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ADAPTING BAUMOL'S INVENTORY THEORETIC TO LANDED COST DECISIONS

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ABSTRACT

Major U.S. corporations have been importers for over 200 years. A significant impetus for "offshoring" has been reducing costs—usually labor costs. Often, other costs were overlooked. There has been a growing disenchantment with sourcing goods overseas, especially when there may be domestic alternatives as other costs begin to dominate. Baumol and Vinod's Inventory Theoretic model was useful in adding transportation considerations. However, Baumol leaves out several important costs that unless considered in offshoring decisions can lead to suboptimal solutions. This paper extends that model, providing a prescriptive model that could be operationalized by firms to evaluate offshore sourcing decisions.

INTRODUCTION

Major U.S. corporations have been importers for over 200 years. Initially, the colonists interests were in importing manufactured goods, but as industries developed their interests turned to importing basic raw materials such as metallic ores and manufacturing machinery. After World War II the U.S.experienced great growth in imports of manufactured goods. Recent years have seen two significant shifts: the widespread practice of securing offshore sources for manufactured goods by firms of all sizes, and the purchase of a wide range of materials and products. The three principal drivers have been and continue to be 1) securing goods at a lower cost, 2) accessing materials not available in the U.S. market, and/or 3) seeking to establish a commercial presence in order to achieve subsequent entry to the foreign market. During the past 20 years growth in imports has been so aggressive that it has on average trebled the growth of U.S. gross domestic product (U.S. Dept. of Commerce).

Securing goods at a lower cost usually means using cheaper labor by locating production offshore or by purchasing goods from foreign producers. Access to raw materials not available in the U.S. could include but is not limited to Chinese tungsten, Jamaican or Australian bauxite, African cocoa beans, Brazilian tantalite and columbite, and coffee from a range of foreign locations. Manufacturers purchase a wide range of sub-assemblies and components ranging from plastic molds, to water pumps to motors, to electrical components (Anon n.d.). Walmart and other mass merchandisers have turned to China for consumer goods that include electronics, hand tools, appliances, footwear and clothing. From a more cynical perspective some firms source overseas because their archrivals are doing so. Relocating production offshore has the strategic benefit of providing better access to foreign markets, but is more difficult to establish than just purchasing from an existing producer.

There has been a growing disenchantment with sourcing goods overseas, especially when there may be viable domestic alternatives (Ferreira and Prokopets, 2009; Goel, Moussavi, and Srivatsan, 2008; Minter, 2009; Mulani, 2002). Moreover, many firms are willing to continue with offshore sources, but want to opt for those closer to home given the myriad problems they have encountered with the complexities involved, including (Anon, 2008; Berstein, 2007; Ferreira and Prokopets, 2009; Minter, 2009; Mulani, 2008; Norek and Isbell, 2005; Smyrlis, 2010; Stalk, 2006):

- Trade regulations including duty and export taxes
- Different languages, cultures, and legal systems
- Spotty product quality
- Problems with intellectual property
- Long and capacity constrained supply chains
- Rising costs

As a result, many businesses are looking at bringing manufacturing back onshore, "nearshoring," "splitshoring," or "peak-load manufacturing" as an alternative to now more expensive offshore manufacturing (Mulani, 2002)

Business needs tools to make informed decisions on 1) whether to proceed to source offshore (or to move onshore or near-shore), or 2) selecting between two or more alternative sources of supply perhaps located in different parts of the world. The problem, as further discussed in the following literature review, is that there has been but scant coverage of this in the research within an array of business disciplines including managerial accounting, marketing, as well as logistics and supply chain management.

LITERATURE REVIEW

The term *landed cost* was investigated within a multi-disciplinary context that included accounting and logistics or supply chain management. Bowersox et al (1968) considered an extensive array of costs within distribution but disregarded offshore purchases. In reviewing total cost concepts, Baumol and Vinod (1970) developed their inventory theoretic model that traded transportation off against inventory holding thus providing two key variables in offshore sourcing. This model was later updated by Tyworth (1991) for transportation sourcing decisions. Corey (1978) discussed sourcing decision-making processes with regard to both measurement systems and other functional areas, but provides no guidance for evaluating offshore purchases.

From an accounting perspective Carr and Ittner (1992) investigated total cost of ownership and attempted to develop conceptual models that embraced all relevant costs beginning with the identification of demand and ending with the ultimate disposition of a spent asset, but did not connect the variables necessary for effective offshore sourcing. Cavinato (1992) developed a model that differentiated costs from value obtained in order that supply chains could become the basis for competitive advantage. To achieve this, incurred costs need to be offset by some perceived value returned.

The application of landed (or total) cost models by industry varies greatly from firm to firm with Mascaritolo of NCR reporting that total cost of ownership is commonly calculated only by comparing the purchase price of a product between the new and the old source (Berstein, 2007). A "best practice" total cost model according to Ferreira and Prokopets (2009) includes four major components: supplier price and terms, delivery costs, operations quality and costs, as well as other costs. Delivery costs include origin, international, and domestic transportation as well as custom duties and value-added taxes. Operations quality and control costs include all types of inventory and quality costs. Other costs include standard costs of risk, seller qualification, and local tax incentives; situational costs of procurement staff, broker fees, infrastructure, exchange rate trend, skills training, and tooling; as well as customer specific costs (Ferreira and Prokopets, 2009).

Although many of the elements of total cost have been known for some time, many relevant costs are regularly not considered. Less than fifty percent

of surveyed manufacturers reported using relevant costs including (Ferreira and Prokopets, 2009):

- Customer service
- Packaging
- Tooling
- Material handling and warehousing
- Increased procurement staff
- Overhead and administrative
- Product qualification
- Inventory
- Costs of quality
- Country specific costs (VAT, customs)

Soft cost considerations are sometimes included in industry total cost models. NCR considers whether a prospective source country is "friendly" (Berstein, 2007). Whirlpool has found that having trained workers, an existing factory, and a large reservoir of available parts suppliers is beneficial (Uchitelle, 2005). Low labor rates have grown less important for some manufacturers like Whirlpool where labor content in top-loading washing machines has declined from 2.5 hours per machine in 2000 to 1 hour per machine in 2005 (Uchitelle, 2005). Brittan of United Technologies noted that purchasing has changed dramatically from purchasing a motor to purchasing "a motor that is in an assembly, manufactured with zero defects and delivered every four hours in the quantity you need to a particular point on your production line" (Berstein, 2005).

The principal contribution of all of these was in illustrating the diverse nature of costs with respect to how they may be incurred as well as how they may be reported within the firm. These authors showed how suboptimal behaviors brought about by firm budgeting processes that are isolated by department, business unit, division, or other organizational factors, are a natural impediment to total cost analysis.

Ellram (1993, 2000) noted that it was functional activities that needed to be linked both temporally and organizationally within the context of total cost of ownership. Perhaps one of the most significant contributions was her segmentation of cost activities into pre-transaction, transaction, and post-transaction phases whereby the estimate of future costs and an entire range of administrative overhead costs would not be overlooked.

Total cost of ownership, however, is different from, albeit related to, landed cost. Where total cost of ownership is by design intended to encompass every conceivable cost during the period that an asset (fixed as well as current) is owned, it is the intention of the landed cost concept to embrace only those costs involved with sourcing items and ultimately putting them in the hands of the anticipated consumer or industrial end user. Logically, landed cost is embedded within the transactional phase of total cost of ownership, but a careful review of the literature for the latter suggests that it may not be present with sufficient detail to prompt effective decision-making. (Young, et al, 2009). Steve Banker (2009) comes closest to a comprehensive approach to assessing total landed costs, but while he discusses the numerous variables to consider, he stops short of developing a useful and actionable model.

Given the growth in international trade, it is instructive to find those sources where the issue of landed cost is not articulated. Citing all of the sources where landed cost was not mentioned in an actionable manner is not a practical endeavor, but some key samples of where one would have expected to find some reference include the topics of procurement, logistics and cost accounting. While Hickman and Hickman (1992) was informative with respect to identifying and negotiating with foreign sources as well as minimizing transportation and customs duty, no provision was made for bundling these costs into an effective decision support tool. Similarly, Wood et al (1995) divided the cost of international distribution into several categories, but did not establish a holistic view of landed cost management. Finally, Kaplan and Cooper (1998) addressed integrated cost systems and how they drive profitability, but also ignored the need to

integrate all costs associated with global procurement decisions.

Even in the international trade literature, one seldom finds a sufficiently encompassing approach that could guide those endeavoring to engage in foreign sourcing. Seeking to include both inventory concerns, transportation and purchase price, Fantasia (1997) sought to understand net landed cost and how it represents the true cost of bringing product to the customer. At the close of the 1990's some software firms as well as those providing international shipment services began to offer technology solutions as chronicled by Atkinson (1999). However, despite these advancements most efforts were relegated to transaction-related costs that are easily identifiable. Consistent with these findings, Coyle et al (2003) defined landed cost as "The total cost of a product delivered at a given location; the production cost plus the transportation cost to the customer." Citing the suboptimality found in most models, Van Der Hoeven (2003) stated that there was value to be found in total landed cost models.

Only recently did the work of Young et al (2009) define landed cost to include cycle inventory carrying costs, inventory in-transit ownership, administrative overhead, and transportation expenditures as major constituents that importers would need to take into consideration if their objective was to achieve strategic cost advantages from their offshore sourcing endeavors. As Coyle and others have pointed out over the years, the management of supply chains is an exercise in identifying and evaluating tradeoffs.

Facilitating the consideration of variables is best done with the aid of models; however, the extensive literature search could not provide a single model that appeared to possess all of the variables that appeared to be potentially operative with respect to offshore sourcing decisions. Nevertheless, there was one model that provided a means for trading off several of the key variables thereby suggesting that it might provide a useful base that could be logically extended—the Inventory Theoretic Model derived by Baumol and Vinod (1970).

BAUMOL'S METHODOLOGY

The most common application of the inventory theoretic has been in the selection of transportation modes based on total annual cost where transportation and inventory carrying costs are the variables most often traded off. Baumol defined total annual cost as the sum of cycle inventory holding plus ordering cost plus the cost of owning goods in transit plus transportation expense, that is:

TAC = Inventory + Ordering + in-transit + Shipping + Safety Stock
holding costs carry costs costs costs

or:

$$TAC = (Q*v*W/2) + A*(D/Q) + t/365(D*v*W) + T*D + S*v*w \quad (1)$$

where:

TAC = Total Annual Cost
Q = Order Quantity
D = Annual demand
v = Unit price of the goods
w = Holding cost expressed as a percentage
A = Unit cost of an order
t = Time in days for transport
T = Per unit transportation cost
S = Safety Stock

While Young et al (2009) identified the major variables and decomposed them into a taxonomy of their key constituents, no prescriptive model that could potentially be operationalized by firms seeking to evaluate offshore sourcing decisions was provided. The key difference is that the expanded equation is used to determine source of supply rather than choice of transportation mode. Those key variables are shown in Table 1 below:

TABLE 1

SUMMARY OF LANDED COST MODEL VARIABLES

Module 1: Price	Module 2: Transportation	Module 3: Customs	Module 4: Inventory	Module 5: Overhead
1. Supplier price 2. Selling terms 3. Payment terms 4. Payment processing cost	1. Foreign inland 2. Line haul 3. US inland 4. Accessorials 5. Insurance 6. Packaging	1. Tariff rate 2. Merchandise processing fee 3. Harbor maintenance fee 4. Custom processing cost	1. Cycle stock 2. Safety stock 3. Inventory in-transit 4. Stock-out costs	1. Sourcing 2. Due diligence 3. Compliance relationship maintenance 4. Supplier learning curve and supplier development 5. Duty management

Although the model is useful for identifying the variables, the process of applying it to the inventory theoretic is threefold in that 1) some model components are fixed costs and some are variable, 2) many of the costs, especially when overhead in nature, may be extremely difficult to determine or may not be separable, and 3) some components may be variable for some import scenarios and fixed for others. Given this, it is our view that the Baumol and Vinod model should be expanded to incorporate various elements common in offshoring operations.

OFF-SHORING EXPANSION TO BAUMOL'S THEORETIC

This extension of Baumol's theoretic adds several components often ignored and yet critical in assessing the total landed costs. These include the purchase price of the item, duties and taxes, and a reconsideration of fixed administrative costs. Incorporating the components of offshoring, the conceptual model therefore becomes:

TAC = Purchase Price + duties & taxes + administrative costs (fixed) + inventory holding + administrative (order) costs + in-transit carry costs + trans. costs + Safety Stock costs

or

$$TAC = D*v + D*v*C + R + (Q*v*W)/2 + A*(D/Q) + t/365*(D*v*W) + T*D + S*v*w \quad (2)$$

Where the new variables are:

C = Customs Duties and Tariffs
R = Fixed Administrative Costs

The Formulation

*Purchase Price (D*v):* It is axiomatic that one of the variables when selecting a supplier will be the price paid for an item. The Baumol theoretic treats the purchase price as a fixed cost and thus does not consider that in the equation, since that theoretic is applied after source selection for determining the transportation modes and inventory policies. This extension of the theoretic moves the decision point earlier, considering the selection of the supplier and as such the price charged by that supplier becomes relevant, and thus variable. This is determined by multiplying the anticipated period (annual) demand by the price per unit (D*v), similar to the inclusion of purchase price when considering quantity discounts from the same supplier (Silver, et.al., 1998).

*Customs, Duties and Taxes (D*v*C):* This component of the extension adds the costs of customs duties and taxes as a fractional or ad valorum (percent) charge of the value of the unit purchased. Just as with the addition of the purchase price, these costs are assumed fixed when a supplier has already been selected but becomes a variable of interest, and thus a relevant cost, when selecting a supplier. There will of course be no international trade costs if a domestic supplier is chosen. When considering international supply partners, these costs (on an ad valorum basis) may vary depending on country of origin of the goods. For example, goods coming from Mexico, Canada or another nation where a free trade agreement is in place or one of the countries designated by Congress to receive preferential treatment under the General System of Preferences (GSP) may be imported with reduced or even no duty. The Harbor Maintenance Tax applies to only ocean transport, but may be avoided by using shipping to a Canadian ocean port and then using overland transport into the United States.

"Fixed" Administrative Costs (R): This cost is the charge associated with procurement activity separate from a per unit charge. Just as with the previous two components, the costs will vary depending on the supplier chosen. Once a source is selected, these costs become fixed but the total costs of "fixed" administration must be considered as an element in selecting the supplier. Fixed costs associated with sourcing as a procurement activity includes identifying and qualifying potential sources of supply, development efforts such as co-locating engineers and designers with the supplier to assure that their output is in conformance with specifications, a vetting for compliance with such initiatives as C-TPAT, and contracting. Of significant interest when considering offshore suppliers is that the maintenance of relationships with offshore suppliers may consume more administrative overhead costs given the need to overcome differences in language, business cultures, legal systems and regulation, and time differences. Finally, the learning curve associated with new suppliers is a consideration as well as a fixed cost.

In some instances the fixed costs may be spread over short time durations of just a matter of days, while in others, for example, the cost of establishing the supplier, may be distributed over many years. With the current practice of more frequent changes in suppliers, the former rather than the latter may be the case.

While continuing to use Baumol's original variables in the inventory theoretic, there are several topics where an expanded definition and underlying understanding is nevertheless required. These are:

*Variable Administrative Costs (A*D/Q):* When originally considered, this was interpreted to mean ordering cost. While this may still represent a major element, the costs of the entire transactional cycle needs to be accounted for, hence the costs incurred by the customshouse broker, the fees associated with establishing and processing letters of credit, the administrative processing of receipts, and the payment of invoices are all elements.

There may be compliance cost elements that are variable. For example, goods may arrive and Customs may elect to conduct an extensive examination that requires that the ocean container be opened, the goods removed and inspected, and then subsequently reloaded. The cost of unloading, reloading, and any required blocking and bracing is done at the importer's expense.

Duty management is an activity where decisions may be made whereby an importer may put goods in a bonded warehouse or enter them into a foreign trade zone . Alternatively, goods can be imported temporarily for processing and then re-exported under several different legal provisions such as temporary import bonds. Moreover, U.S. goods may be exported for further processing and returned under "American Goods Returned" processes The net effect would be to lower the value of variable C while increasing the overhead associated with administering such efforts.

*Transportation cost (T*D):* International commerce consists of more than a single linehaul. This variable needs to contain all of the costs of the various transport legs as well as the accessorial charges that would include terminal receiving fees at the port of loading and terminal handling charges at the port of arrival. Insurance can be accounted for as either a premium paid to the freight forwarder or, in the case of larger and/or more sophisticated importers, as a blanket policy that may likely fall under the fixed administrative costs of the R variable. While currently represented as a single cost per unit for shipping, this component could be expanded to include the specific costs relevant to each leg of transportation.

*Safety stock costs (S*v*w):* Safety stock is a consideration whenever sourcing decisions are made, given the contribution to total annual costs. In an offshore decision this factor is made more critical as the time for transportation, and opportunities for delay are increased. It is acknowledged that this can be reduced through faster (but more expensive) transportation modes such as air, highlighting the trade-off between transportation and inventory costs.

Order Size, or Quantity (Q): The Baumol model determines the optimal ordering quantity balancing ordering and holding/carrying costs. The challenges posed by real-world constraints in offshoring may force a more complex solution. When comparing sourcing from domestic, or off-shore, locations, your order size may not be optimized simply as a relationship of ordering and holding costs, but may be driven by the minimum shipping sizes (containers, pallets, or truck-van loads) and frequency of the shipping routes. As such decisions may need to consider both continuous and periodic review policy approaches.

Packaging costs may be categorized as export packing and included with forwarding costs, or as charges incorporated in the selling price by the supplier.

Whereas the principal tradeoff found with the application of the EOQ model was inventory holding versus ordering cost, the Inventory Theoretic was inventory holding (both as cycle, safety, and in-transit) versus transportation cost. In extending the Inventory Theoretic to look at total landed cost, the tradeoff is the savings in the price of the goods versus all other costs combined. By applying this extension firms not only will be able to determine the optimal order size and transportation modes, but also determine the lowest total landed costs associated with each supplier.

HYPOTHETICAL SCENARIO

Atlantic Medtech (Atmed), located in Au Claire, Wisconsin, a producer of disposable surgery supplies, has begun discussions with a potential Chinese supplier of high purity polyvinyl chloride tubing that has typically been supplied to the industry by St. Gobain under the trade name Tygon© as well as others. Because of the application the tolerances and sterile properties have been the most stringent element of the specification.

A volume purchaser, Atmed's two sources were both domestic producers: one in Houston, and the other in Cleveland. Pricing on a delivered basis varied very little and averaged $5.00 per meter, delivered Au Claire. The average lead time of five days has varied little over the life of the buyer-seller relationship. Annual volume required by Atmed is 400 kilometers and while this is distributed over 15 different gauges and wall thicknesses, the overall mix has held steady over the years.

Admed's purchasing department had begun the quest for lower cost suppliers approximately 18 months prior and ultimately identified a firm in Hunan Province, China that appeared to have the capacity and the expertise even if they were not familiar with medical applications and the requirements of the Good Manufacturing Practices (GMPs) of the U.S. Food and Drug Administration. Given this information, the $3.00 per meter ex works quoted price was sufficient cause for Atmed to send two engineers and their families to China for what was believed to be a two year stay that would involve their respective salaries of $80,000 each plus 30% fringe benefits, and $40,000 each for transportation, housing for their families, and schooling for their children. Prior to the assignment, Atmed also paid $5,000 for immersion courses in Chinese language and culture.

When the purchasing director set out to calculate the cost savings the following cost components were considered: price of the goods at $3.00 per meter, transportation of the quantity in ten 20-foot containers at $3,000 each, terminal handling charges of $700 per container, inland transportation from Los Angeles-Long Beach of $2,500 per container, $300 per entry to the customs broker, and customs duty of 3.7% ad valorum plus a Harbor Maintenance Tax of 0.125% and a Merchandise Processing Fee of 0.21%. Even with all of these extra costs, savings appeared to approach $500,000.

Once Atmed had shifted its source to the Chinese producer, total lead time became eight weeks after placing the order with six of those consisting of average transit time. Depending on whether the freight forwarder in China booked the appropriate sailing, the variance of the lead time could drive total time to 10 weeks. Atmed calculated its inventory holding costs to be approximately three times the prime lending rate or 15%. As experience with the new supplier's material continued, Atmed found quality to be erratic and this necessitated holding additional safety stock for such an eventuality, but also meant that a quality engineer would need to make a quarterly visit to the supplier—at a cost per trip of $15,000.

Expanding this analysis to include those costs that were not built into the total cost calculation resulted in the following:

TAC = purchase + duties + administrative + inventory + administrative + in-transit + trans. + Safety Stock
price & taxes costs (fixed) holding (order) costs carry costs costs costs
or

$$TAC = D*v + D*v*C + R + (Q*v*W)/2 + A*(D/Q) + t/365*(D*v*W) + T*D + S*v*w \quad (3)$$
$$\$1,671,973 = 1,200,000 + 45,180 + 250,000 + 4,500 + 11,000 + 27,616 + 110,000 + 23,676$$

When compared against the domestic source including all of these individual cost elements, the TAC becomes:

$$\$2,019,612 = 2,000,000 + 0 + 0 + 0 + 3,000 + 12,500 + 0 + 0 + 4,112$$

The difference represents a savings of $347,639 and not the $800,000 as first seen when only comparing price. The scenario also states that there have been some subsequent quality problems requiring an engineer to make annual trips costing another $60,000 annually. There also may be some additional administrative burden that is not yet accounted for, such as Chinese inland trucking, a freight forwarder in Shanghai, and a terminal receiving charge at the port. Clearly, the savings continue to evaporate and should one also weigh the potential impact of quality rejections, as perhaps manifested in product recalls and loss of brand equity in the marketplace, the savings are insufficient to warrant the foreign sourcing decision.

CONCLUSION, MANAGERIAL IMPLICATIONS AND RECOMMENDATIONS

Baumol's inventory theoretic has as an assumption either the a-priori selection of a supplier, or alternatively that the cost differences associated between suppliers is trivial. When considering international trade these costs are non-trivial and the failure to consider them in off-shoring decisions can lead to sub-optimal solutions. This model captures many of those costs.

There are substantial fixed and variable costs associated with off-shoring that are frequently not accounted for in most landed cost models. The costs of establishing and maintaining off-shore sources and relationships are perhaps the greatest fixed and variable costs that need to be recognized. Relationship costs take on greater importance as we seek to develop relationships that cross cultural and geo-political boundaries.

There are substantial risks associated with offshore sourcing that are rarely included in any analysis. These can include natural and political/civil disruptions at the source or en-route, volatility of exchange rates and energy prices, and changes in customs and governmental regulations and policy. These are not captured in the proposed model but need to be considered outside the model.

This model does not consider the many strategic motivations that drive offshoring. For instance, firms may choose to produce offshore as a means of entering foreign markets. This decision may fit the long-term growth plan for the firm even if it results in near-term higher landed costs. However, the decision to produce offshore does not necessarily require that onshore production cease. This model could be used as support for maintaining both on-shore production while developing off-shore production and markets.

Using this model is on the face rather simple—collect the data, input the numbers, and assess the results. Unfortunately, the challenges in operationalizing this extended model are more complex, and often are more an organizational challenge than a mathematical one. Such challenges may include that 1) many, if not most firms will not be able to readily identify their true costs of administrative overhead whether fixed or variable, 2) often the time required for making a

decision is too short to allow for the collection of relevant cost data, 3) their organizations are too frequently siloed thereby precluding any single unit from making the requisite analysis, and 4) risks may not be known until bad events occur. That said, none of these are insurmountable obstacles and the pay-off in reduced total landed costs could be substantial.

Firms could follow several approaches to operationalizing this model. Firms should first address the issue of ownership—of the data and the process. By establishing clear lines of ownership, and developing collaborative cross-functional teams, the firm can redress not only the silo nature of their processes but the problems associated with conflicting data elements, assumptions and policies. Once these barriers have been addressed the process teams can collectively document their processes, fitting their requirements for supply support with the options available, collecting the data they believe is appropriate for their particular process. At that point the introduction of the data into the model should result in a clear picture of their supply chain. Improving their visibility of actual costs should allow for better sourcing decisions based on total landed costs

The ability to comprehensively assess offshoring options may be a core competency that heretofore few firms have demonstrated. This model, along with a strategic vision for the organization, provides one step towards that end.

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