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# THE IMPACT OF COMPETITION AND CONSUMER PREFERENCES ON THE LOCATION CHOICES OF MULTINATIONAL ENTERPRISES

NICOLE ADLER and NIRON HASHAI*
*School of Business Administration, The Hebrew University of Jerusalem, Mt. Scopus, Jerusalem, Israel*

*In this study, we argue that when undertaking location decisions, multinational enterprises (MNEs) ought to incorporate their competitors' reactions to such decisions as well as consumer preferences for location, in addition to the more standard cost-benefit analyses. We view MNEs as networks of activities connected via product and knowledge flows and develop a game-theoretic, location-allocation mathematical model. A series of computational analyses leads to competitive outcomes and location choices, where even without an explicit modeling of inter-region differences, MNEs show strong tendency toward regionally focused location configurations. Importantly, such regionally focused location configurations can take the shape of regionally focused MNEs or of globally dispersed MNEs with regional structures. Copyright © 2015 Strategic Management Society.*

## INTRODUCTION

The international business literature has long adopted the view of multinational enterprises (MNEs) as networks of activities connected via knowledge and product flows (Buckley and Casson, 1976, 1998; Buckley and Hashai, 2004; Dunning, 1993, 1998; Hirsch, 1976; Mudambi, 2008; Rugman, 1981). Multiple scholars have evaluated the major determinants of efficient location choices as means to achieve proximity to markets, resources, and suppliers (Dunning, 1988, 1993; Rugman, 1981).

There are two standard approaches to modeling MNEs' location choices. One approach attempts to minimize the total costs arising from location choices, which implies that the firm is a price taker (Adler and Hashai, 2007). The downside of this approach is that it ignores competition as an additional important determinant that ought to be considered in MNEs' location choices (Cantwell and Mudambi, 2011; Shaver and Flyer, 2000), where price is defined as a decision variable and profit maximization is sought. The other approach indeed takes competition into account, yet it assumes that the locations of MNEs' competitors are fixed and invariable, where MNEs choose whether to co-locate or separate from their competitors' networks (Alcacer, 2006; Alcacer and Zhao, 2012; Cantwell and Mudambi, 2011; Shaver and Flyer, 2000). The downside of this approach is that it ignores the strategic interaction between competing MNEs that respond to the each other's location choices.

In the current article, we propose a model which incorporates both rivalry and strategic interaction as means to endogenize the prices and costs of competing MNEs. The model captures the reactions of com-

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*Correspondence to: Niron Hashai, School of Business Administration, The Hebrew University of Jerusalem, Mt. Scopus, Jerusalem, 91905, Israel. E-mail: nironh@huji.ac.il

peting MNEs to each other's location choices while maximizing profits. In the model, MNEs make their location choices, given location and pricing decisions of their competitors, and are free to locate them until a stable equilibrium is achieved. An important feature of our model is the inclusion of consumer preferences, in terms of willingness to pay for products or services. Consumers' decisions whether to buy from a given MNE or another are a function of location choices among other considerations. More specifically, preferences for locally supplied customer support and production in a perceived technologically advanced location are both likely to impact consumers' willingness-to-pay (Almor, Hashai, and Hirsch, 2006; Feit, Beltramo, and Feinberg, 2010; Han and Terpstra, 1988; Johansson and Nebenzahl, 1986; Verlegh and Steenkamp, 1999). Consequently, we account for consumer preferences for location when modeling the location choices of competing MNEs because they reflect additional revenues that may outweigh any additional costs.

The model framework presented in this study links location dilemmas rooted in the international business literature with the game-theoretic, facility location-allocation problems addressed by the operations research literature (Daskin, 1995) in order to analyze the relationship between MNEs' competition, consumer preferences, and location. We bring forward a novel methodology to analyze the location choices of MNEs. This methodology considers the specific potential locations of value chain activities (Porter, 1985) within a holistic approach that accounts for revenues and consumers' willingness-to-pay as well as MNEs' fixed and variable costs.

The impact of the approach taken in the current study is demonstrated through a series of computational experiments. These experiments show that location decisions of competing MNEs striving to fulfill consumer preferences substantially differ from those taken when competitors' locations are ignored or assumed to be set exogenously, and from location decision where consumer preferences for location are not accounted for. Despite the fact that we do not explicitly model region-specific attributes or differences, such as cultural and institutional distance (Delios and Henisz, 2003; Ronen and Shenkar, 1985), regional liabilities of foreignness (Hymer, 1976; Zaheer, 1995; Asmussen, 2009), or regional integration patterns, our computational experiments reveal two dominant location configurations. In one configuration, MNEs concentrate their operations in specific regions (Rugman and Verbeke, 2004), and in the other, globally dispersed MNEs possess a regional organizational structure (Stopford and Wells, 1972). In both cases, it is evident that the regional focus tendency is much more prevalent for R&D and marketing activities than for production activities.

A key insight of our study is that the knowledge flow costs resulting from the coordination of dispersed activities, coupled with MNEs' preference to avoid direct competition, increase the tendency of MNEs toward regionally focused location configurations. It is further evident that geographic distance by itself can be a dominant determinant of regionally focused MNEs, where interregional differences in terms of culture, institutions, and integration patterns intensify regional focus, but are not necessary conditions for the phenomenon to occur as the extant literature implies (Asmussen, 2009; Rugman and Verbeke, 2004, 2007). Finally, and importantly, by specifically modelling the location of value chain activities, such as R&D, production, and marketing we are able to show which of these functions is more likely to become regionally focused, as well as identify the two types of dominant location configurations (MNEs that concentrate their operations in specific regions and globally dispersed MNEs that possess regional organizational structures). These insights could not be gained without the specific modeling of value chain activities.

Our model represents a general framework for analyzing MNEs operating in multiple markets. Given the complexity of location decision making at the global level (Adler and Hashai, 2007; McCann and Mudambi, 2005; Mudambi, 2008), the model introduced in this article may prove to be a useful aid to MNEs in determining their location choices and prioritizing foreign market penetration. The model can further help in setting expected revenue levels through prices while taking into account competitors' reactions and consumer preferences.

The remainder of this study is organized as follows: in the next section, we position our model in the extant location literature. Next, we describe our model and its main features and then present a series of computational experiments that highlight the effect competition and consumer preferences have on MNEs' location choices. Finally, we discuss the results of our computational experiments and draw conclusions.



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## POSITIONING THE MODEL IN EXTANT LOCATION LITERATURE

### Location decisions on a global scale

The international business literature often adheres to the Coasian view of the MNE as a network of value chain activities connected via knowledge and (semi) product flows (Buckley and Casson, 1976, 1998; Buckley and Hashai, 2004, 2005; Dunning, 1998). This view essentially asserts that the geographic location of MNEs' value chain activities is driven by *cost minimization* criteria with respect to the overall costs of operations, transportation, and knowledge transfer (Buckley and Casson, 1976, 1998; Dunning, 1993, 1998; Martin and Salomon, 2003; Mudambi, 2008; Rugman, 1981).

In a recent study, Adler and Hashai (2007) exemplify this view by introducing a location-allocation model (Daskin, 1995) that permits an evaluation of a relatively large number of location decisions based on a specific treatment of knowledge transfer costs, in addition to other tangible costs such as transportation costs and economies of scale. This study demonstrates how the optimal geographic boundaries of MNEs are affected by the requirement for product and process knowledge per unit of a tangible product, as well as by the need for cost efficiency in transferring such knowledge. Adler and Hashai (2007) show that optimal location choices are a function of both the level of knowledge contained in each unit of product and the associated knowledge transfer cost. The main drawback of the model presented in Adler and Hashai (2007), representing a general void in the stream of literature advocating cost minimization, is the assumption that MNEs are price takers; hence, the solution to the cost minimization model is assumed to be equivalent to that of profit maximization.

The major insights of this literature stream describe the tension between the concentration and dispersion of value chain activities. The concentration within a limited geographic space facilitates knowledge transfer within the firm (Buckley and Hashai, 2004; Cantwell and Mudambi, 2005; Galbraith, 1990; Singh, 2005; Sorenson, Rivkin, and Fleming, 2006; Teece, 1977). The dispersion of value chain activities facilitates the knowledge transfer between MNEs and their competitors and customers in various target markets (Alcacer, 2006; Almor *et al*., 2006; Cantwell and Mudambi, 2011; Hirsch, 1989; Porter, 1998), but increases the costs of coordinating activities in dispersed locations (Goerzen and Beamish, 2003; Vermeulen and Barkema, 2002; von Zedtwitz and Gassmann, 2002).

Interestingly, a similar tension is also echoed in Krugman's (1991) work on the location of production in 'core' or 'periphery' locations, where it is shown that increasing returns to scale and lower transportation costs will push toward location in one 'core,' whereas low returns to scale and high transportation costs will push toward location in several 'peripheries.' In a similar vein, the same tension exists in the 'proximity-concentration trade-off' within the international trade literature (e.g., Brainard, 1997; Horstmann and Markusen, 1992). This literature stream essentially shows that greater international transportation costs and tariffs, on the one hand, and lower economies of scale and investment barriers, on the other hand, will lead to greater sales of MNE affiliates at the expense of lower exports from home.

Importantly, this tension is further related to the recent view of MNEs as 'regionally' concentrated, rather than 'globally' dispersed (Rugman and Verbeke, 2004, 2007), where region-specific characteristics such as the liability of foreignness (LOF) (Hymer, 1976; Zaheer, 1995) and cultural and institutional distance (Delios and Henisz, 2003; Ronen and Shenkar, 1985), as well as regional integration patterns are arguably likely to lead to the dominance of regional location configurations (Asmussen, 2009). In essence, liability of foreignness refers to the extra costs incurred by foreign firms when doing business abroad due to differences in cultures and institutions (Zaheer, 1995). In that respect the literature further indicates that intercountry LOF is often larger across than within regions (Asmussen, 2009), giving rise to interregional differences that are substantially larger than intraregional ones and, subsequently, to firms' attempts to achieve greater cohesion at a regional level (Rugman and Verbeke, 2007).

Together these streams of literature imply that both 'first nature' and 'second nature' geography (Krugman, 1993; Roos, 2005) interact in explaining the concentration of activities is specific regions. 'First nature' geography reflects the concentration of activities in locations separated by oceans and sparsely populated landmasses, while 'second nature' geography implies that man-made barriers (e.g., cultural distance, institutional distance, regional integration patterns) reinforce it (Rugman and Verbeke, 2005).



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## Modeling location decisions under competition

To permit profit maximization in an oligopolistic setting, it is imperative to take into account prices and revenue streams in addition to costs and, hence, to consider the role of competition in determining the location decisions of MNEs. A widely held view among economists is that firms distinguish themselves from competitors when choosing product markets in order to soften price competition (Krugman, 1991; Tirole, 1997). Since profits in monopolistic markets are generally higher than those earned in competitive markets, firms prefer to avoid head-on competition in specific markets if possible. It, therefore, follows that firms attempt to chase away competitors from valuable markets (Milgrom and Roberts 1982) or prevent competitors from entering in the first place (Bain, 1956; Spence, 1977). Adler (2005) demonstrates how airline carriers avoid such competition in the aviation market by developing hub-spoke networks to act as barriers to entry, reducing direct contact to only those links connecting the hubs of the competing networks.

This strand of industrial organization literature stream mostly views firms as indivisible units that perform all value chain activities in given geographic markets where, in fact, the division of value chain activities across locations is a common feature among firms in manufacturing industries. Therefore, a more complete modeling of the location decisions of MNEs should not only account for competition, but also shift the unit of analysis from the firm as a whole to specific value chain activities.

Another important consideration is the fact that MNEs observe the location decisions of their competitors and respond accordingly to maximize profits. This implies that the location of value chain activities of competing MNEs must be determined endogenously. This point of view builds on the long tradition of competitive facility location dating to Hotelling's (1929) famous duopolists competing for a market with consumers distributed uniformly along a line. Hotelling's (1929) classic article introduced the idea of firms competing on both price and location and has developed into the subfield of 'competitive location problems' (Gabszewicz and Thisse, 1992; Eiselt, Laporte, and Thisse, 1993; Labbe, Peeters, and Thisse, 1995). Yet, this literature stream has typically assumed a uniform density of consumers along a line or circle, making it less applicable to deal with MNEs' location decisions at the value chain level, where a choice between specific designated locations (typically countries or cities within countries) must be made.

Incorporating competitors' reactions in MNEs' location decisions in a meaningful manner is an important addition when evaluating MNE location choices because the failure to consider competitors' responses may lead to erroneous decisions regarding long-term strategic variables that are complicated and expensive to later change (Tobin, Miller, and Friesz, 1995). Indeed, a few studies within the international business literature have considered the competitive impacts of location choice (Alcacer, Dezso, and Zhao, 2013; Yu and Ito, 1988). Yu and Ito (1988) search empirically for the impact of market structures on foreign direct investment activities. They investigate whether a firm is likely to establish a manufacturing subsidiary in a host country after reviewing the impact of competitors' reactions and host country and firm-related factors using a logit formulation. They argue that rivals' behavior impacts a firm's behavior in an oligopolistic setting but less so in a more competitive setting. Alcacer *et al*. (2013) argue that industries composed of MNEs are generally oligopolistic. They develop a two-firm model that identifies three potential equilibria outcomes: avoidance, co-location, and stronger-chases-weaker. Both studies were confined to foreign market entry decisions at the firm level and to specific foreign markets and, hence, do not present a wider view of the MNE global location choices at the value chain activity level.

Adopting the approach that competing MNEs arrive at pricing and location decisions in reaction to other MNEs' decisions is, therefore, an important component in unraveling the dynamic process in which competing MNEs determine the markets to serve, where to locate value chain activities, and their pricing structures.

## Location decision and consumer preferences

An additional important parameter that should be taken into account is the value consumers attribute to MNE locations. The international business literature has long argued that consumers' decisions whether to buy from a given MNE or another are likely to be affected by MNE location choices (Bilkey and Nes, 1982; Peterson and Jolibert, 1995). More specifically, production in a developed country may indicate higher perceived product quality which, in turn, leads to differentiated products and pricing structures. Alternatively, local marketing and customer



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support facilities provided by a local or foreign firm are likely to imply better perceived service provision (Almor *et al*., 2006; Han and Terpstra, 1988). In the car industry, for example, Chrysler has witnessed negative reactions to the revelation that their K-car is produced in Mexico (Johansson and Nebenzahl, 1986). In addition, while American consumers consider Japanese cars to be reliable, the service costs are perceived to be higher than those of their American competitors (Johansson and Nebenzahl, 1986). All of these perceptions will impact a consumer's willingness to pay for a given product and the subsequent price of the product in the market.

It follows that the locations of production and customer support activities serve as intrinsic 'product cues' (Chao, 1993; Peterson and Jolibert, 1995) where the overall utility derived from a product as perceived by the consumer is dependent on the MNE's value chain location decisions. This view is consistent with a long tradition of research on the connection between consumer preferences and 'country of origin' effects (e.g., Chuang and Yen, 2007; Cordell, 1992; Dmitrovic and Vida, 2007; Elliot and Cameron, 1994). Dichter (1962) was possibly the first to argue that country of origin may impact the success of a product. Others argue that the phenomenon embodies both a sign of perceived quality and emotional attachment (Chao, 1993; Verlegh and Steenkamp, 1999), while Feit *et al*. (2010) have recently demonstrated the value of country of origin in the car market and presented a methodology to quantify its specific parameters.

In summation, we conclude that one should consider both actual and potential competition when considering MNE location decisions. The choice of location impacts the overall costs faced by MNEs and the value of products (or services) to consumers. This, in turn, influences the consumers' willingness to pay and, hence, product prices. The prices then affect the MNEs' probability of survival in each market and, ultimately, their overall profitability. Hence, the decision processes supporting location choices across the value chain ought to take into account the competitors' location choices and consumer preferences simultaneously.[1] Overall, we propose that competition with respect to satisfying consumer preferences, in addition to competition with respect to prices, is likely to substantially affect the location decisions of competing MNEs across the value chain. Next, we formally model this approach for MNEs competing on a global scale.

## THE PROPOSED MODEL

We introduce a game-theoretic, location-allocation mathematical model in which competing MNEs locate value chain activities based on their revenues and market share as well as their operation, transportation, and knowledge transfer costs. Given multiple players in the market, MNEs first choose whether to participate in the specific markets and then determine the optimal prices of their products and where they should be developed, produced, and marketed, given specific consumer preferences and cost parameters. Consequently, the model predicts which of the competing MNEs are likely to survive in a market and their profitability.

The proposed model draws on a strategic multi-echelon location problem considering the trade-off between consumer preferences and facility location and production costs, given the requisite product and knowledge transfer requirements. The mathematical framework analyzes a firm's best-response function, based on a differentiated Bertrand-Nash formulation in which a logit market share model (McFadden, 1973) determines quantities to be supplied. The logit-based market share model requires knowledge of the absolute size of the expected market and the parameters of the consumers' utility functions. We assume that the consumers' decisions whether to buy from a given firm or another are a function of the firm's location choices, its own prices, and the competitors' prices. Hence, building on the work of McFadden (1973) and Anderson, de Palma, and Thisse (1992), we investigate how prices and consumer preferences impact market share and, ultimately, the value chain activity location decisions of competing MNEs.

In the model, MNEs choose a price per each specific market. Consumers decide from whom to purchase, if at all, based on a utility function that is dependent on pricing, personal preferences, and a

[1] Conceptually, the modeling approach should also consider the time frame over which these decisions are made. Location choices are often made over the long term, production plans over the medium term, and prices in the short term (since they are the easiest to change in response to the demand realization). However, a three-stage approach would be substantially more complicated to solve, hence, we solve the framework within a single stage, taking note of the fact that prices represent an expected range of values (Hanjoul *et al*., 1990).



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reservation value, all of which are location dependent. Location-based parameter values permit the model to account for asymmetric purchasing power and market size across the globe. An important novelty of the model is that we have piecewise linearized the revenue function for computational purposes while approximating the nonlinearities inherent in its behavior. We approximate the logit S shape market share model (McFadden, 1973) by replacing the price decision variables with a piecewise linear, backward Z-revenue function (see Appendix Figure 1). This function produces a mixed integer linear that can be much more easily computed relative to nonlinear mathematical formulations. In order to avoid quadratic objective functions, the revenue function then consists of price and market share combined (as shown in Appendix Figure 2).

We model firms as a series of overlapping networks that are capable of simultaneously assessing multiple location and allocation decisions (Daskin, 1995). Each MNE represents an integrated network of value-adding activities that are interconnected through knowledge and product flows. Following Adler and Hashai (2007), Buckley and Casson (1976, 1998), and Mudambi (2008), we focus on three major value chain activities: (1) R&D—the creation of knowledge and consumable technology and other proprietary organizational know-how; (2) production—the transformation of inputs into outputs; and (3) marketing—the process of product promotion, sales, distribution, and customer support services that specifically relate to the firm's interactions with customers. These value chain activities may be located in up to *N* predefined, potential locations and are interconnected by unidirectional knowledge flows. Each location represents a demand point (i.e., a market) and any location may be defined as a potential location for one or more of the different value chain activities (R&D, production, and marketing).

The proposed model includes two product types: tangible products for sale and intangible by-products, namely, knowledge (copyrights, patents, or any other form of explicit or tacit knowledge) per product (Adler and Hashai, 2007). When accounting for knowledge transfer, we assume 'process' and 'product' knowledge (Abernathy and Utterback, 1978; Cohen and Klepper, 1996) is produced in the R&D centers, and then flows to the production facilities and marketing sites, respectively (Buckley and Casson, 1998; Buckley and Hashai, 2004; Casson, 2000). Marketing then passes product knowledge on to the end customers (Almor *et al.*, 2006; Hirsch, 1989), thus acting as a transshipment site. Consequently, we assume that the demand for knowledge is derived from product demand levels.

The production facilities are connected by product flows to the MNE's markets, and marketing sites are connected to customers by knowledge flows. The current model formulation does not consider horizontal flows between value chain activities of the same type.

The competing MNEs seek to maximize their profits by optimizing the location of R&D, production, and marketing activities, given: (1) the estimated costs (operation costs, transportation costs, and knowledge transfer costs) of locating their operations at different sites; (2) the potential market size at each demand location; and (3) the prices and locations of competitors' operations. A given MNE's optimal location decisions emerge from three sets of questions: (1) where to locate each value chain activity; (2) how to allocate the output of R&D, production, and marketing between the various facilities and end customers; and (3) how to price the products in order to maximize profits, given the pricing and location decisions of relevant competitors. The proposed model permits each firm to choose multiple facility locations for their R&D, production, and marketing activities and determine simultaneously, per location, production levels and prices.

The objective function maximizes firms' profits defined as a function of revenue, which is, in turn, a function of price and market share, less costs. Costs include the fixed costs of the different facilities, dependent on type and location, the production costs required to meet customer demand, based on the level of production in relation to a minimum efficient scale, and the transportation costs of moving the product from a production facility to the end customer. Average production costs follow a piecewise linear function that approximates a U-shaped curve, decreasing to a minimum efficient scale and subsequently increasing. As with the revenue function, the production function is translated into a V-shape, i.e., piecewise linear, in order to avoid a nonlinear formulation and remain within the realms of the mixed integer linear program; this ensures, for reasonable-sized networks, that the formulation is solvable to optimality.

All production facilities are capacitated under the model formulation. The fixed facility costs represent



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the amortized value of building a facility as well as the fixed running costs. The R&D facilities are assumed to have an unlimited capacity and costs are purely fixed, so MNEs consider the opening of a second or third R&D facility (Cantwell and Mudambi, 2005) only if knowledge transfer costs are sufficiently high. Marketing facilities also have an unlimited capacity and include both fixed and variable costs. For simplicity, at each location, there is a maximum of one facility per type (R&D, production, or marketing) per company.

Additional variable costs are associated with knowledge production and transfer, including the transfer of process knowledge and product knowledge. It is assumed that the knowledge transfer costs per unit output behave as an S-shaped logistic curve, increasing linearly for short geographic distances, exponentially over medium distances, and reaching a saturation level beyond 10,000 km. This formulation captures recent empirical observations on the effect of distance on knowledge flow cost (Adams and Jaffe, 1996; Alcacer and Chung, 2007). Two logistic curves are formulated and approximated—one for the transfer of knowledge from R&D to marketing and production and another from marketing to end customers.

We proxy the home country of MNEs by adding a constraint to the model requiring one R&D facility to be located in a specific country. The complete set of decisions variables per MNE include the locations of the R&D sites and the knowledge transfer flows to the production sites (product knowledge) and marketing sites (process knowledge). The next set of variables includes the location of the production facilities, the levels of production at each site, and the transportation flows to the end consumers. The third set of variables includes the location of the marketing sites and the knowledge transfer to end consumers. The final set of decision variables includes prices per product per market.

This model is a mixed integer linear program based on a facility location model with interacting facilities and production/distribution systems (Daskin, 1995). Given explicit competition, differentiated Bertrand-Nash equilibria of the noncooperative game are sought by computing a payoff matrix. A Nash equilibrium can be defined as a set of strategy profiles in which each MNE's choice solution is as good a response to other MNEs' choices as any other strategy available to that player (Kreps, 1990). Consequently, we solve a best response formulation per MNE until a cycle is completed under which no MNE changes its decisions in light of the other players' strategy sets. A subsequent overall market analysis allows us to determine the number of competitors that will survive in the market and their profitability. The game is played until a Nash equilibrium is found based on spatial price equilibria (Caplin and Nalebuff, 1991; Anderson *et al*., 1992). A detailed description of the model appears in the Appendix.

## COMPUTATIONAL EXPERIMENTS

We test the effect of competition and consumer preferences on the optimal location decisions of MNEs across the value chain by using the data first published in Adler and Hashai (2007). Following Adler and Hashai (2007), we model a world consisting of nine locations (countries) pinpointing a major city in each country as a reference point. The countries and cities include the United States (Chicago), Canada (Montreal), Brazil (Rio de Janeiro), the United Kingdom (London), Germany (Munich), Russia (Moscow), China (Shanghai), Singapore (Singapore), and Japan (Tokyo). The chosen countries represent a mixture of large and small as well as developed and developing countries located on three continents: America, Europe, and Asia.

The data in Adler and Hashai (2007) was normalized to reflect country-specific characteristics as follows: fixed and variable costs of the various value chain activities were multiplied by the ratio of per country purchasing power parity (PPP) gross national income per capita (GNIPC) to the median PPP GNIPC in order to reflect intercountry cost differences. Demand data, representing the size of the market in the base run, was multiplied by the ratio of per country PPP Gross Domestic Product (GDP) to the median PPP GDP to reflect both intercountry market size differences and consumers' ability to purchase products or services. The operations and demand data collected are detailed in Table 1, which further includes the values used for transportation costs, knowledge transfer costs, plant capacity, knowledge intensity ($\alpha$), and a fixed cost budget assumed to be available to each MNE. In addition, the geographic distance between the respective cities was determined according to Great Circle Distance (GCD) in kilometers.

Figure 1 (adapted from Adler and Hashai, 2007) presents the solution to the single, cost-minimizing MNE in which the same set of costs are accounted



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Table 1. Input data in base run (based on Adler and Hashai (2007))

| Country | Demand (thousands units) | Base reservation value of product | Fixed costs per facility ($ thousands) | | | Variable costs ($ per thousand units) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | R&D | Production | Marketing | Production | | | Marketing |
| | | | | | | For first unit | At MES | At max. capacity | |
| United States (U.S.) | 63,463 | 3,000 | 17,262 | 46,032 | 575 | 284 | 32 | 789 | 1,066 |
| Canada | 5,420 | 2,316 | 13,328 | 35,541 | 444 | 219 | 24 | 609 | 823 |
| Brazil | 8,093 | 606 | 3,486 | 9,296 | 116 | 57 | 6 | 159 | 215 |
| United Kingdom (U.K.) | 10,000 | 2,376 | 13,675 | 36,468 | 455 | 225 | 25 | 625 | 844 |
| Germany | 12,694 | 2,112 | 12,150 | 32,400 | 405 | 200 | 22 | 556 | 750 |
| Russia | 7,688 | 726 | 4,181 | 11,151 | 139 | 69 | 8 | 191 | 258 |
| Japan | 20,598 | 2,268 | 13,058 | 34,822 | 435 | 215 | 24 | 597 | 806 |
| China | 38,880 | 420 | 2,403 | 6,410 | 80 | 40 | 4 | 110 | 148 |
| Singapore | 645 | 2,010 | 11,558 | 30,823 | 385 | 190 | 21 | 529 | 714 |
| **Other costs ($ per thousand units)** | | | | | | | | | |
| **Transportation costs** | 0.015 | | | | | | | | |
| **Knowledge flow costs** | | | **ψ** | **K** | | | | | |
| *R&D to production* | 0.001 | | 50 | 10000 | | | | | |
| *R&D to marketing* | 0.001 | | 50 | 1000 | | | | | |
| *Marketing to consumers* | 0.001 | | 50 | 1000 | | | | | |
| **Capacity (units)** | | | | | | | | | |
| *MES* | 21,000 | | | | | | | | |
| *Maximal capacity* | 90,000 | | | | | | | | |
| **Knowledge intensity per unit (α)** | 0.1 | | | | | | | | |
| **Initial budget ($ thousands)** | 60,000 | | | | | | | | |



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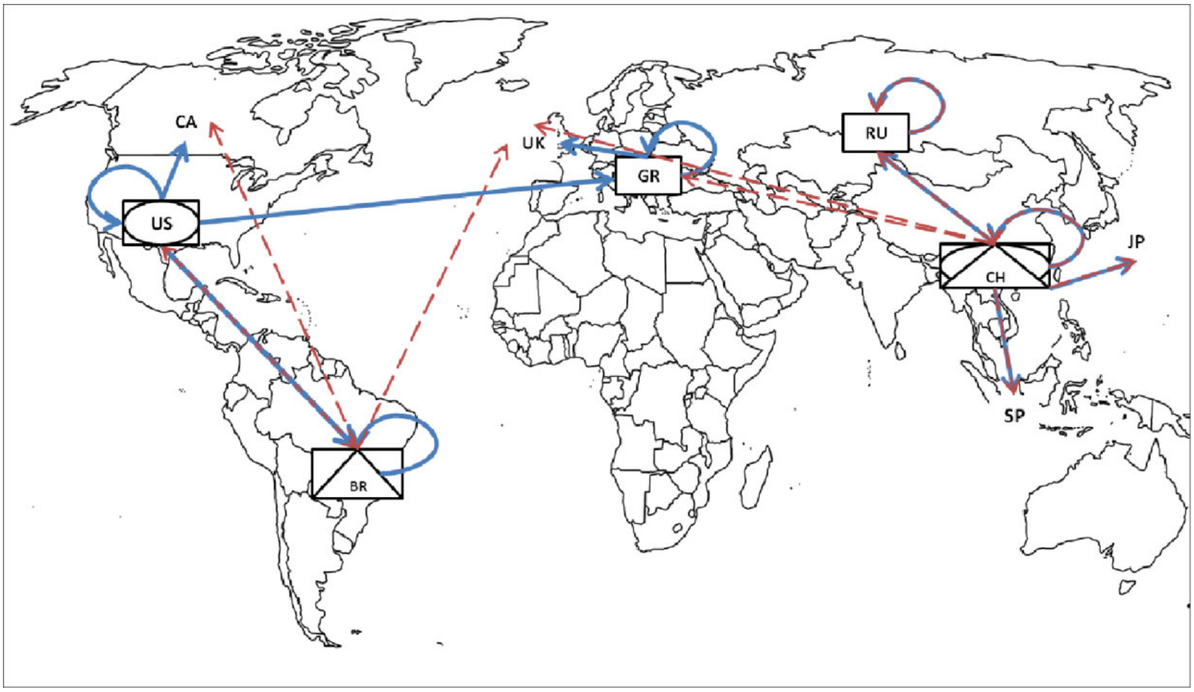


Legend:
**CA=Canada, U.S.=United States, BR=Brazil, U.K.=United Kingdom, GR=Germany, RU=Russia, CH=China, JP=Japan, SP=Singapore.**
**R&D facility= Production site = Marketing site=**

Figure 1. Cost-minimizing U.S.-based MNE

for but revenues are ignored and the company is required to meet all demand, a necessary assumption for a cost minimization formulation. The straight line arrows represent knowledge flows, while the broken line arrows represent product flows. The different shapes next to the location names represent the location of facilities, where an R&D facility is represented by an ellipse, a production site by a triangle, and a marketing site by a rectangle. It can be seen that the U.S.-based MNE (with R&D mandatorily located in Chicago) chooses to locate an additional R&D site in China, operates production plants in China and Brazil, and locates marketing sites in five countries (U.S., Brazil, Germany, Russia, and China). Evidently, this line of modeling reveals an MNE with R&D, production, and marketing activities that are globally dispersed.

Our model refers to competition between U.S.-, German-, and Japanese-based MNEs which are each assumed to face the same level of market demand as that of the single MNE in the cost minimization scenario. We include an additional constraint requiring the location of the R&D facilities of these MNEs to be in Chicago, Munich, or Tokyo, respectively, in order to represent the origin of each MNE. This constraint may be considered as a proxy for the headquarters location of an MNE that produces and transfers firm-specific proprietary know-how.

To apply the formulation of our model, we need revenue-based parameters. For that end, we apply a discrete choice function that includes a reservation value for a single, tangible product less the consumer price. The reservation value was set arbitrarily at \$3,000 which was then normalized according to PPP across all countries other than the U.S. (data appears in Table 1).

In what follows, we first present a base run under these assumptions and compare it to the results of a cost-minimizing MNE. Next, we constrain the location choices of two of the competing MNEs and analyze the location decisions of the remaining MNE as compared to the case where all competing



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MNEs are free to change their locations. This allows us to compare location decisions when competitors' locations are invariable with those where competitors' interactively respond to each other's location choices. We then include parameters in the consumers' utility function assuming Western production and local marketing sites are likely to impact consumer preferences and test their impact on the competitive game outcome and location choices across the value chain. Finally, we undertake a comparative static approach over the parameters that consumers ascribe to specific location attributes and discuss the range over which such attributes impact the location outcomes of competing MNEs.

## Base run

The results of the competition between U.S.-, German-, and Japanese-based MNEs are depicted in Table 2. As indicated in Table 2, the results of the game in the base run lead to duopoly equilibria solution outcomes. Under the three company competitive scenarios, at least one company fails to achieve profitability, in which case we assume that it will choose to exit the market; hence, this will not be an equilibrium solution in the overall game. Consequently, given the simulated demand and parameter levels, the market may support only duopoly solution outcomes. In each cell in Table 2, the profit or loss of each MNE is presented in the following order: U.S.-, German-, and, finally, Japanese-based firms. Two potential equilibria have been found and all subgame perfect outcomes are reported; hence, we remove any solution outcomes that are strictly dominated for all three companies. In the base run, the two potential Nash equilibria include U.S.- and Japanese-based MNEs and German- and Japanese-based MNEs. These two equilibria solutions are shaded in Table 2.

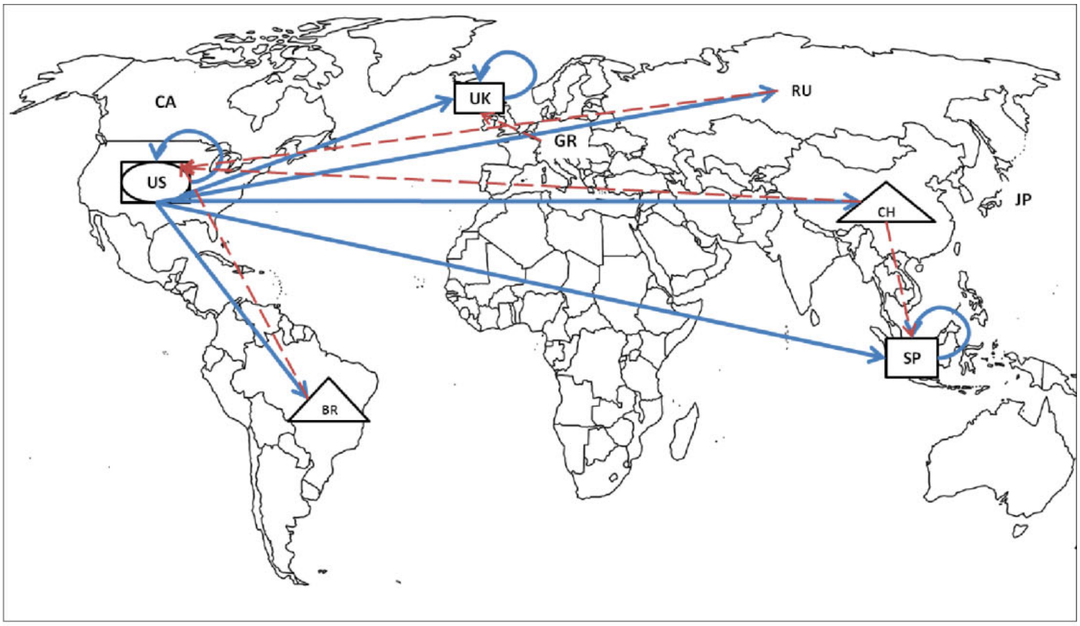
In Figure 2, we focus on the results of the U.S.-Japan MNE duopoly equilibria outcome, in which both MNEs achieve a profit, in order to enable a more focused description of the location implications of our computational analyses. The Japanese-based MNE (the upper diagram) locates an R&D site in Japan (constrained to do so) and has production sites in China and Brazil and marketing facilities in the markets it serves—Canada, Germany, and Japan. The U.S.-based MNE (the lower diagram) locates an R&D site in the U.S. (constrained to do so) and three production sites, in Brazil, Russia, and China; it's marketing facilities are in the markets it serves, namely the U.S., the U.K., and Singapore. Interestingly, in this case, both the Japanese and U.S. MNEs fully use production locations close to their home countries (China and Brazil, respectively) to serve their home countries and then use more remote production sites (Brazil for the Japanese MNE and China for the U.S. MNE) to serve more distant target markets that are closer to these production sites (Canada for the Japanese MNE and Singapore for the U.S. MNE). This choice reveals the preference of many MNEs to first serve their home markets and only serve foreign markets whenever this choice yields additional profit (Porter, 1990; Dunning, 1993).

Table 2. Base run solutions with up to three company competition (values represent net profits (loss) in $U.S. billion)

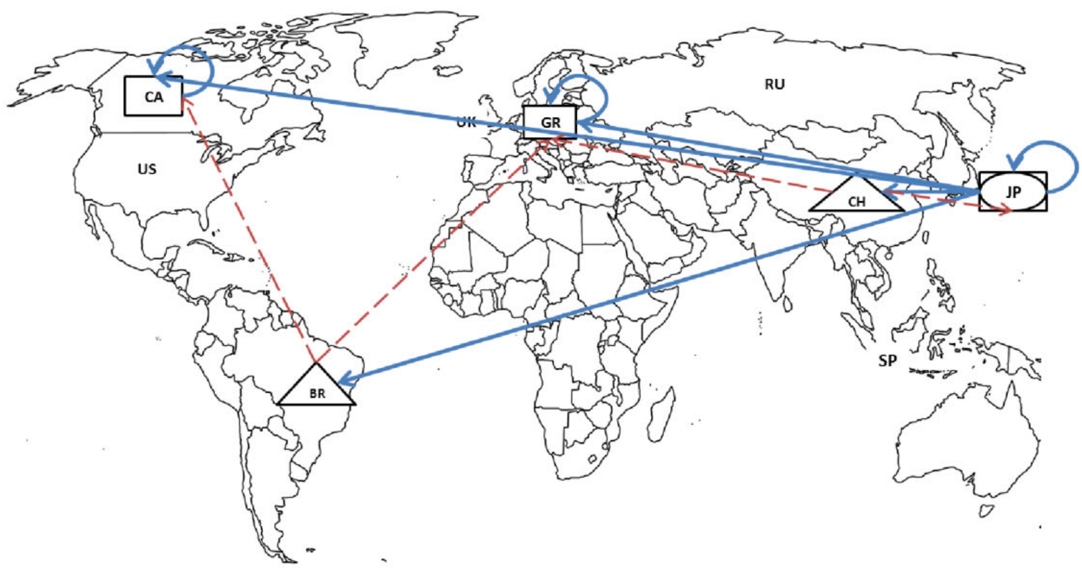
| | | Japan | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Play | | | | | Not | | |
| | | Germany | | | | | Germany | | |
| | | Play | | | Not | | Play | | Not |
| **U.S.** | **Play** | −17 | 3 | 93 | 99 | 31 | 35 | −4 | 501 |
| | | 40 | −12 | 36 | −4 | 98 | −4 | 115 | |
| | | 42 | −12 | −13 | | | | | |
| | **Not** | | 93 | 32 | 594 | | 586 | | |

Note: The results are sensitive to the sequential order in which MNEs enter the game and, hence, there are up to six possible solutions for three players and up to two solutions for two players.

*U.S. MNE network:*




*Japanese MNE network:*




Legend:
**CA=Canada, U.S.=United States, BR=Brazil, U.K.= United Kingdom, GR=Germany, RU=Russia, CH=China, JP=Japan, SP=Singapore.**
**R&D facility=** (oval) **Production site =** (triangle) **Marketing site=** (rectangle)

Figure 2. Duopoly network outcomes: U.S.-Japan duopoly



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The German-Japanese MNE duopoly (not presented graphically) is similar, but has some differences in the allocation of the markets served. The Japanese-based MNE locates an R&D site in Japan, production sites in China and Brazil, and marketing facilities in Canada and Japan, but also in Singapore. The German-based MNE locates an R&D site in Germany and production sites in Brazil, Russia, and China. It's marketing facilities are in the U.S., the U.K., and Germany (its home market). Two main points are evident from these results. One is that the U.S. and German MNEs have very similar location networks. This close similarity is likely to make the U.S.-Germany MNE duopoly less sustainable than the U.S.-Japan and Germany-Japan duopolies where the Japanese MNE location network complements that of the other MNE (either the U.S. or German MNE). The second point is that, like the cost minimization approach, this line of modeling also reveals MNEs with R&D, production, and marketing activities that are globally dispersed.

When examining the location network of the U.S.-based MNE, it is clear that this network is quite different from that presented in Figure 1 for a cost-minimizing U.S.-based MNE. There is a separation of the world between the two competing MNEs that choose to avoid direct competition, and the location of all value chain activities substantially changes when competition is taken into consideration. The U.S. MNE does not open an R&D facility in China, preferring to open another production plant in Russia and to locate marketing facilities in the U.K. and Singapore rather than in Brazil, Germany, Russia and China. Hence, when modeling competition directly, the U.S. MNE location decisions are substantially different compared to those in the cost minimization scenario. The removal of the constraint requiring the company to serve all markets, as is required in a cost minimization model,[2] permits the U.S. MNE to concentrate on a narrower set of developed country markets where it maintains marketing sites (in fact, the U.S. and Japanese MNEs split developed markets between them). This further allows the U.S. MNE to reduce the number of R&D facilities, avoiding the opening of an R&D facility in China, as it faces lower by-product knowledge demand. In turn, the U.S. MNE can now direct the savings from the smaller number of R&D facilities to open an additional production facility (in Russia). This will allow it to serve its chosen markets—the U.K. and Singapore—more efficiently (in terms of the combination of production and transportation costs). Unlike the costs minimization scenario, under the profit maximization objective, the duopoly equilibrium solution does not serve the Brazilian, Russian and Chinese markets. Hence, when costs exceed the value of products given end consumer purchasing power, MNEs ignore potential markets (it is noteworthy that the Chinese market is the second largest in size). Albeit in a somewhat different context, this result could be examined further in the light of anecdotal evidence that Bloomingdale's, after locating a potential site in Toronto, chose ultimately not to enter the Canadian market, arguing that consumers would be unwilling to pay their pricing levels. Apparently the requirement to serve all markets, which is an integral part of cost-minimization models, is too strong.

### Restricting competitors' location choices

We further compare our base run (the U.S.-Japan duopoly) to one in which only the U.S.-based MNE is permitted to relocate, while the German and Japanese MNE networks are set exogenously and cannot be changed. As argued before, following this *ceteris paribus* approach to competitor location fails to account for competitors' reactions to each other's locations. By showing that models allowing for strategic interaction in location choice are different from those that do not, this computational experiment demonstrates the importance of permitting competing MNEs to change their locations in response to their competitors' location decisions.

We constrain the German and Japanese MNEs to locate R&D, production, and marketing sites at their home bases. In addition, we arbitrarily force the German MNE to locate a marketing site in the U.S. and the Japanese MNE to locate a marketing site in the U.K. German and Japanese MNEs are permitted to develop further sites in addition to these requirements. The U.S.-based MNE was not restricted to any specific sites other than one R&D site in the U.S., which is the determinant of the origin of the firm.

It appears that the location restrictions on the German and Japanese firms significantly hamper

[2] Without such constraints, the MNE will choose not to serve any nodes (in order to minimize costs).




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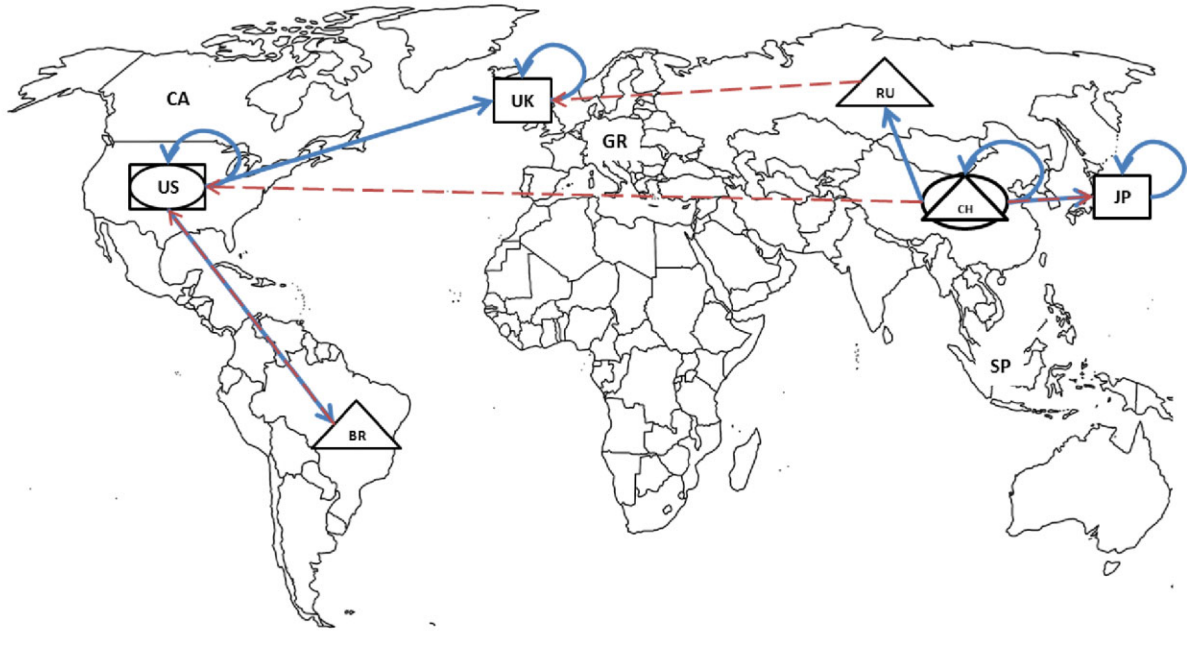


Legend:
**CA=Canada, U.S.=United States, BR=Brazil, U.K.= United Kingdom, GR=Germany, RU=Russia, CH=China, JP=Japan, SP=Singapore.**
**R&D facility= Production site = Marketing site=**

Figure 3. U.S. MNE monopoly network outcomes with set locations for competitors

their ability to compete with their U.S.-based counterpart. Each of these firms fails to achieve profitability if required to compete with the U.S. MNE, and this scenario will likely lead to a U.S. MNE monopoly outcome. These results (depicted in Figure 3), compared to the base run scenario, clearly demonstrate the extent to which assuming that competitors' locations are fixed is unrealistic.

### Consumer preference for 'Western' production and local marketing sites

Our computational experiments thus far have mainly tested the effect of price competition while ignoring consumer preferences. An important component of our modeling approach is including the effect of consumer preferences in the location decisions of competing MNEs. We, therefore, test how competitive outcomes and location decisions across the value chain change if consumers demonstrate a willingness to pay for products from a 'Western-developed' country (Germany was arbitrarily chosen to represent a perceived high quality production location for this purpose) and for local marketing sites (that are responsible for customer support). This scenario allows us to combine the effects of competitors' reactions to each other's location choices with the effects of consumers' willingness to pay for varying levels of product quality and service.

The additional value for locating local marketing sites was set at 10 percent of the reservation value of the product, and production in Germany added 20 percent to the consumers' perceived value of the product at any other location. Table 3 presents the results where the competitive equilibria outcomes of the game include all three sets of duopolies (the shaded cells in Table 3).

Figure 4 depicts the location network for the case of a U.S.-Japan duopoly. The Japanese-based MNE locates its R&D sites in Japan and Russia. It locates production plants in China and Germany, with the latter replacing the Brazilian site chosen in the base



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Table 3. Solutions with consumer preference-based competition (values represent net profits (loss) in $U.S. billion)

| | | Japan | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Play | | | | | Not | | |
| | | Germany | | | | | Germany | | |
| | | Play | | | Not | | Play | | Not |
| **U.S.** | **Play** | 107 | −12 | 30 | 123 | 87 | 101 | 97 | 752 |
| | | 50 | −12 | 13 | | | | | |
| | | −17 | 9 | 63 | | | | | |
| | | 104 | −12 | 23 | 148 | 96 | 148 | 110 | |
| | | 50 | 48 | −13 | | | | | |
| | | 62 | −12 | 21 | | | | | |
| | **Not** | | 132 | 133 | 745 | | 745 | | |
| | | | 136 | 121 | | | | | |

Note: The results are sensitive to the sequential order in which MNEs enter the game and, hence, there are up to six possible solutions for three players and up to two solutions for two players.

run. Marketing sites are located in every market served, including Japan, Singapore, Germany, the U.K., and Canada. The U.S.-based MNE locates a single R&D site in the U.S. Production remains in China, and a second production site is located in Germany, replacing both the Brazilian and Russian sites chosen in previous scenarios. Marketing sites are located solely in the U.S., which is the only market this MNE serves.

This location network is very different from the base run presented in Figure 2. We can see that the consumer preferences lead both MNEs to locate production sites in Germany, in addition to China, which represents the lowest cost country in this sample. The competitive outcome also changes the markets served, whereby both the U.K. and Singapore markets are now served by the Japanese MNE rather than by the U.S. MNE. This leads the Japanese MNE to locate an R&D site in Russia to facilitate knowledge transfer to its production site and to marketing sites in Europe. In contrast, the U.S. MNE contracts in terms of its global dispersion and chooses to serve purely its own market. Yet, this contraction allows it to reduce costs and determine prices that block Japanese competition in the U.S. home market.

Overall, the increased willingness of customers to pay for German production and local marketing sites enables all active firms to achieve higher profits, as can be observed when comparing the results to Table 2. The higher profits are also the direct result of avoiding head-on competition because otherwise the rivalry would have led to lower prices and potentially the same levels of revenue as those of the previous scenario. As a result, the solution outcome yields a location network that is substantially different from the one portrayed in Figure 2, where the best response function considers only competition and not consumer choice.

The resulting location configuration yields another important insight. It shows that the U.S. MNE now fully concentrates in serving its home region and that the Japanese MNE clearly divides its control of operations, in terms of knowledge transfer between Asia and Europe (with the exception of the Canadian market which is served from Russia). While for both MNEs production sites serve the world markets on a global basis, this result highlights the strong effect of knowledge flows between MNEs and their customers on the tendency of competing MNEs toward regional configurations. Specifically, when consumers favor local marketing services, regional configurations are expected to emerge. We, therefore, conclude that our model specification demonstrates two effects that result in the emergence of regionally focused MNEs. First, when striving to fulfill consumer demands, especially in terms of local marketing sites in served markets, competing MNEs are pushed to avoid competition. Second, given the need to reduce knowledge transfer costs, MNEs that decide to compete in multiple regions will organize their R&D and marketing activities (but not their production) on a regional basis.



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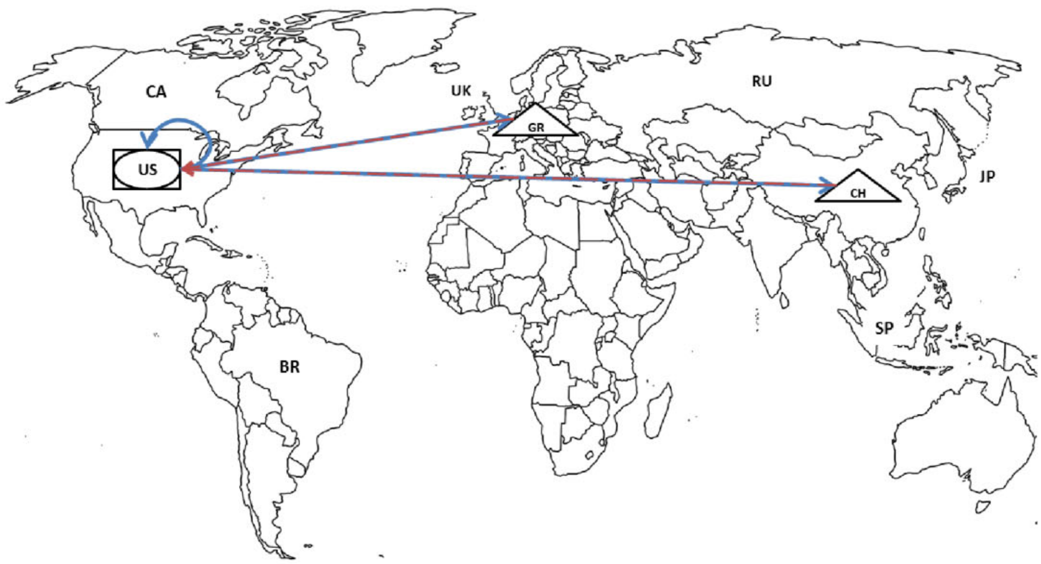
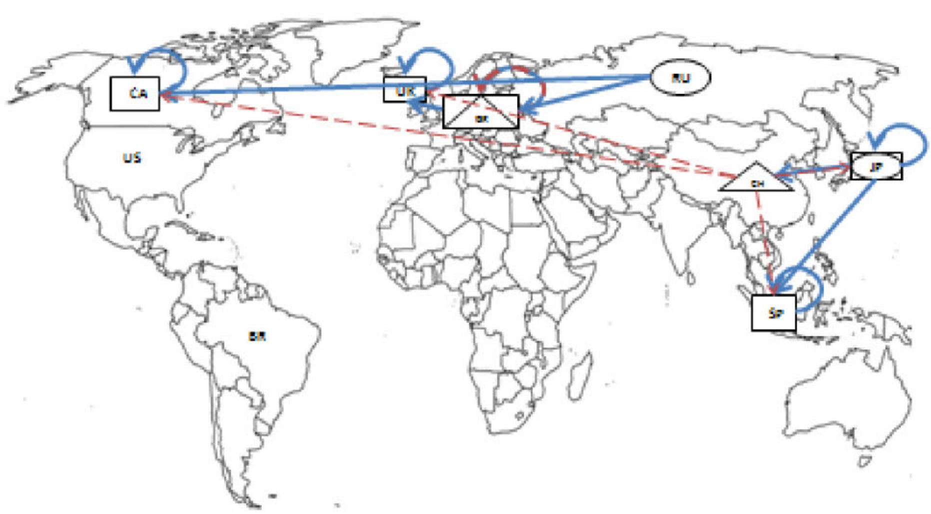
*U.S. MNE network:*




*Japanese MNE network:*




Legend:
**CA=Canada, U.S.=United States, BR=Brazil; U.K.= United Kingdom, GR=Germany, RU=Russia, CH=China, JP=Japan, SP=Singapore.**
**R&D facility= ⬭ Production site = △ Marketing site= ▭**

Figure 4. Duopoly network outcomes with preferences for Western production (20%) and local marketing (10%), U.S.-Japan duopoly



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In addition, we further analyzed the importance of consumer preferences on the MNE location networks. We reduced the additional value of production in Germany in the consumer utility function to 10 percent of the reservation value of the product at each location. This change allows us to test the magnitude of the 'regionally centered' forces described earlier because the reduction of the attractiveness of Germany as a production site should make regional considerations more apparent.

The results of this change (depicted in Figure 5) show that the global market has been carved up such that the U.S. MNE serves Canada, the U.S., Japan, and Russia after producing in Brazil, Russia, and China, while the Japanese MNE serves the U.K., German, and Singapore markets after locating a production site solely in China. Notably, both MNEs increase their regional configurations in terms of knowledge transfer between R&D and marketing activities such that the U.S. MNE separates its operations between American and Asian subsegments, whereas the Japanese MNE separates its operations between Asian and European subsegments. For both firms, production remains organized on a global basis.

The resultant network further demonstrates how, in light of the improvements of emerging countries in terms of quality and image, the likelihood of location of production plants in such countries increases, as compared to Western countries. Indeed, in order to analyze the importance of the wedge in consumer preferences between production in developing and developed countries on the MNEs' chosen networks, we have parameterized the additional value of the German-based production from 0 to 20 percent and discovered that up to a 15 percent perceived additional value, it is not worthwhile for MNEs to locate production in Germany.

## DISCUSSION

This study advances the view that a firm's reactions to the potential location choices of its competitors and to consumer preferences regarding locations should be considered when arriving at location decisions. This view improves on modeling approaches in which cost minimization and fixed competitor locations currently dominate. Thus, the study highlights the importance of considering the trade-offs between: (1) competitors' responses to each other's locations; (2) consumer preferences; and (3) operation, knowledge flow, and transportation costs, in a holistic approach that improves firms' location choices.

The advantage of the combined model is the ability to analyze the fixed and variable costs of serving end consumers, given the size of specific product markets and consumers' preferences. Competing MNEs may choose to avoid direct competition and serve specific markets or to compete head-on, as a function of the demand level, consumer location preferences, and competitor location choices. By using a profit maximization formulation, it is possible to evaluate under what conditions it is worthwhile for an MNE to remain regional and at what point it may be worthwhile to globalize the product or service or leave the market entirely. It is possible to analyze these trade-offs only in a unified framework that captures competitor reactions, consumer preferences, revenues, and costs at the value chain activity level.

An important insight of this study is that even without directly modeling region-specific characteristics such as cultural and institutional distance (Delios and Henisz, 2003; Ronen and Shenkar, 1985), regional liability of foreignness (Hymer, 1976; Zaheer, 1995; Asmussen, 2009), or regional integration patterns, we observe a robust tendency of MNEs to either concentrate their operations in specific regions or become globally dispersed, but maintain regionally focused activities. This implies that 'first nature' geography factors dominate 'second nature' geography factors (Krugman, 1993, Roos, 2005) in explaining the concentration of activities is specific regions. 'First nature' geography reflects the concentration of activities in specific regions due to the fact that America, Asia, and Europe are naturally separated by oceans and sparsely populated landmasses. It has been argued that second nature geography (e.g., cultural distance, institutional distance, and regional trading blocs) arises as a consequence of that separation and reinforces it to shape regional patterns (Rugman and Verbeke, 2005), but our model shows that 'first nature' geography factors are sufficient to explain such patterns.

We find that in either strategy (becoming a regional MNE or a global MNE with a regional structure), firms concentrate R&D and marketing in specific regions and by-and-large coordinate knowledge transfer (between R&D, marketing, and end consumers) on a regional basis. Importantly, both types of regional focus pertain to the location of R&D and marketing activities and their



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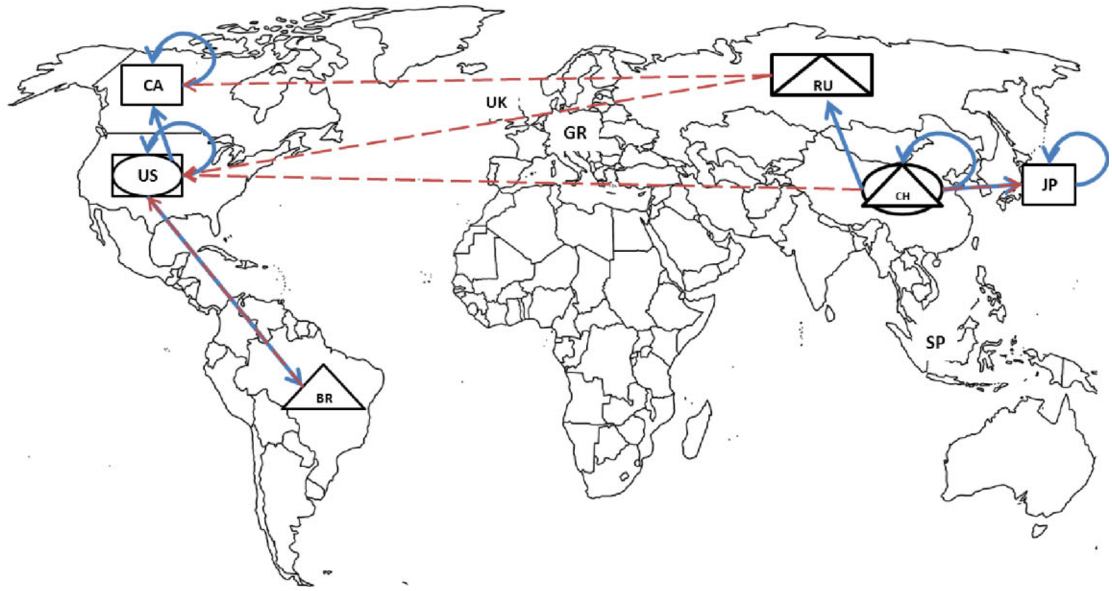
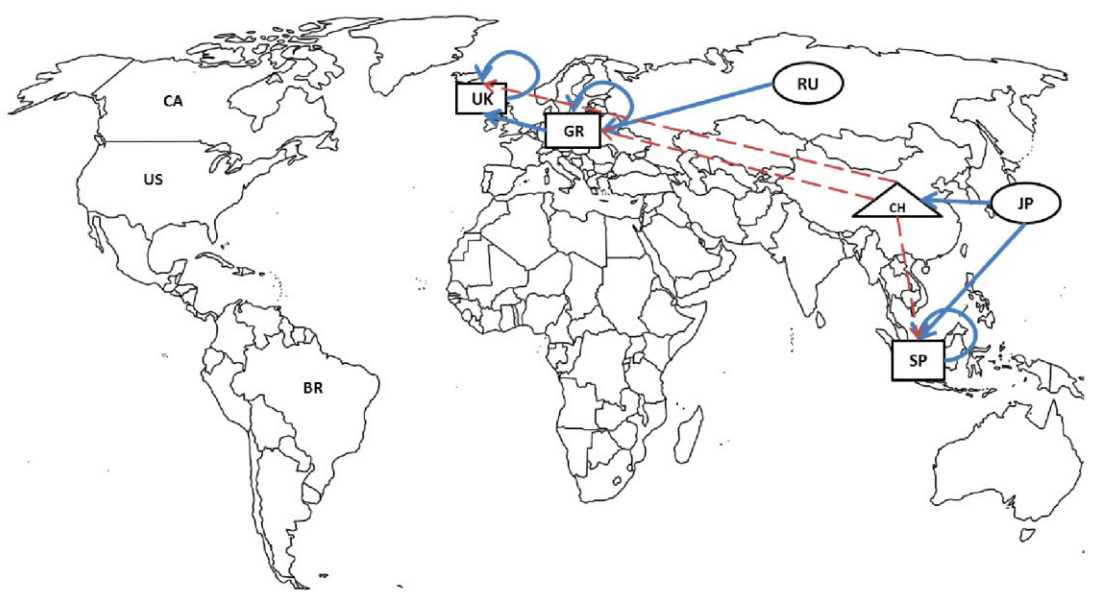
*U.S. MNE network:*




*Japanese MNE network:*




Legend:
**CA=Canada, U.S.=United States, BR=Brazil; U.K.= United Kingdom, GR=Germany, RU=Russia, CH=China, JP=Japan, SP=Singapore.**
**R&D facility=** ⬭ **Production site =** △ **Marketing site=** ▭

Figure 5. U.S.-Japan duopoly with reduced preferences for Western production (10%), U.S.-Japan duopoly



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interconnections via knowledge flows, while production activities remain more globally dispersed. This tendency to coordinate operations on a regional basis seems to be driven by knowledge transfer cost considerations as well as the tendency of competing MNEs to avoid direct competition and split the world markets between them if possible. In that respect, our findings support those of Alcacer (2006), who finds that the production activities of MNEs are likely to be the most dispersed activities, whereas R&D activities are likely to be the most concentrated ones. While Alcacer (2006) builds on the tension between competition costs and agglomeration benefits (which are not part of our model), our model yields similar conclusions.

The identification of the two types of regional configurations draws an interesting parallel between the emerging literature of regional MNEs (Rugman and Verbeke, 2004, 2007; Asmussen, 2009) and the literature stream concerning strategy and structure (Bartlett and Ghoshal, 1989) where the prevalence of a regional 'worldwide area' organizational structure is discussed (Stopford and Wells, 1972). We show that even when MNEs are globally dispersed, it is more efficient for them to organize internally on a semiautonomous regional basis where intensive knowledge flows are confined to specific regions. We further observe that when our models result with a single monopoly, the MNE organizes internally on a regional scale. When we get some kind of competition we witness both regional concentration of competing firms and internal regional organization of the competing MNEs.

The effect of knowledge transfer costs seems to be particularly profound given its relatively low share of overall costs (around 4%). In that respect our model is not only consistent with the emerging stream of literature highlighting the prominence of regional MNEs (e.g., Asmussen, 2009; Rugman and Verbeke, 2004), but also provides an important natural explanation for their existence and expands its logic to intra-MNE organization of operations. The literatures concerning interfirm regional organization (i.e., becoming a regional MNE) and intrafirm regional organization of operations (i.e., becoming a global MNE with a regional structure) mostly pertains to interregional differences in culture, consumer tastes, and institutional characteristics (Bartlett and Ghoshal, 1989; Stopford and Wells, 1972; Rugman and Verbeke, 2004, 2005). In contrast, we show that even without an explicit consideration of such differences, regional configurations are likely to emerge. Geographic distance and its impact on knowledge flow costs is, therefore, shown to be a key driver of regional location configurations. While geographic distance is traditionally considered with respect to transportation costs (Brainard, 1997; Horstmann and Markusen, 1992; Krugman, 1991), our analysis reveals that the effect of distance on location choices is also quite remarkable with respect to the efficient coordination of MNE activities through knowledge flows.

In addition, we find that the tendency of competing MNEs to avoid direct competition (Alcacer, 2006; Krugman, 1991) is another important driver of the observed regional configuration. Competition avoidance mainly leads to regional MNE configuration (rather than the regional organization of intra-MNE activities). This tendency supports the main premise of the current article, which advocates that accounting for competitors' locations (and their reactions to the each other's locations) is a critical element in the analysis of the location considerations of MNEs.

We note that across many of the scenarios, production is generally undertaken globally such that plants in a given region (e.g., Asia) serve other regions too (e.g., Europe and America). This may be due to the trade-off between sharply different production costs at different locations around the globe and transportation costs, which have been shrinking over the last couple of decades due to the standardization of shipping vessels. Overall, we observe that across the value chain, production activities are more likely to be coordinated on a global basis, while R&D and marketing activities are more likely to be regionally concentrated.

Consequently, we conclude that the concentration of MNEs in specific regions may well be a direct result of avoiding competition and intrafirm knowledge transfer costs. It is likely that when accounting for region-specific characteristics (cultural and institutional distance, liability of foreignness, or regional integration patterns), the tendency toward regional configurations will intensify, yet this study shows that such region-specific characteristics are clearly not necessary conditions for regional configurations to emerge.

The need to simultaneously reach decisions over pricing, production, and multiple locations is extremely complex (McCann and Mudambi, 2005), therefore a decision aid of the type developed here may enhance a manager's ability to search for a reasonable solution (Casson, 2000). Furthermore,



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the proposed modeling formulation, which allows MNEs to search for optimal spatial prices and market share simultaneously, is a more realistic approach than that taken to date. The subgame perfect Bertrand-Nash setting permits an analysis of oligopolistic market conditions where MNEs may choose to compete in specific markets or to avoid competition, hence yielding a complex, competitive, decision-making setting. Furthermore, the proposed model is clearly suitable to address a wider range of location decisions at the national or subnational levels, because it takes a network approach—whereas extant literature is often limited to a two locations approach (typically home and host countries). In that respect, the proposed model should, therefore, be seen as a methodology which, given specific firm- and industry-level data, may be an effective analytical tool to develop the location networks of competing MNEs in different contexts and environments.

Two important avenues for future research beyond the scope of the current study are the consideration of outsourcing and alliances when making decisions across the value chain (see Adler and Hashai, 2007; Martin and Salomon, 2003) and the case for agglomeration (Alcacer, 2006; Alcacer and Zhao, 2012; Cantwell and Mudambi, 2011; Shaver and Flyer, 2000). Location decisions of the modern MNE clearly include decisions with regard to whether to internalize or externalize specific value chain activities across different locations. We expect combinations of location and internalization/externalization to affect each other, as outsourcing decisions imply different cost structures (generally leading to a larger share of variable costs and a lower share of fixed costs), subsequently impacting the MNEs' available resources. Thus, outsourcing opportunities given different levels of knowledge transfer costs and consumer preferences are likely to change the overall market outcome which, in turn, will affect the internal location choices of the MNE across the value chain. Likewise, taking into account the impact of interfirm knowledge spillovers on location choices of different value chain activities implies that interfirm knowledge transfer considerations and learning capacity (Alcacer *et al.,* 2013) may also affect MNEs' decisions to locate their value chain activities in proximity or at a distance from their competitors. Indeed, taking agglomeration factors into account may help resolve the discrepancy between our findings that marketing activities are likely to be organized on a regional basis and those of Alcacer (2006), who predicts a wider dispersion of marketing and sales activities.

## CONCLUSION

By marrying insights from the international strategy, industrial organization, and operations research fields, the general framework proposed in this article enables managers and researchers to empirically evaluate various complex, and sometimes contradictory, predictions regarding global competitive outcomes and location decisions. The major premises of this study are that: (1) it would be erroneous to treat competitors' current locations as given and fixed in the long term, hence, the MNE's objective function should be formulated in the form of a best response function; (2) consumer utility functions often include quality parameters that are determined by MNEs' location choices and impact the consumers' willingness-to-pay; and (3) the combination of models within a single formulation better permits the researcher to analyze individual firm choices and the overall market equilbria outcome.

As such, the proposed framework advances the modeling of MNE choices, as it offers a holistic platform to analyze multiple internal and external factors affecting such location, production, and pricing choices. More specifically, the game theoretic, location-allocation model enables a rigorous and complex, but still solvable, analysis of dilemmas facing competing MNEs while accounting for specific consumer preferences. The model handles the difficult task of simultaneously analyzing the impact of a substantial number of location configurations of competing MNEs and considers the impact of customer preferences with a special emphasis on knowledge transfer costs in order to obtain a more complete picture of MNEs' location strategies. An analysis of a global market suggests that (even relatively benign) knowledge transfer costs in combination with a preference to avoid direct competition, under a Bertrand-Nash setting, increases the likelihood of regional location configurations in equilibria to emerge. By modelling location at the value chain activity level (rather than at the firm level), our model highlights that R&D and marketing are more likely than production to become regionally focused, and it further identifies two types of dominant location configurations: regionally focused MNEs and globally dispersed MNEs with a regional organizational structure.



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## APPENDIX

### Detailed model description

*Input*

$i,j,l,r,p \in N$ indices belonging to the set of locations $N$

κ MNE where $\kappa \in K$

$R$ index representing a research and development site

$P$ index representing a production facility

$M$ index representing a marketing and sales site

$S$ set of facility types where $\{R, P, M\} \in S$

$V_i$ base value of product to consumers located at location $i$

$\eta_i^s$ weights in utility function with respect to facility $s$ located at location $i$

$$f(b_{i\delta u\kappa}) = \begin{cases} 1 \quad \mathit{for}\ b_{i1\kappa} = 0 \\ 1 \quad \mathit{for}\ b_{i\delta\kappa} \text{ such that } MS_{\mathrm{i}\kappa} = 0.999, \\ \quad \text{for } \delta \text{ even} \\ 0 \quad \mathit{for}\ b_{i\delta\kappa} \text{ such that } MS_{\mathrm{i}\kappa} = 0.0001, \\ \quad \text{for } \delta \text{ odd} \end{cases}$$

$$g(b_{i\delta\kappa}) = \begin{cases} 0 \quad \mathit{for}\ b_{i1\kappa}^{\tau} = 0 \\ b_{i\delta u\kappa}^{\tau} \quad \mathit{for}\ b_{i\delta\kappa} \text{ such that } MS_{i\delta\kappa} = 0.9999, \\ \quad \text{where } \delta \text{ odd} \\ 0 \quad \mathit{for}\ b_{i\delta\kappa} \text{ such that } MS_{i\delta\kappa}^{\tau} = 0.0001, \\ \quad \text{where } \delta \text{ even} \end{cases}$$

$h_i$ maximum demand at location $i$ in thousands of dollars per consumer

$d_{ij}$ great circle distance from location $i$ to location $j$ in kilometers

$\bar{d}_{ij}$ relevant distance from location $i$ to location $j$, e.g., cultural distance

$FC_i^s$ fixed amortized annualized cost of setting up a type $s$ site at location $j$

$B$ annual budget for facility fixed costs

$c_i^s$ variable cost of type $s$ site at location $i$ per thousand dollars of output

$t_{ij}$ transport cost to move a thousand dollars of output per kilometer from location $i$ to location $j$

$f_{ij}$ cost of knowledge flow from location $i$ to location $j$ per relevant distance

$\alpha$ knowledge by-product (as a percentage of basic product) requested by facility

$a_{lg}$ output level in thousands of dollars at production facility located at location $l$ under returns to scale $g$

MES minimum efficient scale production in thousands of dollars

*Decision variables*

$X_{pi}$ fraction of market share at location $i$ served by production facility at location $p$

$W_{rpi}$ fraction of process knowledge produced by R&D facility at location $r$ for production unit at location $p$ serving demand location $i$




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$\lambda_{lg}$ output at production facility at location $l$ under returns to scale $g$

$b_{i\delta u\kappa}$ variable lying between zero and one defining on which part of the piecewise linear revenue function consumer $u$ at location $i$ purchased from company $\kappa$ lies

$\sigma_{i\delta\kappa}$ utility level at location $i$ based on z-function segment $\delta$ for company $\kappa$

$I^{rm}_{jki}$ fraction of product knowledge produced internally at location $j$ moved to end customers at location $i$ via marketing location $k$

$I^{m}_{jki}$ fraction of marketing produced internally at location $k$ drawing on knowledge from location $j$ for end location $i$

$F_{lg}$ binary variables defining appropriate line segments for production

$H_{idu}$ binary variables defining appropriate line segments for market share and revenue function

$p_{i\kappa}$ company $\kappa$ price to consumers located at location $i$

$Z^{s}_{i\kappa}$ binary variable equal to 1 if company $\kappa$ locates facility $s$ at location $i$; 0 otherwise

In a discrete choice modeling approach, we assume that consumers choose the alternative that yields the highest utility. Utility consists of a systematic part (Equation 1) and a random part, which permits us to acknowledge that not all variables affecting consumer choice have been modeled directly. Equation 1 defines the systematic utility of consumers located at location $i$ from MNE $\kappa$.

$$U_{i\kappa} = V_i - p_{i\kappa} + \sum\nolimits_s \eta^s_i Z^s_{i\kappa} \quad (1)$$

Given that the random utility components are assumed to be independently and identically Gumbel distributed, we define the logit model for the individual MNEs' market share as follows (see Ben-Akiva and Lerman, 1985): the additional constant in the denominator of Equation 2 permits the consumer to choose not to purchase, if preferred, preventing the MNEs from charging excessively even under monopolistic conditions.

$$MS^{\tau}_{i\kappa} = \frac{e^{U_{iu\kappa}}}{1+\sum_{\kappa'} e^{U_{iu\kappa'}}} \quad (2)$$

The objective function maximizes the profits of a specific MNE given its best response to its competitors, which are dependent on the relative cost of operations at each of the $N$ locations (Dunning, 1993; Kogut, 1985; Porter, 1986); the distance between the locations, which is assumed to affect product and knowledge transfer costs; and the location of expected customer demand, which affects the cost of transferring products and knowledge to the end consumers (Dunning, 1993; Ghemawat, 2001; Singh, 2005). The objective function maximizes profits for a multiproduct firm as presented in Equation 3.

$$\begin{aligned} Max \sum_{i,\delta} \left(h_i g\left(b_{i\delta\kappa}\right)\sigma_{i\delta\kappa}\right) - \sum_{s,i}\left(FC^s_i Z^s_{i\kappa}\right) \\ - \sum_{l,g}\left(c^p_{\text{lg}}\left(a_{\text{lg}}\right)\lambda_{\text{lg}}\right) - \sum_{l,i}\left(h_i\left\{d_{li}t_{li}\left(X_{li}\right)\right\}\right) \\ - \sum_{j,k,i,\tau} \alpha h_i \begin{Bmatrix} \bar{d}_{jk} f_{jk} W_{jki} + \left(\varepsilon \bar{d}_{jk} f_{jk}\right) \\ + \bar{d}_{jk} f_{jk} I^{rm}_{jki} + \left(\varepsilon \bar{d}_{jk} f_{jk}\right) \\ + \left(\bar{d}_{ki} f_{ki} + c^m_k\right) I^m_{jki} + \left(\varepsilon \bar{d}_{ki} f_{ki}\right) \end{Bmatrix} \end{aligned} \quad (3)$$

In the objective function depicted in Equation 3, the first expression defines the revenue as a function of price, market share and maximal demand for each product at each location. The second line sums the fixed costs of the different facilities, dependent on type and location, the production costs required to meet the MNE's customer demand, based on the level of production in relation to the minimum efficient scale, and the transport costs of moving the product from a production facility to the end customer. The third line of Equation 3 computes the costs associated with knowledge production and transfer, hence, it is multiplied by the level of knowledge demand. The first expression in the brackets accounts for the cost to transfer process knowledge. The next expression computes the cost to transfer in-house product knowledge to the marketing sites. The last expression sums the variable marketing costs and transfer flow costs to the end consumer.

$$\sum_l X_{li} = \sum_d \sigma_{idc} f\left(b_{idc}\right) \forall i \qquad \sum_j \left(W_{jli} - X_{jli}\right) = 0 \; \forall l, i \quad (4\text{–}5)$$

$$\begin{aligned} &\sum_{j,k} I^{rm}_{jki} = \sum_d \sigma_{idc} f\left(b_{idc}\right) \forall i \\ &\sum_{j,k} I^{m}_{jki} = \sum_d \sigma_{idc} f\left(b_{idc}\right) \forall i \quad I^{rm}_{jki} - I^{m}_{jki} \ge 0, \quad \forall j,k,i \end{aligned} \quad (6\text{–}8)$$



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$$I_{jki}^{rm} \le Z_j^r, I_{jki}^{m} \le Z_k^m \; \forall j,k,i, \quad X_{li} \le Z_l^p \; \forall l,i, \quad W_{jli} \le Z_j^r \; \forall j,l,i \qquad (9\text{–}12)$$

$$\sum_{s,i} FC_i^s Z_i^s \le B \qquad (13)$$

where

$$c_{\lg}^p(a_{\lg}) = \begin{cases} 0 & \text{for } a_{l1} = 0 \\ c_{l2}a_{l2} & \text{for } a_{l2} = \text{MES} \\ c_{l3}a_{l3} & \text{for } a_{l3} = \text{maximum production at facility } l \end{cases}$$

and $f_{ij} = \dfrac{K}{1+\xi e^{-\psi d_{ij}}}$ where K, $\zeta$ and $\psi$ are parameters of the logistic cost function.

Equation 4 requires production to meet the MNE's product demand per end location, where the MNE's demand is a function of its market share and the maximum size of the market at each location per product. Equation 5 requires all product knowledge requirements to be met by R&D. Equations 6 and 7 require all process knowledge to be met at each marketing site and then passed to the end customer. Equation 8 requires the knowledge transfer from the marketing staff at location *k* to be fed from R&D at location *j,* i.e., preserves the knowledge transfer requirements. Equations 9 to 12 specify that a candidate location cannot be used as a specific facility unless the location is designated as such. Equation 13 specifies that the total, fixed, amortized costs per time unit of setting up and running the different facilities must be less than or equal to the prespecified budget limit, *B*.

Equations 14 to 19 are needed to compute the level of production per facility, based on the piecewise linear production function (see Nemhauser and Woolsey, 1988). We have translated the traditional U-shaped production function into a V-shape for computational reasons, thus avoiding a nonlinear profit function over which we could not guarantee an optimal solution. The approximation can be refined by the addition of extra variables, but this model is meant to be strategic in nature, so the V-shape was considered sufficient for current purposes.

$$\sum_i h_i X_{li} = \sum_{g=1}^{3} \lambda_{\lg} a_{\lg} \; \forall l \quad \sum_{g=1}^{3} \lambda_{\lg} = 1 \; \forall l \qquad (14\text{–}15)$$

$$\lambda_{l1} \le F_{l1} \; \forall l, \quad \lambda_{l2} \le F_{l1} + F_{l2} \; \forall l, \quad \lambda_{l3} \le F_{l2} \; \forall l, \quad F_{l1} + F_{l2} = 1 \; \forall l \qquad (16\text{–}19)$$

Equations 20 to 35 specify on which revenue 'triangle' the company is placed, based on whether or not it has a local marketing site or produces in Germany (representing a developed country). Each of these choices may permit a higher price ($\eta_{ic}$), and both permit the sum of the additional values. These decisions could easily be changed according to the context analyzed, and they simply present an example in order to analyze the question as to whether consumer preferences should or could affect an MNE's network choices.

$$\sum_{\delta=1}^{9} \sigma_{i\delta\kappa} = 1 \; \forall i \qquad (20)$$

$$\sigma_{i1\kappa} \le H_{i1} + H_{i3} + H_{i5} + H_{i7} \; \forall i \qquad (21)$$

$$\sigma_{i2\kappa} \le H_{i1} + H_{i2} \; \forall i, \quad \sigma_{i3\kappa} \le H_{i2} \; \forall i \quad \sigma_{i4\kappa} \le H_{i3} + H_{i4} \; \forall i \qquad (22\text{–}24)$$

$$\sigma_{i5\kappa} \le H_{i4} \; \forall i \quad \sigma_{i6\kappa} \le H_{i5} + H_{i6} \; \forall i, \quad \sigma_{i7\kappa} \le H_{i6} \; \forall i \qquad (25\text{–}27)$$

$$\sigma_{i8\kappa} \le H_{i7} + H_{i8u} \; \forall i, \quad \sigma_{i9\kappa} \le H_{i8} \; \forall i \qquad (28\text{–}29)$$

$$\sum_{\delta} H_{i\delta} = 1 \; \forall i \quad 2H_{i1} + 2H_{i2} \le 2 - Z_{i\kappa}^m - Z_{i'\kappa}^p \; \forall i, \; i' \in \{west\} \qquad (30\text{–}31)$$

$$H_{i3} + H_{i4} \le Z_{i\kappa}^m \; \forall i \quad H_{i5} + H_{i6} \le Z_{i'\kappa}^p \; \forall i, i' \in \{west\} \qquad (32\text{–}33)$$

$$2H_{i7} + 2H_{i8} \le Z_{i\kappa}^m + Z_{i'\kappa}^p \; \forall i, i' \in \{west\}, \quad H_{i7} + H_{i8} - Z_{i\kappa}^m - Z_{i'\kappa}^p \ge -1 \; \forall i, i' \in \{west\} \qquad (34\text{–}35)$$



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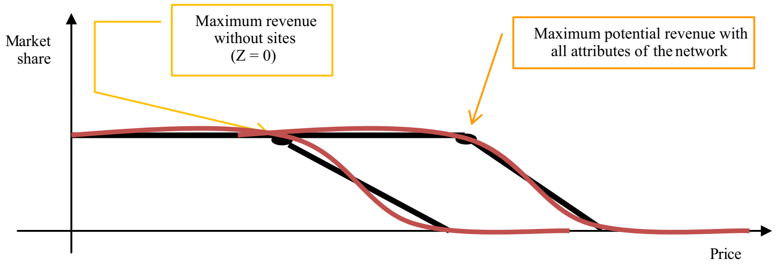
Equations 36 and 37 represent the non-negativity and integrality constraints necessary for the logic of the model.

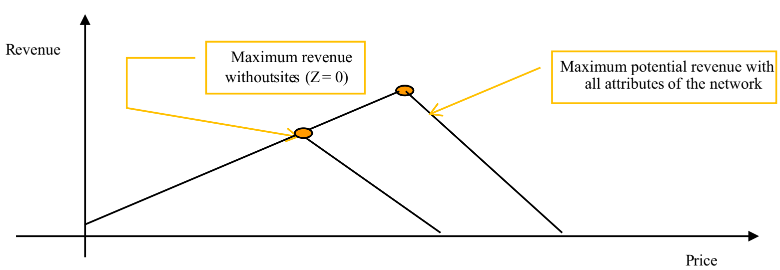
$$X_{li} Y_{jki} W_{jki} \lambda_{lg}, I^{s}_{jki} p_{i\kappa}, \sigma_{id\kappa} \geq 0, \quad Z^{s}_{i\kappa}, F_{lg}, H_{id} \in \{0,1\}, \quad \forall s, i, l, g, d \qquad (36\text{–}37)$$

Consequently, Equation 38 permits the computation of average, location-based, prices directly, once the formulation has been solved.

$$\sum_{\delta=1}^{9} \sigma_{i\delta\kappa} b_{i\delta\kappa} = p^{\delta}_{i\kappa} \ \forall i \qquad (38)$$




Appendix Figure 1. Approximating a logit market share model using a piecewise linear function




Appendix Figure 2. Adapting a quadratic revenue function using a piecewise linear function

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