results, we note that the fluctuation of the home country tax rate may not affect the MNC's total profit by much unless the rate drops quite low; however, we recommend that the buying division closely watches the home-country's tax rate to see if it drops lower than the buying division's local tax rate.

[1] The 55% tax rate is loosely based on the extreme U.S. case when adding the upper limit of federal, state and local taxes. ⟨http://en.wikipedia.org/wiki/List_of_countries_by_tax_rates⟩. Last accessed on April 20, 2015.

Table 11
Results under different buying-division-country tax rates.

t_l	10%	20%[a]	30%	40%	50%	60%
$p(\$)$	409	409	1266	1265	1265	1263
π_{total} (*10 ^ 7)	2.4692	2.1904	1.9475	1.9462	1.9444	1.9416

[a] Base value for the buying country's tax rate.

Table 12
Results under different selling-division-country tariff rates.

k_h	2%	4%[a]	6%	8%	10%	14%	18%
π_{total} (*10 ^ 7)	2.2157	2.1904	2.1650	2.1397	2.1144	2.0638	2.0131

[a] Base value for the home-country's tariff rate.

Table 13
Results under different buying-division-country tariff rates.

k_l	4%	6%	8%[a]	10%	12%	16%	20%
π_{total} (*10 ^ 7)	2.2296	2.2100	2.1904	2.1708	2.1511	2.1119	2.0727

[a] Base value for overseas country tariff rate.

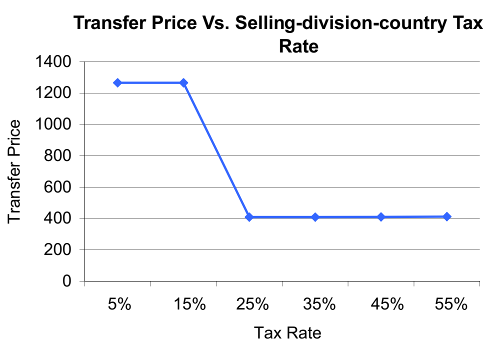

Fig. 3. Sensitivity of transfer price on selling-division-country tax rate.

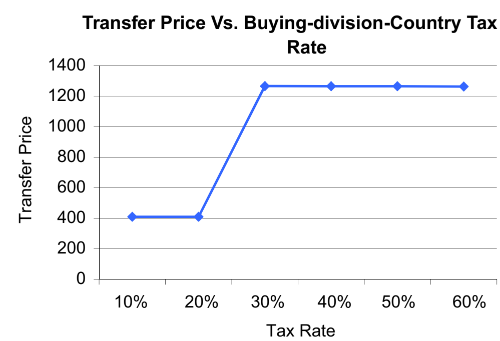

Fig. 5. Sensitivity of transfer price on buying-division-country tax rate.

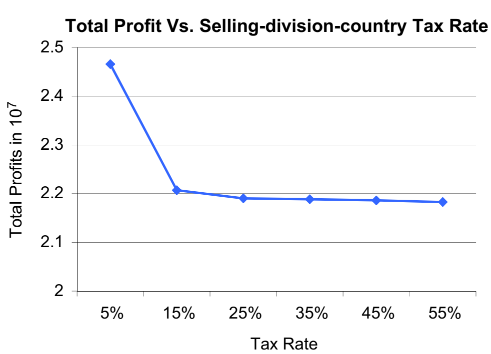

Fig. 4. Sensitivity of total profit on selling-division-country tax rate.

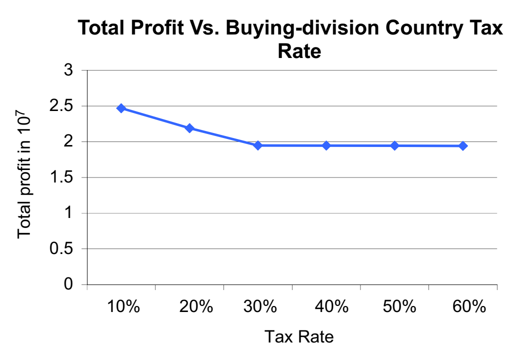

Fig. 6. Sensitivity of total profit on buying-division-country tax rate.

5.4. The buying-division-country tax rate

In this sensitivity analysis, the buying-division-country's tax rate $t_l$is adjusted from 10% to 60% in 10% increments (Table 11; Fig. 5-6).

Contrary to the last analysis, at first glance, with the local-country tax rate increasing, the transfer price first shows a dramatic growth from \$409, (close to the cost of raw materials), to \$1266 (close to the selling price), when the local country tax rate rises from 10% to the base value 20%. After 20%, the price drops slightly with increasing speed at each step (Fig. 5).

After a closer look at the results, however, we see that once the buying-division-country tax rate is higher than that of the selling-division country (25%), the transfer price skyrockets, once again due to tax avoidance. The slight change in price later reflects the buying division's minimum profit requirement.

The total profit also decreases in this case, which is not surprising since the buying division is paying taxes based on an increasing rate. And again, the curve is relatively flat except for the front end, where at the first increment the transfer price stays the same but the buying-division-country tax rate increases, and at the second step, both the transfer price and the tax rate change significantly (Fig. 6).

Similar to the home-country tax rate analysis, we find that the fluctuation of the home-country tax rate may not affect the headquarters by much unless the rate drops quite low; in this

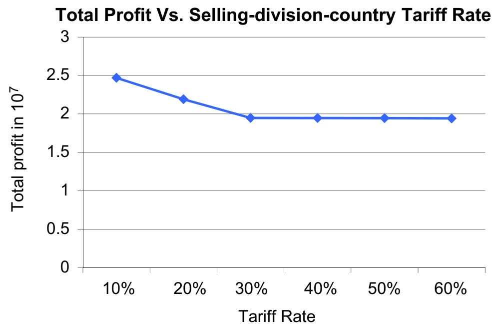

Fig. 7. Sensitivity of total profit on selling division country tariff rate.

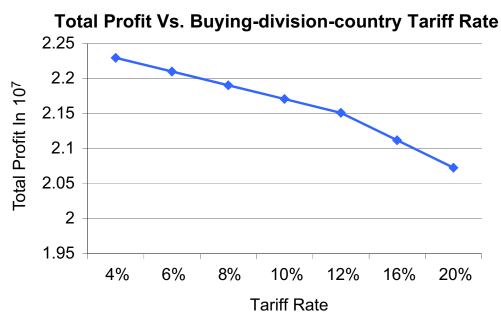

Fig. 8. Sensitivity of total profit on buying-division-country tariff rate.

case, we recommend the selling division watch for revenue losses in the event the local-country tax rate drops below the selling-division-country tax rate.

5.5. The selling-division-country tariff rate

Let the selling-division-country's tariff rate $k_h$change from 2% to 10% with increments of 2%, and from 10% to 26% in increments of 4% (Table 12).

There is hardly any change in$p$among these instances. The total profit goes down slowly and quite steadily within the range (Fig. 7).

5.6. The buying-division-country tariff rate

Let the buying-division-country tariff rate $k_l$change from 4% to 12% with 2% increments, and from 12% to 28% in 4% increments (Table 13).

Again, we see minimal change in$p$in these instances, and the total profit slowly decreases (Fig. 8). Based on this result, we find that subtle changes in tariff rates have little effect on the company or its divisions.

6. Conclusions and discussion

This paper developed a realistic mathematical model that solves for the optimal transfer prices for multinational corporations. The model presented includes cost elements that have been overlooked in the literature including second tariffs, holding costs, and international transportation costs.

Both a basic model and a generalized model were presented. We used the basic model to illustrate the concepts and to further discuss two scenarios where transfer prices are set in different currencies. Managerial insights are summarized into two theorems as guidelines for division managers to control the profit risks resulting from exchange-rate uncertainty. To reiterate the two theorems: (1) if all final products are sold in the buying-division country, profit risks will be reduced for the division whose currency the transfer price is set in. In other words, division managers will be in a favorable position if the transfer price is set in their own currency. (2) If all final products are sold back in the selling-division country, both divisions' profit risks will be lower if the transfer price is set in the selling-division's currency. Based on Theorem 1, if all final products are sold in the buying-division country, we encourage division managers to evaluate their risk-taking level and leverage their bargaining power to convince headquarter top management to use their own divisional currency. Based on Theorem 2, a mutual agreement on choice of transfer price currency should be reached between the selling and buying divisions. For any other cases where final products are sold in both countries, managers are encouraged to apply their actual operation parameters (selling-division-country sales revenue vs. buying-division variable-manufacturing costs) to our model and, at the same time, evaluate their own risk-taking level to devise a negotiation strategy.

A generalized model was also presented to illustrate how our model can be used in actual business cases. To signify the additional cost elements added in this model, a comparative numerical example was given for Kassicieh's (1981) model. The results provided evidence that the additional cost elements do in fact impact the optimal solution to a fair extent. It is worth noting that this numerical example was solved using a built-in Matlab function, which makes the real-life application by companies affordable and adaptable.

Later in the paper, we reported our findings from sensitivity analyses on controllable and regulatory parameters; the results are summarized as follows: transportation size selection and both parties' tariff rate change will minimally affect the bottom line of the headquarters or the divisions, but both divisions are advised to watch for revenue losses or cost increases in the event that its counterpart's tax rate decreases.

To sum up, this article contributes to the existing body of literature in several ways: (a) we further developed the topic of transfer pricing and profit maximization by building a holistic model that includes at least two more practical cost elements compared to existing researches; we also supported this with a numerical comparative example with Kassicieh's (1981) model; (b) we offer innovative insights for risk-averse managers. The model provides guidance to division managers on whether to set the transfer prices in local currencies or the other parties' currencies under different scenarios which the final products are sold in different countries; (c) we performed a sensitivity analysis on controllable and regulatory parameters and found that division managers should keep a close eye on tax rate fluctuations of the selling/buying counterparts as a decrease in the tax rate might lead to the other party's revenue loss or cost increase.

This paper offers several future research directions. They can be changing the variable manufacturing cost to a non-linear function; including customer delivery transportation costs; or examining scenarios where free trade zone is in effect. One limitation of this paper is the assumption that the sales allocation is fixed. In reality, companies can adjust this parameter based on demand fluctuations and tax rate changes. To better understand how to incorporate this parameter as a decision variable, future analytical research is necessary.

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Appendix A

By collecting terms, we have

$$E(\pi_{total}) = Ap_{12}q_{12} - Bq_{12}$$

where A collect all the terms that is a multiplier of $p_{12}q_{12}$ in $E(\pi_{total})$, and Bcollect all the terms that is a multiplier of q_{12}. Then the Hessian Matrix of the nonlinear optimization problem is

$$H = \begin{vmatrix} 0A \\ A0 \end{vmatrix}$$

It can be seen that H is neither negative semi-definite nor positive semi-definite. So the objective function is not well behaved. To solve the problem, we have to use extensive numerical search given the parameter values.

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