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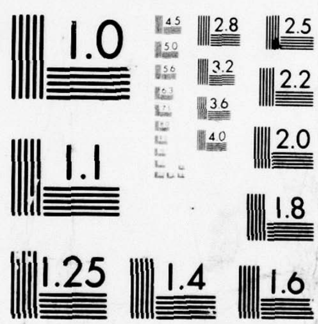

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STRATEGIC MANAGEMENT OF MULTINATIONAL COMPANIES: NETWORK-BASED PLANNING SYSTEMS

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ABSTRACT

Great environmental uncertainties have increased the importance of formal planning structures to assist multinational firms in adapting to a rapidly changing world. It is our belief that the information needed by multinational planners can best be generated by superimposing the strategies of the firm on the operating system. In the past, fully integrated optimization operations planning models were infeasible because of the enormous complexity of multinational companies resulting in extremely large models and very slow solution time--if a solution could be obtained at all. This has led to non-optimization simulation modeling which provides some but not enough relevant information. With the recent advance in network modeling and solution technology, a move to optimization procedures is feasible and desirable. The power of these procedures over simulation models is demonstrated in an application for the U.S. Treasury, where we show how a network model can lend insight into important planning issues and develop hard cost information for soft constraints.

1.0. INTRODUCTION

Dramatic shifts in the world's eco-political system are challenging the very survival of the multinational firm. Inflation is a continuing phenomenon in the developed as well as the less developed countries; interest rates in world money markets are higher and fluctuating more than at any time in recent history; the lack of exchange rate predictability has disrupted virtually all multinational treasury functions while recent changes in financial reporting standards are exaggerating this disruption on U. S. balance sheets. Concurrently, awakening third world nations are becoming more determined and effective in controlling their internal business sectors and demanding a larger share of the fruits of world productivity, and deterioration of U. S. dominance is leading to more competition and restrictions among the developed western nations. The convergence of these destabilizing trends in world events is beginning to challenge fully the remarkable versatility of multinational managers demonstrated so clearly in the past two decades.

Unfortunately, repetition of past successful actions may fail to achieve the desired results in this new environment. The multinational firm finds itself increasingly in a vise between national governments with greater power and desire for influence, and owners who are focusing more on economic performance in what they see as a threatening international environment. On top of having to live with rapid change, the multinational corporation has become so complex that anticipating the systemic impact of any action without a formalized planning system is extraordinarily difficult.

Disruption of product and financial markets has enhanced the importance of defining and interpreting the firm's strategies within the context of its operating environment if a meaningful gap analysis is to be conducted. Prospective projection of strategic factors from the current operating situation of the company can provide clues about the continued appropriateness of the present course of action and can suggest alterations in strategy and/or operations to exploit more fully the implications of various environmental scenarios. Strategies are based in part on assumptions about their impact on the firm's operations, but they are sterile until imposed on the firm's activities. Thus, effective strategic planning cannot be divorced from its operational implementation.

Integration of these two dimensions into a multinational planning structure entails providing meaningful information on the impact of policies as they relate to all elements of the production, marketing and financing components of the company. The structure should be amenable to testing many environmental scenarios and policy alternatives, while, at the same time, be complete enough to capture the interrelated complexities of the system. Also implied in this are the requirements for rapid processing time and for the ability to collate and synthesize the various input and output data in a manner comprehensible to the analyst.

The techniques for building, solving, refining and analyzing computer-based planning models such as those required for this application have undergone a steady evolutionary development as computer hardware has changed. As reported in (3-6) generalized networks are particularly adept for structuring such planning systems. In this paper we describe an application of generalized networks to the problem of multinational corporate planning that we developed for the U. S. Treasury (1). This model was originally constructed to evaluate the impact of potential changes in the tax regulations on optimal multinational goods and funds flows. Thus, it is capable of shedding light on broad macroeconomic relationships. But, as will also be demonstrated, the model has great power to examine critically the micro-dimension that is also of interest to corporate planners.

In the next section, the structure of the Treasury model is described. Since the major focus of the paper is on the planning process per se--how large-scale network models can be used in the planning process to extract the maximum amount of pertinent and timely information rather than the mathematical specification of all parameters and model relationships--the model description is necessarily restricted to the more critical elements and interrelationships. After building up the model we then examine in detail the analysis conducted for the U. S. Treasury. Recent developments in the environment of multinational firms are then discussed in light of the findings of the analysis. These developments suggest policy areas of particular current importance, and their treatment by the model demonstrates its power and the range of information provided. The paper concludes with a discussion of the characteristics of the modeling process that facilitate implementation in an actual firm, and how the model can be used as a policy-making vehicle with consideration of the contribution to specific decisions and its potential fit in the planning process.

2.0. THE MULTINATIONAL CORPORATION CASH FLOW PLANNING MODEL

A fundamental problem that must be confronted before a corporate planning model can be constructed is how to subdivide the worldwide operations into strategically meaningful units. We believe that, at the minimum, the firm should be broken down into Strategic Business Units (SBUs) (2), each of which is further subdivided into relevant geographic areas. Note that these geographic areas may be grouped into Strategic Business Areas (SBAs) or Strategic Influence Areas (SIAs), but for purposes of the model, national boundaries should be recognized. The reason for this is that, for instance, the European Economic Community may be a relevant

SBA, but segregating operations as occurring in France and Great Britian will permit exchange rate considerations to be evaluated by the model.

The firm utilized for the following descriptive example is assumed to include only a single SBU, but operating in two different geographic areas. Centralized planning dictates a common two-year planning horizon for each operation. Obviously, including many more operating units and more and shorter time periods are simple extensions. The objective assumed for this representative example is that the firm desires to maximize the worldwide net revenue (total revenue minus total cost) generated by the corporate system, although again, other objectives can be substituted easily. The model structures the production-inventory decision for each subsidiary, intersubsidiary trade credit, transfer pricing, local and international money market investment and borrowing, dividends, royalties, fee payments, direct loans, and changes in internal capital as a multi-period, generalized network.

2.1. BACKGROUND

To facilitate understanding of the multinational model developed in the next subsection, a brief description of the fundamental elements of generalized network models is now presented. Due to page limitations, the discussions in this subsection are brief. The reader is referred to (4, 5) for a more detailed discussion.

Figure 1 depicts a generalized network, the graph of which will be described in a cash flow setting. The arrows shown in Figure 1 are called *arcs* and the circles are called *nodes*. In the multinational cash flow setting, the nodes (A, B, C, and D) may be thought of as subsidiaries located in different countries. The *supplies* and *demands*, which are shown in the directional triangles leading into

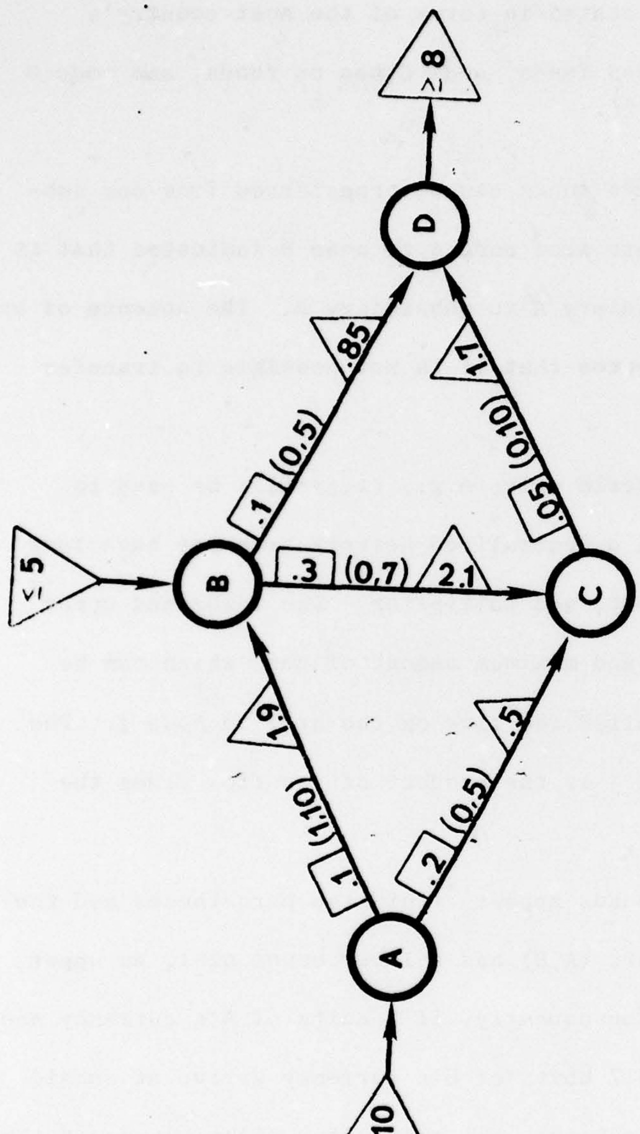

Figure 1. CASH FLOW EXAMPLE

a node for a supply and out of a node for a demand, represent excess or deficit cash positions. The cash positions are stated in terms of the host country's currency. Thus, nodes A and B have excess funds, node C has no funds, and node D has deficit funds.

The arcs indicate the admissable ways funds can be transferred from one subsidiary to another. For instance, the arc from node A to node B indicates that it is possible to transfer funds from subsidiary A to subsidiary B. The absence of an arc between a pair of subsidiaries indicates that it is not possible to transfer directly between them.

Arcs are commonly denoted by an ordered pair, e.g., (i,j) will be used to denote an arc from node i to node j. In a generalized network arcs may have four parameters--lower bound, upper bound, cost, and multiplier. The lower and upper bounds on arc (i,j) specify the minimum and maximum amount of cash which can be shipped out of node i (which is often called the flow on the arc) to node j. The actual amount of cash which reaches node j is the product of the flow times the multiplier.

In Figure 1, the lower and upper bounds appear within the parentheses and the multiplier within the triangle. Thus, arc (A,B) has a lower bound of 1, an upper bound of 10, and a multiplier of 1.9. Consequently, if 3 units of A's currency are shipped to subsidiary B, then 3(1.9) = 5.7 units of B's currency arrive at subsidiary B due to the multiplier. In this instance, the multiplier might represent the exchange rate less any per unit charge of the exchange.

The cost on arc (i,j) appears within the rectangle and represents the cost of shipping a unit out of node i to node j. Note that the cost is applied to the number of units shipped out and <u>not</u> to the number of units arriving at node j. For instance, the cost on arc (A,B) is 0.1. If 3 units are shipped out of node A to node B, then the cost would be 3(0.1) = 0.3.

The objective in a generalized network model is to determine how much to ship along each arc, subject to bound restrictions and supply and demand restrictions, in order to minimize the total cost. The supply and demand restrictions refer to the property that the total flow out of the node minus the total flow into the node must satisfy the supply and/or demand conditions. For instance, the supply condition on node B is that at most units 5 more can be shipped out of node B than is shipped to node B. Since node C has no supply or demand, the flow into node C must be equal to the flow out of node C.

2.2. MULTINATIONAL PLANNING MODEL

The model will be explained by using the two subsidiary, two period model shown in Figure 2. In this figure, the subsidiaries are called A and B and the nodes labeled A1, A2, B1, and B2 denote subsidiaries A and B at the start of time periods 1 and 2, respectively. The nodes labeled A master sink and B master sink denote subsidiaries A and B respectively at the end of the planning horizon. The node labeled system sink denotes the firm at the end of the planning horizon. These nodes and the arcs connecting them are drawn in heavy solid lines and will be referred to as the operations subnetwork of the model.

For exposition purposes, the model is broken down into three additional subnetworks called the *production subnetwork*, the *intertemporal financial resource allocation subnetwork*, and the *cross-sectional financial resource allocation subnetwork*. These subnetworks correspond to the primary response elements of a multinational firm. The operations subnetwork ties these subnetworks into an integrated system.

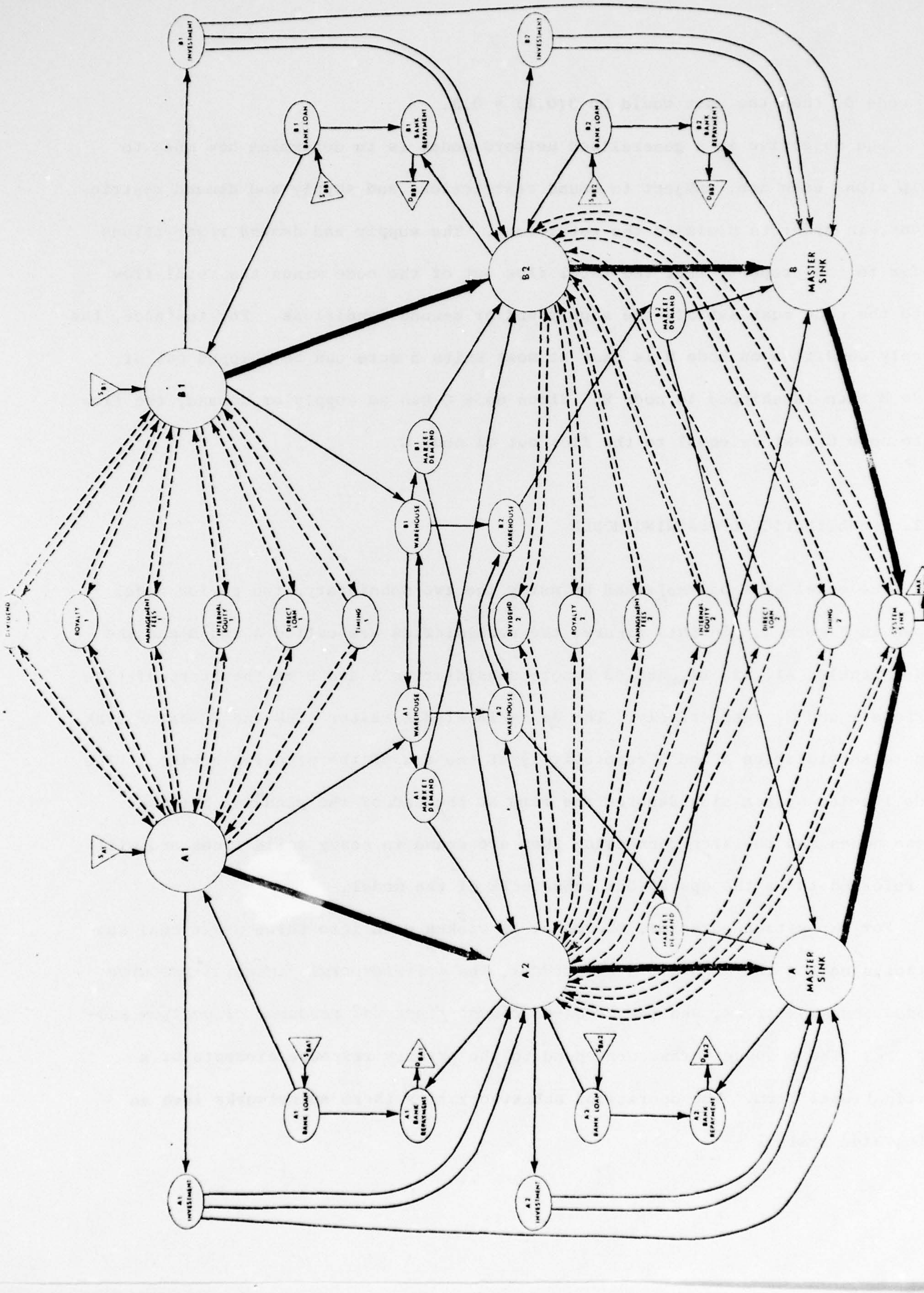

Figure 2. NETWORK MODEL

The components of the cross-sectional financial resource allocation subnetwork consist of the nodes and arcs displayed with dashes in Figure 2. This subnetwork permits the allocation of liquidity and profits through internal cash flow transfer channels in the manner of greatest benefit to the overall corporate system.

In Figure 2, the components of the production subnetwork consist of all nodes and arcs displayed with light solid lines and lying inside the components of the operations subnetwork. The production subnetwork determines the optimum level and mix of production, and the level of inventory and sales at each subsidiary (facility) in each time period. Thus, it represents the links over time between the company and the worldwide product markets.

The components of the intertemporal financial resource allocation subnetwork consist of the nodes and arcs displayed with light solid lines and lying outside the components of the operations subnetwork. This subnetwork represents the financial links over time between the firm and the worldwide capital markets.

The following subsections discuss each of the subnetworks in more detail. It is important to remember that this is an integrated model and that all subnetworks are mutually interdependent. Thus, the generalized network formulation simultaneously considers the interaction of all subnetworks in the context of the overall firm.

2.3. THE OPERATIONS SUBNETWORK

The differences in national factor endowments and economic structures of the various host countries lead to major differences in productivity and operating characteristics for the subsidiaries. Properly articulated, these differences can be used to benefit both local economies and the multinational corporation. Thus, the individual subsidiaries form the heart of the model.

In Figure 2, the nodes and arcs drawn with heavy solid lines are utilized to describe subsidiaries A and B in both periods of the planning horizon. It is assumed that at the beginning of the planning period each subsidiary has a given equity (cash) position. This is modeled as currency supplies, where the currency is denominated in the unit of the subsidiary's host country. Thus, nodes A1 and B1 have supplies of S_{A1} and S_{B1}.

Normal indenture provisions, standard industry practices, and other restrictions will in some cases set minimum requirements for various components of working capital. Lower bounds on the arcs (A_1, A_2), (B_1, B_2), (A_2, A master sink), and (B_2, B master sink) that connect a given subsidiary between two periods in time represent the minimum stock of cash working capital that must be maintained to operate the subsidiary. Any funds in excess of this minimum amount can be treated as a residual to allocate among the components of the system in the most efficient manner. A deficiency in a subsidiary will cause funds to be made available from another element of the system. The upper bounds on these arcs allow management to store working capital in subsidiaries with favorable market outlooks and strong currencies (a relatively larger upper bound) or restrict the working capital investment in cases of uncertain political situations or weak currencies (a relatively smaller upper bound). In general the multipliers on these arcs will equal 1.0 since no revenues or costs are generated by the flow and it is not necessary to translate or convert from one currency to another.

The costs, c_{ij} coefficients, on all arcs, except the arc leading out of the system sink node are zero. The cost attached to the arc leading out of the system sink node is -1 in order to maximize the flow out of the system sink (that is equivalent to maximizing the equity (cash) position of the firm at the horizon). The upper and lower bounds on the arcs (A master sink, system sink) and (B master sink, system sink) may be used to ensure that each subsidiary maintains an acceptable operating posture at the termination of the model. The multipliers on these arcs are used to convert all sub idiary funds into a single standard currency such as U. S. dollars.

2.4. THE PRODUCTION SUBSYSTEM

One of the major elements influencing the location of corporate subsidiaries is the potential to make use of local factors of production and other socio-political characteristics for the mutual benefit of the host economy and the overall corporate system. Each potential production facility has different structural combinations of factor inputs and product distribution channels. The model includes these considerations so that location of production, level of production at each chosen facility, product distribution channels and inventory carryover are integrated systematically as functions of factor supply and market demand in each market segment served.

These activities are treated in the model as follows. Production occurs by assigning a flow of currency on any of the arcs (A1, A1 Warehouse), (A2, A2 Warehouse), (B1, B1 Warehouse), or (B2, B2 Warehouse). See Figure 2. The currency flows are converted into "product" by the multipliers on these arcs so that the corresponding units of output arriving at the warehouse nodes are the number of units of product produced. Thus, the multipliers reflect the per unit cost of production and distribution to the subsidiary's home warehouse in the specified time period. A lower bound may be used on these production arcs to force a minimum level of production, and an upper bound may be used to represent production capacity. By using multiple arcs, the model can incorporate increasing production cost functions (e.g. the use of overtime to increase production capacity) in a linear framework.

Once currency is transformed into product on the production arcs, the output is available for distribution in the various marketing channels at "warehouses" serving different market segments. At the warehouse, there are three alternatives. The product can be transferred to another market segment (or product from other locations transferred to this market) via the arcs joining nodes A1-Warehouse and B1-Warehouse, or A2-Warehouse, and B2-Warehouse. Alternatively, product can be held in inventory until the next period via the arcs (A1-Warehouse, A2-Warehouse) and (B1-Warehouse, B2-Warehouse). Finally, product can be sold in the local marketplace via the arcs (A1- Warehouse, A1-Market Demand), (A2-Warehouse, A2-Market Demand), (B1-Warehouse, B1-Market Demand), and (B2-Warehouse, B2-Market Demand).

The upper bound on arcs joining nodes A1-Warehouse, and B1-Warehouse may be used to reflect tariff restrictions with the multiplier showing product lost in transit. The upper bounds on the inventory arcs represent inventory capacities, the multiplier being product spoilage. The lower bounds may be used to represent management policies of maintaining a minimum level of inventory.

The upper bounds on the market demand arcs represent maximum anticipated market demand in the associated time period. The multipliers on these arcs convert units of product back to units of currency. Consequency, the multipliers represent selling price less transportation costs and other expenses associated with moving the product from the warehouse to the marketplace. Thus some amount of currency arrives at the market demand node and is either transferred to the subsidiary node for use in the next time period via arcs (A1-Market Demand, A2), (A2-Market Demand, A master sink), (B1-Market Demand, B2), or (B2-Market Demand, B master sink), or used to pay the product transfer pricing costs via arcs (A1-Market Demand, B2), (A2-Market Demand, B master sink), (B1-Market Demand, A2), (B2-Market Demand, A master sink). The arcs (A1-Market Demand, A2) etc. have no upper bound and a multiplier of one.

With the exception of transfer pricing, all aspects of the production subsection have been discussed. Transfer pricing deals with the price and payment of goods received from another subsidiary. For example, if subsidiary A supplies subsidiary B with 10 units of product in time period 1, then a flow of 10 units originates on the arc (A1-Warehouse, B1-Warehouse). Thus, the model has not included subsidiary B paying subsidiary A for these goods. This aspect is included in the model arcs (A1-Market Demand, B2), (A2-Market Demand, B master sink) etc.

The multipliers on the arcs are current exchange rates. The flow which results on these arcs when the model is solved determines the transfer price. If after solving, the imputed transfer price would be unacceptable to the host country's government, the model may be rerun with lower bounds used to force a higher transfer price.

2.4.1. THE INTERTEMPORAL FINANCIAL RESOURCE ALLOCATION SUBSYSTEM

The multinational firm has access to worldwide capital markets, so the firm can borrow or lend in many different currencies to take advantage of structural rigidities in the world financial system. This does not mean, however, that the decision to build a factory in a particular country can be made independently of capital market considerations. When consideration of techniques to reallocate funds within the system is also introduced, certain locations may prove to be more advantageous than others. Combining production considerations with capital market factors may lead to an optimal operating policy that is quite different from that obtained if each decision area is considered separately. Thus, outside sources and uses of capital are included explicitly.

Capital can be obtained from a variety of sources within the host country and without, and even in countries in which no subsidiaries are located. In Figure 2, the acquisition of debt capital is shown as coming from a "bank" where the term is broadly intended to signify various sources of debt capital. The maximum amount of the loan is shown as the supply (S_{BA1}, S_{BA2}, S_{BB1}, S_{BB2}) available at the bank loan nodes (A1 Bank Loan, A2 Bank Loan, B1 Bank Loan, B2 Bank Loan). Demand (D_{BA1}, D_{BA2}, D_{BB1}, D_{BB2}) at the bank repayment nodes equals principal plus interest due if the line is fully subscribed. The arcs connecting the bank loan nodes to the bank repayment nodes have multipliers equal to one plus the rate of interest so that if the loan is not fully subscribed, demand for repayment will be reduced accordingly. The amount repaid in this case will equal the amount actually borrowed plus the accrued interest on that amount. Loans of longer maturity could also be modeled, but are excluded here to simplify the exposition. Likewise, more sources of debt, each with its own characteristics, are available to each subsidiary; but again for simplicity, only one per subsidiary is included.

If, instead of excess market demand there is a surplus of cash, the model incorporates elements that represent short-term investments. They are structured as wholly within the local economy, but multiple investment possibilities, some of which are in countries other than the host country, can also be modeled. The investment nodes (A1 Investments, A2 Investments, B1 Investments, B2 Investments) collect the excess funds for investment, perhaps adjusted for transaction costs, and determine the maturity structure of the short-term portfolio. Return on the investment is included on the maturity arcs with the cash impact imbedded in the multipliers. The system allows for both single-period and multi-period investments. For example, the arcs (A1 Investment, A2) represent different single period investments. The arc (A1 Investment, A master sink) represents a two period investment.

2.4.2. THE CROSS-SECTIONAL FINANCIAL RESOURCE ALLOCATION SUBSYSTEM

When the multinational corporation is viewed as an integrated system, liquidity often can be shifted internally among the subsidiaries to meet the goals of the firm. However, since there are really several entities operating in different host environments and subject to different constraints, there are limitations on the movement of funds within the system. There are five major methods generally available to a multinational corporation for shifting capital internally:

1. shifting funds by dividend payments,
2. shifting funds by royalties,
3. shifting funds by management fees,
4. extending direct intrasubsidiary loans, and
5. changing the internal equity position.

To represent these five methods a node is created for each method in each time period. Thus, nodes Dividend 1 and Dividend 2 in Figure 2 represent the use of dividend payments in periods 1 and 2, respectively. The flow on the arcs into and out of these nodes indicates where the funds are coming from and where they are going. It is assumed that the dividend nodes have no supply or demand. Thus, all funds coming in from subsidiaries must be sent out to the parent or to other subsidiaries. The use of double arcs between subsidiary nodes and the dividend node provide for funds to be transferred either in or out of each subsidiary.

Upper bounds on the dividend transfer arcs usually indicate repatriation restrictions, although company policy can also enter the picture, particularly if *less transfer* is desired than is legally permitted. Lower bounds can be used to force the model to repatriate earnings, for example, from a weak to a strong currency area. The multipliers on these arcs represent the relevant exchange rate, perhaps suitably modified for the impact of local withholding taxes.

The other four methods are modeled in a similar fashion as shown in Figure 2. The major differences come from the interpretation of the cost, multiplier, and lower and upper bounds on the arcs connecting each method node to a subsidiary node.

Royalties are payments made by a subsidiary to another element of the firm for use of patents, processes, or other technical know-how. Host government agencies watch this channel carefully so that it is not abused. If the host country perceives that contrary to government policy, royalties are being used as a conduit for channeling profits out of the country, restrictions may be forthcoming. Upper and lower bounds must therefore be set with care to guard against such actions. Generally, the multipliers represent the exchange rate from one currency to the base currency and costs are set at zero.

Payment for services rendered, such as the subsidiary's share of centralized management functions, is included in management fees. Thus, it is in some sense similar to royalties and is treated in much the same way by host government officials. When using this device to allocate funds, care must be taken to maintain a justifiable posture, otherwise the payments may be regarded as dividends. Exactly the same procedure and qualifications apply to the modeling of management fees that apply to royalties, and the arc parameters are set and interpreted similarly.

The final two methods by which funds can be shifted internally are through direct loans and changes in the equity investment in subsidiaries. These two systems permit two-way flow between various elements of the firm. Care must be taken in specifying bounds on these flows because of their political sensitivity, particularly in Third-World nations and in countries that are experiencing balance of payments problems.

In the situation where there is a physical exchange of merchandise between subsidiaries of a company, alteration of the credit terms by speeding up or retarding the settlement of the accounts and by varying the transfer price can be used to shift liquidity from one subsidiary to another. For example, if there is a desire to concentrate liquidity in subsidiary A at the expense of subsidiary B, A could delay payment of accounts payable to A, and subsidiary B could prepay its payables to A (A's accounts receivable from B), and/or the transfer price from A to B could be increased. Although this device is clearly of the same generic variety as the five cross-sectional resource allocation devices, recall that it was included more conveniently in the production subsystem. Where it is included is not particularly important; that it is included somewhere is critical.

3.0. PLANNING IN THE MULTINATIONAL ENVIRONMENT

For the Treasury analysis mentioned earlier, an interactive two-period planning model of a representative electronics firm (a single SBU) consisting of a U. S. holding company with producing subsidiaries in the U. S., France, Mexico, and Taiwan was formulated. Corporate data were drawn from various Commerce Department sources, specialized manufacturers policy manuals, audited financial reports, and other sources of information on this industry. For non-firm-specific data such as tax rates, interest rates, exchange rates, tariffs, and transportation costs, sources such as the Federal Reserve, the International Monetary Fund, and the Internal Revenue Code were used.

Only the U. S. and the Taiwanese subsidiaries were given sufficient production capacity to completely satisfy domestic demand for the product. For purposes of this study, it was assumed that unsatisfied demand in any market would be forfeited to a competitor, and that for higher levels of production, marginal cost would finally exceed marginal revenue.

Market demand (and the firm's market share) is assumed to be stable in Mexico and Taiwan. Demand in the U. S. is growing at about ten percent per period, and in France the growth is about twenty-one percent. France--particuarly in period two--and then the U. S. are quite a bit more profitable to serve than the other markets, but Taiwan is also fairly lucrative. The Mexican market is rather soft and is sometimes unprofitable to serve on a large scale.

4.0. RESULTS OF COMPUTER ANALYSES

In the Treasury analysis over 250 different runs were made testing the response of the system to various exchange rates, selling prices, raw materials cost and availability, and interest rates. In this section we focus attention on three representative runs that are of particular benefit for showing the close correspondence of the model results to what would be expected from international trade theory, and for showing the analytical power of the model to provide hard-to-obtain information so vital for adequate planning in today's environment.

The first example trial employs data corresponding to the situation that existed in the 1960s and early 1970s (before devaluation of the U. S. dollar). Using this as a base-case, two additional runs are described. The first shows the impact on the corporate system of a fifteen percent devaluation of the U. S. dollar. The second departure from the base case demonstrates the impact of cost-push inflation on the firm's operations. It is worth noting at the outset that for all runs in the Treasury study the overall level of profit for the firm was rather stable, but *how* and *where* the profit was earned was altered substantially. We turn now to the base-case analysis.

As structured in the model, the U. S. subsidiary has greater production efficiency than either the French or the Mexican facility and thus has a comparative advantage over them, even when transportation costs and taxes are included. Production in Taiwan is very inexpensive, but shipping charges offset their advantage. Thus, for all but the domestic market in Taiwan, the U. S. is quite competitive. The operations in Taiwan are justified, though, since the home market is profitable and adds to the net revenue of the firm.

Since production capacity in the U. S. is not sufficient to satisy the combined demand in the U. S., Mexico and France, other facilities must also produce output. The U. S. produces enough to satisfy domestic requirements and to export to both France and Mexico. Demand is met in those markets by local production supplemented by imports from the U. S. There is excess production and an inventory build-up in Taiwan of 30,000 units because of an expected cost increase in the second period that is greater than the current period warehousing charges. Thus, in the first period demand is satisfied in all markets and Taiwan builds up inventory of 30,000 units over current demand.

Both Mexico and France rely on imports from the U. S. and consequently are holding down local production, so liquidity tends to build up in these subsidiaries. All facilities, including Taiwan, repatriate earnings to the maximum extent permissible under local law. These funds flow to the U. S. parent. The French subsidiary still has excess liquidity as is evidenced by the build up of short-term investments and cash.

In the second period, both France and Mexico pay for the goods supplied by the U. S. in the first period. Mexico and Taiwan continue to repatriate the maximum level of earnings, but France chooses to repatriate less than permitted. The French subsidiary also draws down its liquid investments as much as possible and borrows additional capital to increase production.

The French market is increasing rapidly while that in Taiwan and Mexico is static. The U. S. market is also increasing, but not nearly as fast as for France. After supplying the domestic market, excess U. S. production capacity is used to produce exports for France. The French likewise produce at a higher capacity to be able to satisfy their market demand. Taiwan produces some goods in the second period and draws down the 30,000 units in inventory to meet local requirements. U. S. exports are no longer available to augment Mexican production since all U. S. production was diverted to the highly profitable market in France. It is not profitable to produce at high levels of output in Mexico because of the cost structure, so market demand is not entirely met.

Mexico and Taiwan are both holding down production, so they invest as much as possible in short-term liquid investments. Thus, the model determines where and how much production is to take place, import-export flows, liquidity positioning, and whether or not it is profitable to satisfy market demand.

We now look at the effects on these flows of a fifteen percent devaluation of the U. S. dollar. France, Mexico and Taiwan again repatriate the maximum amount of earnings, but these now represent more U. S. dollars. Since U. S. exports are now cheaper, the U. S. subsidiary takes all transfer payments, supplements them with local borrowing, and increases the production of exports. All available funds are devoted to this purpose, so short-term liquid investments are not made.

With the higher U. S. exports, France, Mexico and Taiwan invest to the maximum. France even has high idle cash balances. As with the base case, Taiwan overproduces to supply its second period as before, but Mexican production shuts down completely--it cannot compete with U. S. exports. The U. S. satisfies the Mexican market entirely plus part of the French market, but, significantly, it does not fully satisfy the U. S. market.

In the second period, the increasing profitability of the French market causes production in that country to increase. Not only does the French subsidiary not repatriate earnings, but also the U. S. subsidiary extends a loan to them. This loan compensates for having to pay for imports from the U. S. in period one. Mexico also pays for the first period imports, repatriates the maximum, and again produces nothing, preferring to invest the funds in liquid assets or leave them in cash balances.

The U. S. continues to satisfy demand in Mexico and to export to France while most but still not quite all U. S. demand is met. Taiwan uses inventory reductions and local production to satisfy demand, but continues to find it unprofitable to produce for export--transportation costs are too high. The Taiwanese repatriate the maximum to the U. S. and invest all they can in liquid assets.

This change in the allocation follows closely what happened when the U. S. dollar was devalued in the early 1970s. Consumption shifted to home goods as imports became relatively more expensive, and production shifted to export goods. Demand for home goods was higher than firms were willing to supply, so prices increased and high inflation resulted. Thus, the allocations indicated by the model anticipated these pressures very accurately.

As a further verification that the shifting patterns predicted by the model are consistent with the underlying theory of international trade, we return to the base case and see what effects cost-push inflation in the U. S. will have on the allocations. In this series of runs, a five percent increase per period in costs and prices is assumed.

With the increase in costs and prices, the comparative advantage of the U. S. is lessened and rather dramatic shifts in the allocation pattern occur. Mexico repatriates the maximum amount in period one, but chooses not to import the higher-priced goods from the U. S. Mexican production supplies only about half of its anticipated market demand, even though all remaining resources are devoted to production--thus, nothing is invested in liquid assets in Mexico.

France repatriates less than the maximum since the increase in price of U. S. goods means it can produce more goods profitably in France. Nevertheless, France does import some goods from the U. S. to satisfy total demand.

Liquid investments in the U. S. are the maximum, but the increase in cost causes production to be insufficient to satisfy both French and U. S. demand. Hence, goods are imported from Taiwan to cover the increment. Taiwan produces enough goods to satisfy its own market and export to the U. S., so it repatriates some earnings (but not the maximum) to the U. S. Taiwan also invests in liquid assets as much as it can.

In the second period these same patterns are observed except that the Taiwanese repatriate nothing and the U. S. must channel previous investment capital into production because of higher costs. Again, Mexican demand is left partly unsatisfied.

Clearly; these shifts are consistent with international trade theory--as inflation increases, imports will increase and exports will decrease in a way similar to that shown in the allocations. Going further, we can say that in all of the tests conducted with the model, the overall response of the system supports the hypothesis one would propose from international economic theory, but, the sensitivity of these flows to changes in the firm's environment and the ability of the firm to offset detrimental environmental shifts through adjustment of the product-funds flows pattern was surprising. As further examples, when the dollar was devalued, return on investment (ROI) increased slightly even though demand was inelastic. When interest rate relationships were changed, the firm shifted its borrowing and investing locations with little overall earnings impact. With demand-pull and cost-push inflation combined with devaluation imposed on the system, the firm, again shifted production to maintain profit levels.

These sensitivity tests also highlighted the intertemporal connections: the timing of flows was very sensitive to environmental changes. Thus, it is seen that the worldwide corporate system can change its reaction to external events to maintain business as usual, but the ways in which it must react are not obvious. Simply reacting to environmental events on an isolated basis rather than on a systemic basis drastically reduces the profitability of the firm.

5.0. CONTRIBUTION OF THE MODEL TO DECISION-MAKING

The model indicates the best financing-marketing-production decisions in terms of funds and product flow patterns for any specified objective function and constraint set. The constraint set is imposed externally by the environment, as in the case of economic or governmental requirements, or by management to reflect strategic and/or social considerations. Through post optimality analysis or rerunning the model for various constraint configurations, management may analyze the sensitivity of the firm's cash flow to various environmental scenarios and strategic plans.

The ease in imposing upper and lower bounds on each fund or product flow provides the connector between the strategic and operations dimension of planning. In production, for example, if no limits are placed on the flow of goods among subsidiaries (beyond their capacity limits) or between production and marketing sites, the model will suggest an optimum production-marketing-financing pattern on a centralization basis. In financing, the bounds may arise from the concern of the minister of finance over local borrowing to replace funds that had been provided by the parent. In other cases, they could come from a need to push local facilities to inefficient production levels to cut back on imports. Thus, the costs of strategically-determined soft constraints, determined by analysis of the optimization results, provide one of the few sources of hard information available for strategic planning. Moreover, in those cases where management imposes internal constraints as a means of implementing a local social objective, the ability to impute a systematic cost ot this action is critical.

Liquidity, another strategic decision, is maintained on a firm-wide basis. The ability to cover cash emergencies at one point in the system from far away sources provides an advantage to the multinational firm over its uninational competition. Optimal liquidity positioning depends on the availability and location of operating cash in the system and on governmentally imposed restrictions on funds movements, but it takes an integrated model to sift through the various alternatives.

Although not part of the Treasury study, with the model described in this paper, it is possible to trace the impact of fluctuating exchange rates through the corporate system. After investigating the sensitivity of the cash and product flows to changes in exchange rates, the decision maker can impose various exchange policies on the model and examine their impact on the profitability of the system. In this way exchange policy can be developed based on the unique characteristics of the multinational firm as a worldwide entity. In other words, production, investment, and liquidity transfer devices serve as complements to hedging, covering forward or other traditional tools in setting the exchange policy of the firm.

In each of these examples, the cost impact of an isolated decision or event can be investigated. Given the complexity and changeability characterizing the multinational environment, a less formal model could not trace these impacts through the interconnecting links. Moreover, in each of these uses, the ability to impute costs--available only with an optimization model--is critical. "Simulation" models simply cannot provide this type of information.

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