FOREIGN EXCHANGE EXPOSURE IN INTERNATIONAL CONSTRUCTION

by

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Submitted to the Department of Civil Engineering
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Abstract

The objective of this dissertation was to provide a conceptual and analytic framework for understanding and analyzing the economic and competitive aspects of foreign exchange exposure in international construction. The central argument developed is that fluctuating nominal and real exchange rates present the industry with major challenges across the cost, time, quality and coordination elements of international projects, and require contractors to increasingly globalize their operations, in order to manage more effectively their foreign exchange exposure in the short run, and strengthen their competitive position in the long run.

The thesis establishes the significance and uniqueness of foreign exchange exposure in international construction and studies the applicability of international corporate finance theories and policies in analyzing and modeling such exposure. The key dimensions of accounting and economic foreign exchange exposure are examined in the context of construction operations. Most significantly, a framework for understanding the impact of foreign exchange rates on the international construction firm's competitiveness is discussed.

Foreign exchange exposure is defined with multicurrency construction cash flow models that incorporate a contractor's contractual and noncontractual cash flows. The thesis emphasizes the to-date underestimated contribution of noncontractual exposure to a contractor's risk. Then, models of microeconomic analysis are presented and the conclusions are discussed, as they apply to the construction industry. The analysis suggests that the home currency value of foreign cash flows is not only affected by shifts in exchange rates, but also by changes in the value of foreign cash flows, in response to changes in exchange rates. In addition, the importance of purchasing power parity in international competition is analyzed and highlighted with empirical evidence that demonstrate the existence of competitive advantage among selected countries.

The economic analysis supports operational hedging decisions, that include production, marketing and financial management approaches to reducing exposure, and leave financial hedging instruments for covering residual exposure. Among the key operational hedging approaches, input sourcing and mixing, currency of cost and revenue selection, geographic specialization and contractual vehicles are discussed.

The thesis examines the impact of international project and currency diversification and the risk-return tradeoffs of the construction firm. The applicability of adjusted present value methodologies for valuing operational and financial hedges is also examined. Finally, an overview of international project cases emphasizes the criticality and complexity of foreign exchange exposure, but also highlights the intellectual and practical issues facing the industry in managing its foreign exchange risks.

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Chapter 1 : Introduction

1.1 Background

Construction is the precondition for economic development and growth. Constructed facilities provide shelter and protection for human activities, physical infrastructure for the support of economic activities, and social infrastructure for the support of social needs. According to United Nations annual national economic data, construction usually contributes from 4 to 8 percent to a country's Gross Domestic Product (GDP). Most notable is its contribution to Gross Fixed Capital Formation (GFCF), which ranges from 40 to 70 percent. Because construction generates employment to skilled and unskilled workers, it has been used by government policy makers as a vehicle for providing employment opportunities. Construction also has strong linkages with other industries. Input-output studies for the US construction industry show that its purchases of goods and services from other industries were about 58 percent in 1977 of the total value of construction put in place (Construction Review, 8/1985).

The annual value of world construction put in place has been over $1.6 trillion dollars in the 1980s. In recent years, over 90 percent of it occurred in North America, Europe and Asia and the Pacific. Industrial countries accounted for over 77 percent, while about 75 percent of world construction is concentrated in twelve countries. A large part of this world construction demand, particularly in developed industrial countries, is satisfied by domestic construction industries. However, due primarily to the technology, know-how and resource availability gap between developed and less developed countries in construction, most of international contract awards (about 60 percent, according to annual Engineering News Record reports) come from LDCs.

Uniqueness of International Construction

The construction industry shares individual characteristics with other, especially project-oriented, industries. However, it also has unique economic, organizational, business development and operational features. Construction product purchases are typically pre-demanded and non-speculative, i.e., the constructed facility is purchased before it is manufactured in predefined locations. Moreover, through the contractual agreements used, the client defines the framework for pricing the job. Supply and demand are influenced by the technical and managerial skills and experience of contractors. Entry barriers emphasize the know-how and human, rather than physical capital. The high fragmentation of the industry and expert skills required have resulted in the extensive subcontracting of construction work (about 25 percent of the total volume in the United States). In addition, due to the uniqueness of each project, costs can be highly uncertain.

International construction exaggerates the unique features of domestic construction. Project demand and supply are defined in global rather than local context, with the project location in foreign territories, at bigger distance from the home base and input sources. Projects are typically publicly owned and, therefore, almost always pre-demanded and client specified. A key criterion in the demand for international construction services is the expertise of the contractor vis a vis local needs and skills. In recent years, opportunities for product differentiation have been created with design and build, turnkey, package deal and project financing needs of international clients.

International construction projects are typically larger in size and more complex technologically and organizationally. With high bid, mobilization and overhead expenses involved, the project size can be a major motivation to bid a job. Complexity comes from the demand, supply and global input sourcing necessary for the profitable construction of these projects. Due to the distribution of construction opportunities in many countries, there is often discontinuity in matching demand with supply: most project organizations are temporarily assembled for the purpose of constructing a specific facility. The international contractor is more of a project-specific organization, more mobile and subject to more environmental influences.

Much more than in domestic projects, or other international business, the international construction client defines the framework for pricing, packaging and managing the job. The contractual agreements are often influenced by the policy making priorities of the owner country. Bonds constitute a high percentage of the project value and have serious cash flow implications throughout the project and sometimes years after its completion. In addition, contractual restrictions regarding the sourcing of inputs, including the use of local inputs, as well as the currency of denomination of costs and revenues, are additional factors that limit a contractor's operational and financial options. The high fragmentation that characterizes the industry is even more prevalent internationally, with the variety of local materials, expertise and construction traditions. Local subcontracting is not only more often required, but sometimes more desirable than domestic subcontracting for organizational effectiveness. International subcontracting contributes to higher cost and currency uncertainties.

Like other international investments, construction services are subject to, and equally affected by, official government policies. The barriers to construction services trade include currency restrictions, restrictive government procurement, government subsidies towards local contractors, investment barriers requiring local participation, and personnel qualifications that make difficult the entry of skilled labor (Lee, 1989).

Government involvement affects not only the ability to compete in that government's domestic market, but also against contractors from it in other countries. The strongest influence on international competition comes from state ownership of construction firms and from the willingness and ability of a government to provide financing, preferably subsidized, for a foreign project.

Evolution of International Construction

The growth of international construction during the past four decades has taken place in three phases. The first phase ranged from the end of World War II to the early 70s, and is characterized by bilateral business relationships and project financing. Western industrial countries, led by the United States, provided substantial financial and technical aid for development projects, and encouraged the flow of private capital in foreign direct investment that generated construction work in industrial facilities. The role of the United States and other industrial countries as leaders in international construction was gradually reduced, as LDCs acquired the construction technology and management know-how to develop their indigenous industries. In recent years, some of the most aggressive and capable LDCs have succeeded into becoming major construction service exporters.

The second phase in the evolution of international construction started with the quadrupling of oil prices in 1973 and lasted through the early 1980s, i.e., until the oil revenue started to decline and external debt of LDCs mushroomed. The growth was unprecedented in volume and scope of work, with most opportunities coming from development programs and enormous spending on physical infrastructure projects by oil exporting countries, particularly in the Middle East. During that period, construction grew at annualized rates of over 50 percent in some oil producing countries. Although the majority of work went to developed country contractors, it also attracted competitive contractors from LDCs who often claimed substantial market shares in their niches, like the South Koreans in building construction.

In addition to projects constructed in oil rich countries, much of the revenue surplus was recycled to other developing countries to finance development projects. The recycling was accomplished by development banks and private capital markets and supplemented LDCs' domestic savings for public rather than private projects. Therefore, the 1970s are characterized by multilateral construction project financing, with a growing role of the World Bank and other regional development banks, and, therefore, a shift towards more international competition for construction projects.

International construction awards reached an all-time high volume of 236 billion US dollars in 1981. The decline in contract awards to about 74 billion US dollars in 1987 parallels the decrease in oil prices and revenues and the increase in foreign debt by a large number of LDCs. Between 1981 and 1986 the current account of OPEC countries shifted from a surplus of 44 billion US$ to a deficit of 33 billion US$. During that period, construction growth rates in OPEC countries were substantially negative (up to -15 percent) compared to the relative stability observed globally (United Nations, 1987). In addition, the external debt of LDCs has increased in nominal value and relative to exports. Most notably, the external debt of 15 major LDC debtors ("Baker 15") has increased in nominal US$ terms, from 348 billion in 1981 to 505 billion in 1988, and as a percentage of exports, from 212 percent in 1981 to 315 percent in 1988 (Morgan Guaranty, 1988).

Given these dramatic changes, international construction entered the third and current phase of its evolution in the early 1980s. The period is characterized by changes in the contractual and economic relationship with client LDCs that reflect the scarcity of funds for infrastructure projects and the lack of hard currencies for construction work payments. As a result, most international projects in LDCs are now bid with some form of project finance component (Slavich, 1988). In addition, contractors have to increasingly compromise the method of payment to fit their LDC client financial capabilities, including accepting more often soft local currencies. Failure to address these issues means that the contractor will have to accept decrease in its market share or move to new markets.

Most significantly, the decline in LDC construction, has resulted in a shift of international contractors' strategy towards developed countries, i.e., for most of them, towards each other's markets. Critical to international contractors' success in penetrating such markets is their ability to deal with and overcome trade barriers, network with local project owners and successfully ally with local contractors and suppliers. The trend has been more visible in the United States where the 43 billion dollar trade surplus in international construction services in 1981 has shrinked to only 9 billion dollars in 1987. At the same time, the US trade in building materials has gone from a 311 million dollar surplus in early 1980s to an increasing deficit of over 3 billion dollars. Foreign firms, led by Japanese, have focused their activity on industrial and office building construction associated with foreign direct investment in the United States and real estate development. Similar increased construction activity is observed in Europe, where many US and Japanese contractors are considering establishing a presence, in order to compete more effectively after 1992, when internal trade and technical barriers are planned for removal.

The emerging conclusion is that construction has been, and is increasingly becoming more international in contract work and organization. Actually, recent

Engineering News Record data show that the top international contractors average about 45 percent of their total contract volume in foreign countries. Some of this internationalization of the industry's nature can be explained by the geographic shifts in demand for construction, following international economic developments. This is a valid traditional, although static, explanation of the internationalization of construction. Implicit in this view is the assumption that there are transactional, indirect advantages associated with international contracting.

The economic theory of multinational enterprises provides additional explanations that fit the internationalization of construction. Some of the strongest arguments are based on the intangible assets of the contractor, i.e., those associated with nonproduction activities that complement the contractor's main construction operations (Caves, 1980). These represent technologies owned, as well as management, financial and marketing expertise possessed by the contractor's employees. For example, many contractors have developed niching strategies and specialized for years in project types, such as tunneling or power plant, that give them special knowledge of the technical and management issues of construction. Or, in finance, some contractors have in recent years been developing expertise in arranging project financing, with over 50 percent of requests for proposal among top contractors in 1987 including project financing proposals. Among successful contractors, these abilities and associated intangible assets can be frequently and quickly renewed to maintain the competitive advantage.

Given the possession of these intangible assets by successful contractors, a reasonable question is why pursue foreign projects and not expand domestically. The reasons are associated with restrictions and limitations of the domestic markets. For example, the extent to which some of these technologies and knowledge is shared by large numbers of competing contractors makes them more of a public good in domestic markets. As a result, the contractor may not be able to realize above marginal revenue for them, due to the competitiveness of the domestic industry. In addition, some of the specialized project types that depend heavily on innovations and investment in technology and management, and thus require a critical volume of work to sustain the associated costs, may be faced with relatively low demand in any individual country. These circumstances necessitate that the contractor be more international, in order to tap opportunities from a wider possible market base. The trend will probably increase among US contractors, as the more aggressive of them are increasing their investment in research and development (R&D). For example, Bechtel has maintained a large R&D operation in computer technologies, and recently established a subsidiary that markets software. Other construction firms are establishing R&D functions following the example of Japanese contractors. The empirical evidence in the US and other developed countries is that industries with significant investments in R&D are more often involved in foreign operations (Swedenborg, 1979; Caves 1980).

Construction has also been international by virtue of foreign direct investment of other industries and the quasi-contractual relationship it may have with them. The empirical evidence (Servan-Schreiber, 1968; Caves 1980) shows that service industries with intangible assets in management skills, such as accounting, banking and management consulting, have been the most successful in internationalizing their services, most often by following their multinational clients. Similarly, construction firms have also followed their domestic clients in foreign direct investment. This mode of internationalization is more visible in recent years, with Japanese contractors following Japanese investment in manufacturing plants in the United States (MacAuley, 1986). Construction firms have also traditionally worked in foreign projects following government policies towards the less developed world with financial aid programs that typically support infrastructure investments.

Another reason for the internationalization of construction is the absence of extensive and complicated distribution network requirements, that often need substantial investment of resources and time to be established. In addition, once involved in foreign jobs, contractors are forced to be international, or, more accurately, global in operations, by virtue of the worldwide procurement and allocation of physical, capital and human resources. Worldwide procurement stretches throughout the construction project, i.e., across the construction project value chain, to use Porter's framework of international operations (1986).

Some of the internationalization of construction can be attributed to the intensifying competition among contractors in each other's domestic markets. The strategic initiative is to prevent a foreign contractor from entering one's domestic market, by competing and containing the foreign contractor in its own market. In that sense, for example, US contractors focused in domestic operations, should increasingly become international in nature, because of the increased presence of, and competition with, foreign contractors in the United States. This may also be one of the reasons why international contractors are currently seriously developing strategies for the European markets of the 1990s ("Europe 1992"), in order to balance the increased European presence in projects and construction firm acquisitions in the United States..

Because the construction industry has effectively operated for years in LDCs, it has today more of an international character and capability than other multinational enterprises, which have focused their foreign direct investments in developed countries. The theory of multinational enterprise suggests that expansion to foreign markets typically goes through easier to operate business environments first, with reduced investment costs in adaptation and incremental revenue benefits from operations. Then, they move to other, more complex markets using the experience, and investing excess profits from previous operations. By contrast, following the existing demand for construction, international contractors begun their expansion from the most difficult markets. Because of that, they have been presumably exposed to more complex international business environments, subject to greater risks and uncertainties, and, therefore, more international in nature.

Foreign Exchange Risk Significance

The current shift of international construction activities towards industrial countries and the declining capability of LDCs to finance their projects and meet hard currency payments are altering the risk profile of international construction projects and raising the significance of foreign exchange risk factors. Political and business risks are relatively low in developed countries, although they have been relatively high in LDCs (Rogers, 1988). By contrast, exchange risks can be substantial, and nominal and real exchange rates very volatile, even among developed countries, where monthly changes of up to 3 percent were observed in 1988 (Morgan Guaranty Trust Co., 1988). In addition, projects in LDCs are now more often tied to cost/revenue structures with exposures in local soft currency. Business and political risks also have impact on a contractor's foreign exchange exposure, as they can directly or indirectly affect foreign currency cash flows.

Foreign exchange exposures result from unmatched, in a given time period, cash inflows and outflows in multiple currencies at the project and company levels. Such positions are the result of forced or voluntary utilization of human, capital and physical resources in global markets and multiple currencies. Forced exposure comes from client requirements that the contractor use local resources, or be paid in a form (monetary or nonmonetary) not preferred by the contractor (and implicitly by its investors). It can also result from obligations to source inputs from the sponsor country's markets, in projects financed by government entities. Voluntary currency exposure results from the conscious decision to source costs globally, including the home country, in a variety of currencies, in order to be competitive. In addition, the contractor's bonding obligations often leave him with substantial exposure in home currency. Foreign exchange risks exist, and losses can be incurred, well before the contractor formally enters a contractual agreement, as the contractor is automatically exposed to currency fluctuations between bid and award dates. And, once contractually committed to a project, the contractor does not have the flexibility of other industries to shift prices and production, in order to cope with foreign exchange risks.

A key differentiation, not explicitly, or even implicitly, accounted for in the international construction industry and literature, is that between contractual and noncontractual exposure. Contractual cash flows are fixed in nominal currency terms, while noncontractual are not. As a result, noncontractual cash flows are expected to fluctuate with macroeconomic and market trends, including changes in exchange rates. When bidding a job, international contractors are typically committing themselves to contractually fixed revenue (cash inflows) through fixed-price contracts, although they do not necessarily have similar contractual commitments from their suppliers and subcontractors. This leaves them with varying noncontractual exposure in their costs (cash outflows), especially those associated with later tasks of a project.

Despite the recent increase of international contract awards from industrial countries, LDCs have traditionally been, and are expected to continue being the target of international contractors. In recent years, construction services to LDCs have accounted for about 60 percent of US contractors' foreign business, while other industries, including services, have averaged only 25 percent of their business to LDCs (Department of Commerce, 1988). Currency exposure in LDCs is more often the result of cost/ revenue structures defined by local government and foreign aid conditions. Local sourcing can be required even when the project is financed by the contractor's home country.

If part of a contractor's revenue is denominated in local currency, it is exposed to currency controls that may be imposed unpredictably, while a project is in progress. Another consideration is the nontradeability of local currency which, in addition to the conversion inconveniences and transaction costs, reduces the contractor's access to standard and, presumably, cheaper currency hedging instruments. Similar exposure and transaction costs can be associated with barter (or countertrade) types of construction finance arrangements, where the contractor agrees to receive payment in kind, rather than currency. Moreover, contractors with project in LDCs with hyperinflationary economies are wary of the dramatic reduction in local currency value in short periods of time.

Unlike foreign investment in industrial countries, construction in LDCs may be associated with relatively limited access to alternative sources of inputs and cost sourcing, according to interviewed firms, because of the relatively smaller and less competitive markets. Costs of work subcontracted by contractual obligation to local firms are subject to greater uncertainty, due to potentially monopolistic position of the subcontractors. This reduces a foreign contractor's leverage against local subcontractors and suppliers, who may be able to force changes and new terms, and, therefore, increase its foreign currency exposure, with the contractor having limited, if any, options to respond.

Foreign exchange risk is not a new subject for internationally diversified investors and multinational corporations (MNCs). MNCs have traditionally employed financial hedging techniques for managing their accounting exposure. These techniques include fund flows adjustment (such as making hard currency investments and repaying hard currency debt), entering currency futures, forward and options contracts, exposure netting among operations in multiple countries and currencies, and, recently, currency swaps. The objective is to increase assets and decrease liabilities in currencies likely to appreciate, while decreasing assets and increasing liabilities in currencies likely to depreciate. Financial hedging in widely traded currencies is often accomplished cost-effectively with standard, although typically short-term focused, instruments of the financial markets. Longer term exposures, especially in currencies not traded extensively, are covered with tailored transactions, not typically available to the average investor (Shapiro, 1986).

International construction firms have been utilizing standard instruments and tailored transactions to financially hedge their accounting exposure. The cases reviewed in this dissertation demonstrate the applicability to construction of contingent financial instruments, such as currency options, when bidding international projects; of forward contracts, when dealing with contractual cash flows; and of lending or borrowing in currencies likely to appreciate or depreciate respectively. In recent years, contractors have been using currency swaps to periodically exchange, over a relatively long period of time, liabilities in two currencies with foreign counterparts. Currency swaps can hedge risks to existing liabilities, such as projected costs in likely to depreciate local currencies, when the international contractor does not have access to local credit for long-term borrowing. Being increasingly standardized by investment banks, currency swaps have the potential of providing in the future long-term standard instruments that will complement the currently available short-term forward contracts (Solnik, 1988).

Construction's unique features, including the prevalence of fixed revenue contractual obligations, and the lumpiness and nondivisibility of its projects, stress the need for evaluating operational approaches when managing foreign exchange exposure. The importance of operational hedging techniques, vis a vis traditional financial hedging, increases when the contractor is faced with noncontractual cash flow exposures, which are sensitive to market conditions. The present thesis proposes to study the noncontractual, economic aspects of foreign exchange exposure in international construction, provide an analytic framework for measuring it, and suggest operational exposure management and hedging methods to coping with it, that exploit the contractor's production, marketing and financial management capabilities.

1.2 Objective, Scope and Contribution of the Thesis

The objective of this thesis is to study foreign exchange exposure in international construction. The thesis develops the necessary methodology for understanding and quantifying the exposure and identifies strategies for coping with it in international construction.

The literature and research in international financial economics suggests the complexity of foreign exchange risk analysis, evaluation and management. Most studies have focused on the determination of exchange rates at the macroeconomic level. The body of knowledge regarding the implications for managing internationally competing firms in multiple currency environments is relatively limited.

The construction industry literature has only sporadic and unstructured references to the issue, and only from a cost accounting perspective. The thesis develops an analysis framework that addresses the economic and competitive aspects for internationally competing construction firms. The scope of the work is limited to international construction projects; developing a methodology for understanding and modeling foreign exchange exposure; applying principles of microeconomic and international finance theories to provide a multicurrency exposure analysis framework; and understanding the impact of foreign exchange factors on international construction industry competitiveness.

The first contribution is the extension of traditional cash flow analysis models to account for multiple currencies. This extension, combined with appropriate cash flow breakdown structures, provides the basis for the systematic evaluation of construction cost and revenue component exposure, as a function of their individual sensitivity to foreign exchange fluctuations.

Second, the thesis proposes an operational hedging approach to managing foreign exchange exposure, which exploits the production, marketing and financial management opportunities available to international contractors, before resorting to traditional financial hedging instruments for covering residual risks. Principles of microeconomic and finance theory are applied to provide the international contractor with the conceptual framework for making input sourcing and mixing decisions; market, pricing and project type strategies; and support the use of financial hedging instruments.

The thesis explicitly differentiates contractual from noncontractual cash flows in international construction and addresses the unmatched cost/revenue structures typically facing international contractors. It is shown that foreign exchange exposure goes beyond traditional accounting and foreign currency translation practices. Noncontractual project cash flows are subject to changes with market conditions, including exchange rate fluctuations. Foreign exchange elasticity measures of cash flow are defined to quantify the sensitivity of project cash flows and value. This contributes towards understanding the contractor's real economic exposure and making more informed cost and revenue structure decisions.

Finally, the thesis shows how the competitiveness of international contractors is affected by deviations from the exchange rate equilibrium relationships suggested by the theory of international corporate finance. Real exchange rates are defined to provide measures of competitiveness in international construction. These measures provide the quantification of conventional wisdom arguments regarding the possession or lack of competitive advantage due to weak or strong base currency.

1.3 Thesis Outline

Following this introduction, chapter 2 discusses the key dimensions of accounting and economic foreign exchange risk in the context of construction operations. It also provides the framework for understanding the impact of foreign exchange rates on the international construction firm's competitiveness, and makes the case for managing foreign exchange exposure in international construction.

In chapter 3, the components of a multicurrency construction cash flow model are incrementally developed. Then, models of economic analysis of noncontractual cash flow exposure are presented, followed by discussion of their applicability to international construction. The importance of purchasing power parity in international competition is also discussed, including the evaluation of some relevant empirical evidence. Chapter 4 introduces analytic approaches to making cost and revenue structure decisions in international projects and emphasizes the benefits from international project and currency diversification. The usefulness of adjusted present value methodologies, featuring the valuation by components methodology, for valuing international projects and incorporating exchange rate factors is also established.

The interesting cases summarized in chapter 5, were provided by the treasurer of a large international contractor, and highlight practical aspects of foreign exchange exposure management in construction. Finally, chapter 6 provides a summary of the conclusions and recommends areas for future research.

Chapter 2 : Foreign Exchange Exposure Dimensions in International Construction

The business development and operational decisions of the international construction firm affect its present financial structure and future cash flows. A critical aspect of foreign exchange risk management is to know how expectations about exchange rate changes are incorporated in these decisions, and, therefore, how they affect the financial and economic performance of the contractor. In addition, these decisions typically create exposed currency positions, i.e., long (surplus) or short (deficit) cash flow positions in a number of currencies. The management of these exposures requires the understanding and measurement of what is at risk, in order to decide how to cope with it (Shapiro, 1986).

The measurement and management of foreign exchange risk has traditionally been influenced by accounting practices that take a balance sheet approach to defining foreign exchange exposure. The accounting approach focuses on analyzing the impact of expected exchange rate changes on the present financial structure, i.e., on the assets and liabilities of the firm. In contrast, economic theory emphasizes the impact of foreign exchange rate changes on the present value of the construction firm's future cash flows. Exchange risk is then defined as the variability of the project or firm value due to foreign exchange rate changes (Cornell et al., 1983).

Furthermore, international finance theory proposes that true economic exposure is also affected by key equilibrium relationships between foreign exchange rates, interest rates and inflation. These relationships are summarized in Appendix A. Among them, purchasing power parity (PPP) implies that exchange rate movements are offset in the long run by changes in prices, and provides information about the relative strength of currencies when PPP does not hold. The impact of deviations from PPP can be traced in the costs of the international contractor, relative to foreign competitors, as well as in the relative value of profit and dividends to construction firm shareholders.

Foreign exchange rate determination, measurement and management are in the heart of international corporate finance, including the investment and financing decisions, and the financial management of foreign operations. Although foreign exchange risk stands out as an equally critical difference between domestic and international construction, the previous work and present practices of the construction industry do not reflect the relevant state-of-the-art theories and policies of international corporate finance. Part of the reason is that modern theories of corporate finance are not automatically applicable to construction, as they are heavily focused on the allocation of investments in divisible financial assets, such as stocks and bonds. Construction firm investment decisions are primarily project selection and management related, in large, nondivisible and unique in complexity projects.

The limited discussion of corporate finance theories and policies in the construction literature has been to-date focused in domestic operations. Most writings use a domestic, single currency framework, without the political or country, business, and exchange risks of today's international competition. The analysis of costs and revenues in a single currency, effectively reduces the uncertainties about cash flows and values, especially in fixed-price contracts, to uncertainties about the domestic cost of construction inputs. As such, it does not provide guidance for international operations or for domestic operations affected by the international competition and costs.

The economic criticality of foreign exchange rate fluctuations is reflected by the volatility of reported international construction profits. For example, in 1986, a US contractor with profit expectation in US dollars of about 4.5 percent (Engineering News Record, 7/16/87) could see its US dollar contracted profits wiped away, following the sharp decline by over 20 percent in the nominal and real value of the US dollar between 1985 and 1986. In contrast, it could have realized substantial nominal and real gains in US dollars, if its profit was contracted in currencies that appreciated vis a vis the US dollar during the same period of time.

Expectations about exchange rate changes can be incorporated in (a) construction estimating and bidding models, which analyze direct and indirect costs and help determine the markup, profit and optimum bid for a project, using deterministic or probabilistic approaches (Rosenshine,1972; Vergara,1977; Adrian, 1982) ; (b) construction risk analysis models, which deal with the variability of future construction cash flows, due to endogenous and exogenous to the project factors and use portfolio and capital asset pricing theories to quantify the risk-return tradeoffs (Kangari, 1981; Au, 1983; Helfat, 1988) ; and (c) cost planning and monitoring models, such as the critical path method (CPM) and program evaluation and review technique (PERT), that provide future construction cash flow profiles dynamically integrated with the construction schedule, for analysis and management control decisions (Wiest et al., 1977; Sears, 1981).

This chapter defines and discusses separately the accounting and economic aspects of foreign exchange exposure. The economic issues of foreign exchange risk are also considered in the context of their long-term impact on the competitiveness of international construction firms. It becomes apparent from the discussion that the exclusive focus on accounting exposure, associated with the need to report translation gains and losses in the contractor's financial statements, can underestimate the true economic impact of foreign exchange risk, and prevent the contractor from incorporating foreign exchange risk into its project selection and operational decisions. Finally, the fundamental theoretical question of whether foreign exchange exposure should be managed at all is also examined. By management of foreign exchange exposure we mean the systematic evaluation of what is exposed, and the decision on how to deal with exposures. Such an evaluation does not necessarily imply covering an exposed position. Dufey et al. (1984) summarized the arguments for both views and presented their case for corporate management of foreign exchange risk. These arguments are evaluated here for international construction.

2.1 Construction Firm Accounting Exposure

The denomination of balance sheet and income statement items in a variety of currencies compounds the endogenous and exogenous problems of international construction business. Foreign exchange risks became more visible with the introduction of floating rates in the early 1970s. Since then, exchange risk reporting has become more crucial for the understanding of the value of corporate assets. One of the important tasks of the construction treasurer, is to identify the different perspectives of accounting exchange risk, analyze and measure the exposure using appropriate assumptions, so that financial statements reflect the firm's overall exposure (including economic) as accurately as possible. This section discusses the sensitivity of international construction firms' financial statements to foreign exchange rate changes (2.1.1) and the current foreign currency translation practices (2.1.2).

2.1.1 Sensitivity of Financial Statements

Accounting exposure becomes visible when local currency assets and liabilities are translated to the functional currency for consolidation with the parent's financial statements. Construction firms are required under FASB (Financial Accounting Standards Board) No.52 to translate their local financial statements to their home currency using rules dependent on their functional currency. The functional currency is defined as the one that is most relevant to the contractor's business. If overseas operations are considered extensions of the parent company, the functional currency is the US dollar ("domestic" currency). However, if foreign projects' costs and revenues are heavily influenced by other currencies, a foreign currency may be "functional". The foreign "functional" currency may be the currency of host country ("local" currency) or even the currency of a third country (Choi et al., 1984).

The accounting exposure can be analyzed through the financial statements. Gains and losses from currency translations are typically reported. The magnitude and extent of translation losses depend on the translation method used. It is important to state that accounting exposure and gains/losses of this type do not necessarily relate to the value of future cash flows and, therefore, may or may not indicate economic exposure of the firm. It is also important to restate that economic exposure of an international construction firm can in fact be more or less serious than financial statements may indicate. Table 2.1 provides an illustration of the impact of accumulated translation losses on the financial ratios of an international construction firm.

TABLE 2.1

IMPACT OF TRANSLATION ADJUSTMENTS ON FINANCIAL RATIOS
OF CONSTRUCTION COMPANY

(thousands of dollars)

		Scenario 1 loss	Scenario 2 neutral	Scenario 3 gain
Net Income After Taxes	a	$11,257	$11,257	$11,257
Translation Adjustment	b	($4,504)	$0	$4,504
Total Assets	c	$362,141	$366,645	$371,149
Long-Term Debt	d	$39,774	$39,774	$39,774
Shareholders' Equity	e	$118,233	$122,737	$127,241
Return on Assets (ROA)	f	3.1%	3.1%	3.0%
Return on Equity (ROE)	g	9.5%	9.2%	8.8%
Return on Investment (ROI)	h	7.1%	6.9%	6.7%
Debt/Equity Ratio (D/E)	i	2.06	1.99	1.92

Notes : (1) ROA : f = a/c
ROE : g = a/e
ROI : h = a/(d+e)
D/E : i = (c-e)/e

(2) Scenario 1 relates to actual data.
Scenarios 2 and 3 relate to hypothetical data regarding translation adjustment in row b.

Source : From the 1987 Annual Report of an International Construction Corporation.

2.1.2 Example of Accounting Exposure Measurement

The reporting of gains and losses due to foreign exchange positions can be a very complex and time consuming job. Although accounting exposure does not constitute the focus of this thesis, we will briefly outline the alternative methods of translation with a numerical example. Tables 2.2A, 2.2B and 2.2C provide a simplified illustration of what could be the result of three alternative translation procedures of a Canadian subsidiary of a US construction firm. All three scenarios are consistent with the FASB 52 standard accounting procedures. The difference among them is the assumption about the "functional currency, i.e., the currency of the primary economic environment in which the company does its business. The original financial statements are in Canadian dollars. The "functional" currency is assumed to be the Canadian dollar, the US dollar and the British pound respectively in each of the three scenarios. FASB No.52 has a different translation procedure for each of the above assumptions: The "current", "temporal" and a combination of the "current" and "temporal" methods are used to translate the financial statements in US dollars.

The resulting versions of the financial statements in US dollars have differences both in the expressed value of the items reported, as well as the financial ratios resulting from them (return on assets, equity and investment). These observations reinforce the concerns about the value of accounting information, which is historical in nature and subject to questionable assumptions, for economic and business decisions which are future oriented. In specific, the ability to draw economic information about the value of its future cash flows, and, therefore, about the value of the firm from its accounting data is questioned.

TABLE 2.2

FINANCIAL STATEMENTS OF INTERNATIONAL CONSTRUCTION FIRM
UNDER DIFFERENT FUNCTIONAL CURRENCY SCENARIOS

TABLE 2.2A : Current Method of Translation

	Relevant Currency
Parent in U.S.A. :	US$
Foreign Subsidiary in Canada :	Can$
Statement in :	Can$
Functional currency :	Can$
FASB 52 guidelines :	Translate Can$ to US$ using Current Method

1. BALANCE SHEET	31-Dec-83	31-Dec-84 Can$	Ex. Rate	31-Dec-84 US$	
Assets					
Cash	10,000	9,500	0.76	7,189	
A/R	25,000	24,500	0.76	18,541	
Other cur.assets	10,000	9,500	0.76	7,189	
Net fixed assets	20,000	19,000	0.76	14,379	
Total assets	65,000	62,500		47,298	
Liabilities					
A/P+other c.liab.	37,000	33,500	0.76	25,352	
Long-term debt	6,000	5,800	0.76	4,389	
Capital stock	20,000	19,000	0.82	15,580	
Retained earnings	2,000	4,200		2,697	
Translation adj.(cum.)				(720)	
Total liab. + S.E.	65,000	62,500		47,298	
2. INCOME STATEMENT		31-Dec-84 Can$		US$	US$
Sales		50,000	0.77		38,567
Expenses					
Cost of sales	30,000		0.77	23,140	
Depreciation	5,000		0.77	3,857	
Other	7,000	42,000	0.77	5,399	32,397
Operating income		8,000			6,171
Income taxes		2,800	0.77		2,160
Net income		5,200			4,011
Ret.earnings 12/31/83		2,000			1,000
Dividends		3,000	0.77		2,314
Ret.earnings		4,200			2,697
Return on Assets	8.5%				
Return on Equity	22.8%				
Return on Investment	18.3%				

(Table 2.2a cont'd)

COMPUTATION OF TRANSLATION ADJUSTMENT

1. Cumulative (to 12/31/83) Translation Adjustment

Net Assets (Cap.Stock+Ret.Earnings), 12/31/83				Can$	22,000
Exchange Rate, 12/31/83				US$/Can$	0.80
				US$	17,679
Le (as reported stockholders equity, 12/31/83)					
Capital Stock		20,000	0.82	16,400	
Retained Earnings				1,000	17,400
					279

2. Current Year's (1984) Adjustment

Net Assets (Cap.Stock+Ret.Earnings), 12/31/83				22,000	
Change in current rate during year 1984					
Rate, 12/31/83	US$/Can$	0.80			
Rate, 12/31/84	US$/Can$	0.76		(0.05)	(1,030)
Change in Net Assets during year 1984 (Net Income--Dividends)			Can$	2,200	
Difference Between Average and Year-End rate:					
Average Rate	US$/Can$	0.77			
Year End Rate	US$/Can$	0.76		(0.01)	(32)
					(783)

TABLE 2.2B : Temporal Method of Translation

		Relevant Currency
Parent in U.S.A.	:	US$
Foreign Subsidiary in Canada	:	Can$
Statement in	:	Can$
Functional currency	:	US$

FASB 52 guidelines : Translate Can$ to US$ using Temporal Method

1. BALANCE SHEET	31-Dec-83	31-Dec-84		
Assets				
Cash	10,000	9,500	0.76	7,220
A/R	25,000	24,500	0.76	18,620
Other cur.assets	10,000	9,500	0.76	7,220
Net fixed assets	20,000	19,000	0.77	14,630
Total assets	65,000	62,500		47,690
Liabilities				
A/P+other c.liab.	37,000	33,500	0.76	25,460
Long-term debt	6,000	5,800	0.76	4,408
Capital stock	20,000	19,000	0.82	15,580
Retained earnings	2,000	4,200		2,242
Translation adj. (cum.)				
Total liab. + S.E.	65,000	62,500		47,690

2. INCOME STATEMENT		31-Dec-84			
Sales		50,000	0.77		38,500
Expenses					
Cost of sales	30,000			23,320	
Depreciation	5,000		0.77	3,850	
Other	7,000	42,000	0.77	5,390	32,560
Operating income		8,000			5,940
Aggregate translation gain (loss)					348
Income taxes		2,800	0.77		2,156
Net income		5,200			4,132
Ret.earnings 12/31/83		2,000			420
Dividends		3,000	0.77		2,310
Ret.earnings		4,200			2,242

(Table 2.2b cont'd)

Return on Assets	8.7%
Return on Equity	23.2%
Return on Investment	18.6%

1. COST OF SALES

Beginning inventories	3,500	0.81	2,835	IV 1983
Purchases	34,500	0.77	26,565	AV.1984
	38,000		29,400	
Ending inventories	8,000	0.76	6,080	IV 1984
	30,000		23,320	

2. EXCHANGE GAIN (LOSS)

2a. Monetary assets 12/31/83	35,000		
Monetary Liabilities 12/31/83	43,000		
	(8,000)		
Change in Ex.Rate		(0.05)	375

2b. Change in net monetary position

12/31/83	(8,000)
12/31/84	(5,300)
	2,700

Composition of change			
Sources of monetary items			
Net Earnings	5,200		
Depreciation	5,000		
	10,200	(0.01)	(102)
Uses of monetary items			
Increase in invent.	(4,500)		
Dividends	(3,000)		
	(7,500)	(0.01)	75

2c. Aggregate translation adjustment 348

TABLE 2.2C : Current and Temporal Method of Translation

		Relevant Currency
Parent in U.S.A.	:	US$
Foreign Subsidiary in Canada	:	Can$
Statement in	:	Can$
Functional currency	:	Sterling Pound
FASB 52 guidelines	:	Remeasure to Sterling Pound using Temporal Method Translate Sterling Pound to US$ using Current Method

1. BALANCE SHEET	31-Dec-83	31-Dec-84						
	Can$	Can$	£/Can$	£	£	US$/£	US$	
Assets								
Cash	10,000	9,500	0.65	6,544	6,216	1.33	8,241	
A/R	25,000	24,500	0.65	16,359	16,032	1.33	21,252	
Other cur.assets	10,000	9,500	0.64	6,363	6,045	1.33	8,013	
Net fixed assets	20,000	19,000	0.56	11,200	10,640	1.33	14,105	
Total assets	65,000	62,500		40,466	38,933		51,611	
Liabilities								
A/P+other c.liab.	37,000	33,500	0.65	24,212	21,921	1.33	29,059	
Long-term debt	6,000	5,800	0.65	3,926	3,795	1.33	5,031	
Capital stock	20,000	19,000	0.56	11,200	10,640	1.60	17,024	
Retained earnings	2,000	4,200		1,128	2,577		3,462	
Translation adj. (cum.)							(2,966)	
Total liab. + S.E.	65,000	62,500		40,466	38,933		51,611	
2. INCOME STATEMENT		31-Dec-84						
Sales		50,000	0.58		29,225	1.35		39,454
Expenses								
Cost of sales	30,000			16,997		1.35	22,946	
Depreciation	5,000		0.58	2,922		1.35	3,945	
Other	7,000	42,000	0.58	4,091	24,011	1.35	5,524	32,415
Operating income		8,000			5,214			7,039
Aggregate translation gain (loss)						(614)	1.35	
Income taxes		2,800	0.58		1,637	1.35		2,209
Net income		5,200			2,963			4,829
Ret.earnings 12/31/83		2,000			1,367			1,000
Dividends		3,000	0.58		1,753	1.35		2,367
Ret.earnings		4,200			2,577			3,462

(Table 2.2c cont'd)

Return on Assets	9.4%
Return on Equity	27.6%
Return on Investment	21.4%

1. COST OF SALES

Beginning inventories	3,500	0.55	1,922	IV 1983
Purchases	34,500	0.58	20,165	AV.1984
	38,000		22,087	
Ending inventories	8,000	0.64	5,090	IV 1984
	30,000		16,997	

2. EXCHANGE GAIN (LOSS)

2a. Monetary assets 12/31/83	35,000		
Monetary Liabilities 12/31/83	43,000		
	(8,000)		
Change in Ex.Rate		0.10	(803)

2b. Change in net monetary position

12/31/83	(8,000)
12/31/84	(5,300)
	2,700

Composition of change			
Sources of monetary items			
Net Earnings	5,200		
Depreciation	5,000		
	10,200	0.07	713
Uses of monetary items			
Increase in invent.	(4,500)		
Dividends	(3,000)		
	(7,500)	0.07	(524)
2c. Aggregate translation adjustment			(614)

(Table 2.2c cont'd)

COMPUTATION OF TRANSLATION ADJUSTMENT

1. Cumulative (to 12/31/83) Translation Adjustment

Net Assets (Cap.Stock+Ret.Earnings), 12/31/83			BP$	12,328
Exchange Rate, 12/31/83			US$/BP$	1.45
			US$	17,883
Less (as reported stockholders equity, 12/31/83)				
Capital Stock	11,200	1.60	17,920	
Retained Earnings			1,000	18,920
				(1,037)

2. Current Year's (1984) Adjustment

Net Assets (Cap.Stock+Ret.Earnings), 12/31/83			12,328	
Change in current rate during year 1984				
Rate, 12/31/83	US$/BP$	1.45		
Rate, 12/31/84	US$/BP$	1.16	(0.29)	(3,626)
Change in Net Assets during year 1984 (Net Income--Dividends)	BP$		1,209	
Difference Between Average and Year-End rate:				
Average Rate	US$/BP$	1.33		
Year End Rate	US$/BP$	1.16	(0.17)	(205)
				(4,867)

Exchange Rates used in Tables 2.2a, 2.2b, 2.2c.

Year	Month	Can$/US$	US$/£	US$/Can$	Can/£	£/Can
83	10	1.2325	1.4953	0.8114	1.8430	0.5426
	11	1.2392	1.4647	0.8070	1.8151	0.5509
	12	1.2444	1.4506	0.8036	1.8051	0.5540
84	1	1.2493	1.4035	0.8004	1.7534	0.5703
	2	1.2520	1.4890	0.7987	1.8642	0.5364
	3	1.2765	1.4426	0.7834	1.8415	0.5430
	4	1.2845	1.3965	0.7785	1.7938	0.5575
	5	1.2946	1.3852	0.7724	1.7933	0.5576
	6	1.3194	1.3527	0.7579	1.7848	0.5603
	7	1.3114	1.3060	0.7625	1.7127	0.5839
	8	1.2974	1.3107	0.7708	1.7005	0.5881
	9	1.3180	1.2480	0.7587	1.6449	0.6080
	10	1.3147	1.2174	0.7606	1.6005	0.6248
	11	1.3240	1.1994	0.7553	1.5880	0.6297
	12	1.3214	1.1565	0.7568	1.5282	0.6544
Average Rates						
IV,83		1.2387	1.4702	0.8073	1.8210	0.5492
IV,84		1.3200	1.1911	0.7576	1.5722	0.6363
84		1.2969	1.3256	0.7713	1.7171	0.5845

Source : IMF, Int'l Fin. Statistics, 1985

In brief, the following are concluded from the study of accounting exposure measurement techniques:

(a) The data of an international firm's financial statements are a function of the translation method used and the adopted "functional" currency. Although the selection of the "functional" currency is not arbitrary, it potentially introduces inaccuracies about the value of the firm.

(b) The selection of a "functional" currency for reporting purposes does not address situations in which different components of economic exposure may be denominated in different "functional" currencies (work item dimension).

(c) The "functional" currency may vary over time. However, international firms may not have the flexibility to readjust their accounting procedures in line with such real economic changes (time dimension). In other words, the value of cash flows over time is not addressed properly, with implications for the computation of the value of the project/firm.

2.2 Construction Firm Economic Exposure

In this section, the contractor's economic exposure are conceptually contrasted to their accounting exposure. The critical factors contributing to the economic exposure of construction business, including the deviations from purchasing power parity (PPP), government tax policies and the existence of noncontractual cash flows, in addition to contractual, in international projects.

2.2.1 Definition of Economic Exposure in International Construction

Economic exposure arises when the present value of a project or a firm's future cash flows are affected by currency value fluctuations. From a project investor's viewpoint, exchange rate fluctuations can affect:

(a) the value of a project's or company's cash flows, and

(b) the distribution of these cash flows (change in the risk profile)

Short-term economic exposure may arise when a contract to sell project related services is made in a currency and the currency appreciates or depreciates before payment is made (gain or loss respectively). Depending on the time lapse between the time the agreement is made and the payment, the international contractor may or may not be able to hedge cost-effectively in forward currency and options' markets against this transaction exposure, as these markets typically cover short- term transactions. Other than financial hedging approaches have to be used to cover contractual medium to long-term transactions.

Long term economic exposure of construction related operations is much more complex and requires detailed knowledge of the company's operations and their sensitivity to exchange rate changes. This type of exposure is becoming more important with the increasing involvement of construction firms in project financing schemes, especially if they get locked to some type of equity position.

Among the key considerations when dealing with economic exposure in international projects are:

(a) Construction firm shareholders are interested in the purchasing power of anticipated project and company cash flows. If nominal changes in exchange rates are offset by relative price changes, real exchange rates remain effectively unchanged, purchasing power parity holds and, therefore, no real exchange risk exists. However, PPP does not always hold at the aggregate or industry (including construction) level. Deviations from PPP lead to real exchange rate changes and result in real, economically important exchange gains or losses.

(b) Economic risk may not be identifiable in a contractor's financial statements. For example, companies having an overvalued functional currency may be prevented from winning new contracts and, as a result, the volume of their international work may decrease. In addition, profit margins are also likely to be reduced for such companies. Such an occurrence will have an accounting exposure element and an impact on financial statements, as no sales will be recorded and profits will be reduced. However, the most important underlying exposure and risks in such cases are economic, fundamentally different from accounting exposure and risks : the ability of the company to keep its market share in the future is at stake. It is important, therefore, to go beyond the financial statements in order to identify the economic exposure of a construction firm.

2.2.2 Factors Contributing to Economic Exposure

A major factor contributing to economic exposure has already been defined sufficiently for the scope of this dissertation : it is the often observed deviations from purchasing power parity. As we have seen, relative changes in prices not reflected in exchange rates give rise to real exchange risks. Economic exposure and real currency risks are equally if not more important under fixed rates systems, where relative price changes are typically not followed by moves of exchange rates. This is against what may be conventional wisdom, that is that fixed rates may be preferable from a foreign exchange exposure perspective.

Studies on the cost of individual commodities suggest that the costs of nodifferentiated traded goods (like steel) may respond quickly to exchange rate changes while costs of differentiated traded goods (like electronic equipment) and nontraded goods (like labor) tend not to respond quickly. This is a failure of the Law Of One Price and of the Purchasing Power Parity doctrine, with economic consequences for international firms.

Even when PPP does hold at the aggregate level (i.e., if exchange rate changes are consistent with aggregate inflation rate differentials), a construction project and firm may be exposed to real exchange risks, if the price changes facing the firm differ from the price changes in the national economy, or even from the aggregate price changes in the industry. This is a usual phenomenon. For example, construction costs in the United States rose at an annual rate of 3.4 percent between 1983 and 1985, while the annual national rate of inflation was at 1.6 percent. During the same period, construction material prices rose at the annual rate of about 2.1 percent (Construction Review, 5/86).

Another factor introducing economic exposure relates to government tax policies. More specifically, assuming that PPP holds, the taxation of nominal rather than real income alters real cash flows of a project/firm. If the foreign affiliate of a construction company has debt in its base currency and the base currency depreciates in line with inflation (no real exchange rate change), the taxation of nominal interest paid for the debt results in taxable gains for the foreign affiliate although the real value and cost of the debt may not have changed.

An important categorization of a project's cash flows is that of contractual versus noncontractual. Contractual cash flows are fixed in nominal currency terms and their exposure is measured with the nominal value of exchange rates. These cash flows include debt, accounts payable, accounts receivable, long term leases, labor contracts and other contracted items. Noncontractual cash flows fluctuate in keeping with market conditions and their exposure is measured with the real rate, i.e., the nominal adjusted for inflation. They include future costs not covered by current contracts and prices of goods to be sold in the future.

A construction firm's project cash inflows are typically contractual in nature. The contractor very often agrees to perform the job on a lump sum or guaranteed maximum price basis. Most construction firms will subcontract part of the work at a later time and will normally pass the owner's policies to their subcontractors. Nevertheless, there is an obvious difference in the degree of certainty between the owner/contractor and contractor/subcontractor agreements due to their relative timing. The owner/contractor contractual agreement is reached a little before the commencement of construction and is subject to changes in the future after negotiations. The contractor/subcontractor agreements are reached at a later time under changing conditions in the dynamic environment of the international construction process.

The bid to the owner usually reflects surveys of subcontractors and expectations of costs based on these surveys as well as on historical cost data. At any point in time of a project, the contract amount agreed with the owner is contractual in nature, while the subcontract amounts are contractual for work items purchased and noncontractual for work items not purchased. Costs of items purchased toward the beginning of the project (like excavations and foundations) will normally tend to be more predictable than those of items purchased towards the end of the project (like roofing).

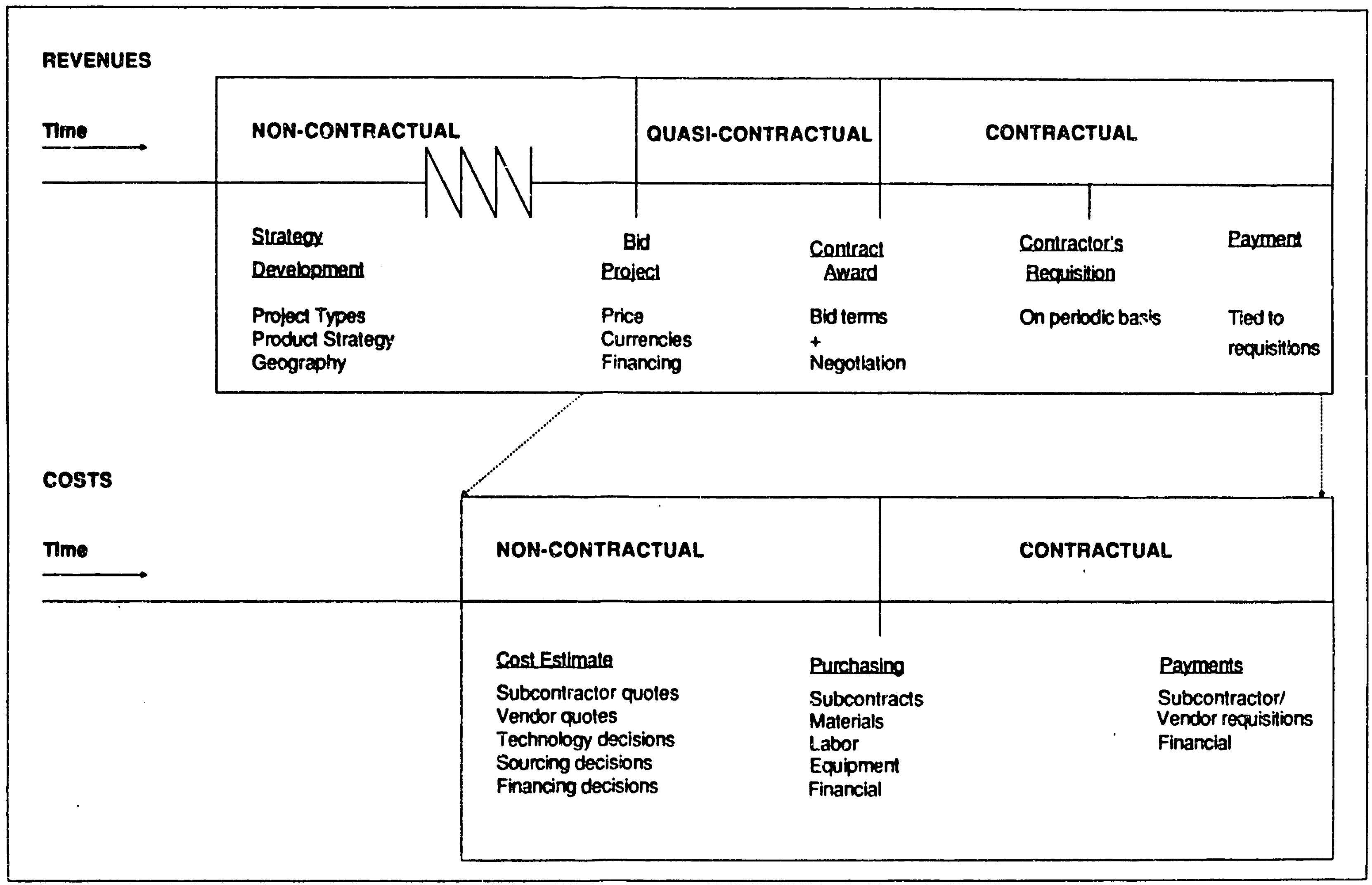
Therefore, contractual cash flows typically relate to short- and medium-term parts of a project. Currency exposure of contractual cash flows increases as projects tend to be long in duration. It is usual for international projects to last more than two or three years. Some superprojects have lasted for more than ten years. In such cases, there is a clear element of uncertainty over the real value of cash flows expected beyond the six month one year range of the invoice type of foreign currency exposures. There is also increasing difficulty to hedge against currency fluctuations as the timing of these cash flows goes beyond the near future.

Economic exposure, whether contractual or noncontractual, becomes more important in projects where the contractor gets involved beyond the construction phase. Contractors increasingly arrange financing and participate in the operation and maintenance of projects they build in international markets. Such longer term commitments may contain elements of contractual exposure, for the part of the project's cash flows that is contractually predefined in nominal terms. Most often these projects will also be characterized by noncontractual exposure when the business depends on revenues which are subject to future market conditions. The risk here is twofold: both the income itself and the value of the currency of its denomination are uncertain.

Figure 2.1 shows in a simplified fashion the timing of contractual and noncontractual exposures in international projects. The framework presented in it is rather general, but nevertheless illustrates the potential complexity arising from the existence of noncontractual exposures. Of course, reality can be more complex. Projects

FIGURE 2.1

EXCHANGE RATE EXPOSURE IN INT'L PROJECTS : GENERAL TIME FRAME



that tie a construction firm beyond the construction phase into its operation, because of financing arrangements or equity participation, may have long-term noncontractual components that increase substantially the project's risk. But even within the construction phase, change orders, for example, can introduce significant non- or quasi-contractual cash flows.

The conclusion is that noncontractual cash flows can be economically important and, therefore, require special attention beyond the standard analysis of contractual cash flows.

2.3 Exchange Rates and International Competitiveness

This section discusses the link between exchange rates and international competitiveness. It uses an industry analysis framework that accounts for the forces driving the international competition in construction, and focuses on the exchange rate relevance of these forces.

The framework is adapted from Porter (1980), and includes the following forces that drive the competition among existing rival firms :

(a) the suppliers of construction inputs,

(b) the buyers of construction services,

(c) the potential new competitors, and

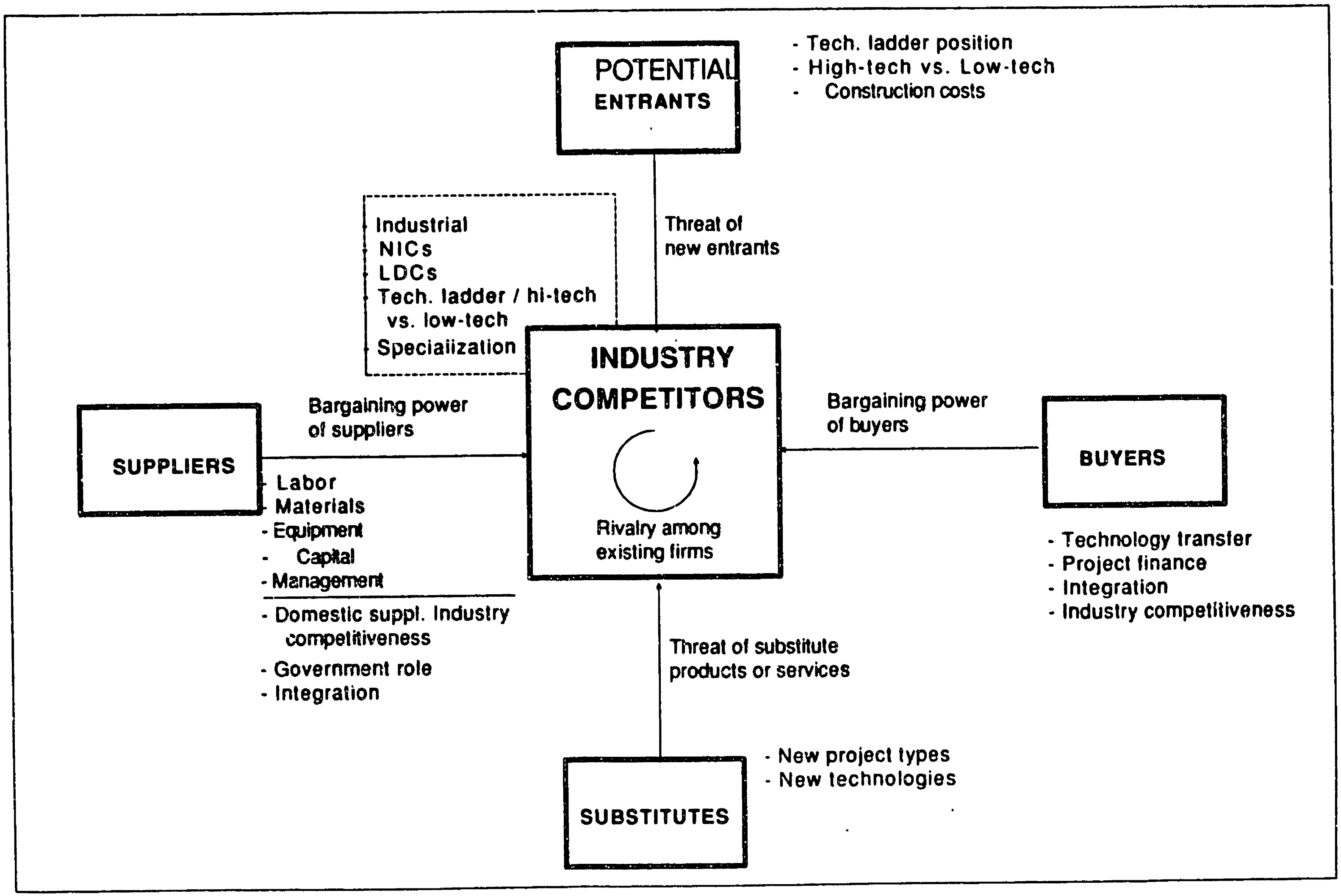
(d) the substitutes for construction services.

Figure 2.2 illustrates the generic concept of forces driving the competition with construction related comments which are briefly discussed below.

FIGURE 2.2

INDUSTRY ANALYSIS: FORCES DRIVING INDUSTRY COMPETITION

(adapted from M. Porter, 1980)



2.3.1 The Existing Rival Firms

The existing rival firms are a major component of the competition. The data of table 2.3 clearly suggest that the international competition is mainly concentrated among the developed countries, such as the United States, the European Economic Community and Japan. Together with South Korea, these countries accounted for over 90 percent of the contracts awarded.

The reported data also imply the specialization of companies in types of projects, and reveals that companies from developed industrial countries are most successful in types of projects with significant technological component or projects that require turnkey integration and project management skills (Demacopoulos, 1985; Engineering News Record, 7/15/82). Know-how and complexity are the most important characteristics of these projects. In contrast, developing countries are more successful in simple-technology projects where cost-minimization and experience in well known, traditional construction processes are sufficient to become successful. In other words, firms from industrial countries compete at the top, while firms from developing countries compete at the bottom of the technological ladder.

Many developing countries, after developing their infrastructure facilities to satisfy their basic needs, have committed themselves to the objective of industrialization. Therefore, they gradually move to the construction of industrial, power, chemical and particularly petrochemical plants, which are highly dependent on high technology. For these projects, bidders are routinely invited from countries mature and experienced in the related technologies. Most of the times, the contracts cover all the phases of the project's cycle, i.e., its design, construction and installation of the equipment. U.S. contractors, with the assistance of the related industries have a decisive advantage in these markets. It

TABLE 2.3

RECIPIENTS OF INTERNATIONAL CONTRACTS, 1982-1987

Current Billion $	1982	1983	1984	1985	1986	1987
American	44.9	29.4	30.7	28.2	22.6	18.1
Japanese, Korean	23.1	19.1	13.9	16.4	12.0	12.0
European	46.5	38.1	29.9	32.6	33.7	39.7
All Other	8.6	7	6.1	4.4	5.6	4.1
Total	123.1	93.6	80.6	81.6	73.9	73.9
1980 Billion $	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**
American	39.5	25.5	26.1	23.7	19.3	15.1
Japanese, Korean	20.3	16.6	11.8	13.8	10.2	10.0
European	40.9	33.0	25.4	27.4	28.7	33.1
All Other	7.6	6.1	5.2	3.7	4.8	3.4
Total	108.2	81.2	68.4	68.5	63.0	61.7
PPP of US dollar	0.879	0.867	0.849	0.840	0.852	0.835
Percentages	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**
American	36.5	31.4	38.1	34.6	30.6	24.5
Japanese, Korean	18.8	20.4	17.2	20.1	16.2	16.2
European	37.8	40.7	37.1	40.0	45.6	53.7
All Other	7.0	7.5	7.6	5.4	7.6	5.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source : Engineering News Record, Annual Top International Contractor Issues, 1983-1988.

is characteristic that Saudi Arabia does not invite contractors from countries other than the United States for some types of high technology projects, while also requiring that U.S. participation in joint ventures be at least 50 percent in other types.

Foreign Exchange Relevance

The national origin of competitors and the status of their domestic currency are very important in international competition. The purchasing power of their currency in domestic and international markets determines the competitiveness of the firm in pricing and winning jobs, as well as in making a reasonable profit on them. In addition to this static, project focused impact of real exchange rates, the home country's macroeconomic policies towards its currency affect the long-term competitiveness of the construction industry. A sustained rise of a company's base currency real value vis a vis the currencies of competitors, adversely affects a company's competitive costs, sales, profits. Eventually, it affects its market share and the present value of the firm.

In recent years, governments of industrial countries have been negotiating and implementing policies towards coordinating their monetary and fiscal policies. Exchange rates have been part of the coordination policies. From the US perspective, the decrease of the dollar's value vis a vis other major currencies has made US contractors more competitive, because their costs have declined in nominal and real terms. This is a valid conclusion only for those firms that have not lost market share through the long years of persisting strong US dollar. Recapturing market share is not as easy as changing exchange rates. In addition, the weakening of domestic currency decreases the project financing and foreign aid potential that contributes to international competitiveness in LDCs. Japan for the first time aggressively provides foreign aid on the basis of its stronger yen and will shortly surpass the United States in it. The popular press reported that Japan will provide $9.6 billion against $9.0 billion of the US (Business Week, 2/6/1989). This came as an unpleasant negative side effect of the dollar's weakness for US contractors.

A number of countries with large share in international construction do not participate in the currency rate coordination process, or in other official international processes (e.g. General Agreement on Trade and Tariffs, GATT). The South Korean won, for example, has not appreciated as heavily as the French, German and Japanese currencies. As a result, S.Koreans maintain some of the competitive advantage associated with their home currency that the Japanese and Europeans may have lost.

2.3.2 The Suppliers

The suppliers to the construction industry provide the various inputs in the construction process, including labor, materials, equipment, management and finance. They are product vendors or subcontractors to the general contractor. All inputs can be sourced globally and transported to the project site. The markets are most competitive globally, and less competitive when constrained to local industries. However, in practice it is easier to coordinate resources if the domestic market can provide most or all of the inputs at competitive prices. The competitiveness of the construction industry is linked to the competitiveness of the supplier industries in costs and technologies.

Getting a big job internationally often demands the integration of a variety of resources that come from different industries with varying governmental involvement. Sometimes, the role of the government in the process is critical. The government is the supplier of the glue that sticks it all together and helps the firm get the job. U.S. administrations have been traditionally reluctant to play that role. International trade agreements are increasingly directing services towards free trade rules. Those that sign these agreements will have to comply or show that they comply. One should keep in mind, however, that a lot of developing countries (e.g. South Korea) do not participate in such international organizations and are, therefore, excluded from the resulting obligations.

Foreign Exchange Relevance

Construction bids are derived from cost estimates that analyze the resource requirements and unit prices of the various project inputs (labor, materials, equipment etc.). Therefore, they are heavily dependent on the prices set by vendors and subcontractors in domestic and international markets and on the negotiating power of these suppliers.

The suppliers' negotiating power depends on the competitive structure (how many firms compete, how differentiated the products are) of the industries that constitute the backward linkages to the construction industry. The international economics literature and research indicate, that price trends can be linked to exchange rate trends based on the competitive structure of the supplying industry. Construction suppliers can be anywhere from perfect (e.g. globally priced materials) to oligopolistic (e.g. contractually forced local procurement) competitors.

The contractor's currency exposure is increased by noncontractual early arrangements with vendors and subcontractors in the process of generating cost estimates. Even when a formal agreement precedes the offer to the client, the stability of prices depends on the leverage of the involved parties.

The client forced cost/ revenue structure issue, as it results from the obligation to locally source inputs to the construction process, was discussed in previous sections. Cash flows affected by such arrangements are exposed to currency rate changes. In addition, such cash flows are also subject to price changes due to the oligopolistic power often possessed by local suppliers.

2.3.3 <u>The Buyers</u>

The sources of international contracts have been discussed in chapter 1 and are also summarized in table 2.4. As already commented, following a record high volume of work awarded in 1981, we observe a sharp decline in international contract awards and a shift towards European and North American markets. The question to be asked is how the buyers of construction services influence the competition with their requirements and negotiating power. Two major areas where the buyers are increasingly influencing the competition in the last few years are the local participation and project financing.

Local participation is important because of the technology transfer and hard currency savings involved. Technologically, the indirect, long-term perceived benefit is the development of the technological capability of the developing country that awards the contract. The direct, short- and medium-term benefits include the capability of the recipient country to operate and maintain the project, the ability to increase its value-added contribution in future projects, and the possibility of exporting at similar services. In other words, the possibility of the recipient country to graduate to the higher levels of the technology ladder in international competition. Of course, such technology transfer benefits may not be cost-effectively transferrable. Equally important are the hard currency

TABLE 2.4

SOURCES OF INTERNATIONAL CONTRACTS, 1980-1987

Current Billion $	1980	1981	1982	1983	1984	1985	1986	1987
Mideast	83.9	87.3	51.2	33.0	26.6	21.6	16.1	13.4
Asia	30.1	38.9	23.5	15.4	18.3	17.8	17.3	15.5
Africa	32.3	43.7	17.7	21.4	12.5	15.3	13.1	9.0
Europe	21.5	20.1	11.1	9.5	9.2	10.2	11.9	17.2
North America	15.1	11.7	9.3	8.0	8.5	10.0	10.4	11.5
Latin America	32.3	34.2	10.3	6.3	5.4	6.6	5.2	7.4
Total	215.0	235.9	123.1	93.6	80.5	81.5	74.0	74.0

1980 Billion $	1980	1981	1982	1983	1984	1985	1986	1987
Mideast	83.9	80.0	45.0	28.6	22.6	18.1	13.7	11.2
Asia	30.1	35.7	20.7	13.4	15.5	15.0	14.7	12.9
Africa	32.3	40.0	15.6	18.6	10.6	12.9	11.2	7.5
Europe	21.5	18.4	9.8	8.2	7.8	8.6	10.1	14.4
North America	15.1	10.7	8.2	6.9	7.2	8.4	8.9	9.6
Latin America	32.3	31.3	9.1	5.5	4.6	5.5	4.4	6.2
Total	215.0	216.0	108.2	81.2	68.3	68.5	63.0	61.8
(PPP of US dollar	1.000	0.916	0.879	0.867	0.849	0.840	0.852	0.835)

Percentages	1980	1981	1982	1983	1984	1985	1986	1987
Mideast	39.0	37.0	41.6	35.3	33.0	26.5	21.8	18.1
Asia	14.0	16.5	19.1	16.5	22.7	21.8	23.4	20.9
Africa	15.0	18.5	14.4	22.9	15.5	18.8	17.7	12.2
Europe	10.0	8.5	9.0	10.1	11.4	12.5	16.1	23.2
North America	7.0	4.9	7.6	8.5	10.6	12.3	14.1	15.5
Latin America	15.0	14.5	8.4	6.7	6.7	8.1	7.0	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source : Engineering News Record, Annual Top International Contractor Issues, 1981-1988.

savings with the local procurement of products and services. The issue has already been sufficiently discussed.

Project finance has become extremely important because of the lack of funds facing many construction firm client countries. To list a few categories of such countries, we have the oil exporters, the indebted countries and those that have never recovered from the recession. Project owners are often asking contractors to help finance all or part of the project. Engineering News Record reported that over two thirds of requests for proposal in 1984 in 1985 required contractors to bid both specifications and financing.

Some U.S. firms have responded to the project finance challenge/ opportunity with the development of project finance units or ad hoc initiatives (Bechtel has created its Bechtel Financing Services). The issue is hot, because U.S. firms complain that other countries' governments provide extensive financial support and export/ project financing services to their firms.

Foreign Exchange Relevance

The relationship between the owner/buyer is dominated by the evolving project related requirements of the world market and by the competitive structure of the construction industry. At the project level, for example, the owner/buyer may require that construction firms accept payment in local or other soft currency, recover their costs and make their profit from the operation of the project, or agree to any other form of innovative compensation instrument. Banks may also wish that the contractor participate and have a stake in the successful completion, maintenance and operation of the project. Contractors, especially non-US, sometimes propose such project financing procedures to gain competitive advantage.

The involvement in project financing increases the overall economic exposure and the exchange risks in particular, as the contractor becomes equity partner by force. There may be other side effects. By satisfying the owner's request for such a participation, the foreign contractor increases the possibility of future work in the same country. This is a good prospect. However, a long-term commitment to a foreign market carries economic implications with it. The value of the company gets tied to local exchange rates, especially if its business expands substantially to other non-construction activities with economic and business structures different from the construction industry.

2.3.4 The Potential Entrants

The potential entrants are a function of a firm's position on the technology ladder. Firms in the high technology market subsegment may have to worry about low technology firms moving up the ladder. For example, it could be a major problem for U.S. and European firms, if South Korean or other developing country construction industries get more of the "know-how" of such projects. It is well-known, for example, that Koreans were very aggressive in learning the secrets of heavy construction projects while working in joint ventures with U.S. firms in the Korean market.

Similarly those at the low end of the technology ladder have to worry about those potential competitors who are hardly on the ladder in the first place: countries that have one or more good skills or competitive advantages for construction but who have not yet been able to integrate them to get major jobs. As examples, I list India for its unique engineering manpower and skills and China for its disciplined, experienced and low cost workforce.

Foreign Exchange Relevance

Potential entrants set the long-term equivalent of today's competitive environment. They have to be considered in the context of the firm's specialization. If the expectation is that LDCs will graduate to the high technology construction, it must be expected that they will carry the exchange rate competitive advantages that they have today, unless these are cancelled by international economic events.

The impact that potential entrants have in terms of exchange rates is twofold. First, they directly affect the short-term competition with the exchange rate advantages that they may have. Second, they indirectly affect the long-term competition by changing the competitive structure of the industry and, therefore, the pricing and output decisions and the profitability of the firm.

The impact of potential entrants is increasingly felt in domestic markets. A construction firm does not have to go overseas for work to be considered "international", with all the implications stemming from such a strategy. If market and other (including currency) conditions are favorable, foreign companies may come to the domestic markets and compete for domestic projects. Again, this is a case where currency values affect the competitiveness of and become important to a broader segment of the domestic construction industry that was not until now concerned with them.

2.3.5 The Substitutes

Substitution in construction may occur when shifts occur from one type of projects to another (relative to a contractor's portfolio), because of change in macroeconomic trends (e.g. from transportation to energy related projects). It may also occur with the development of new technologies and processes that render traditional approaches to construction obsolete. Such changes affect the cost structure of the firm, as the project cost profiles change.

Foreign Exchange Relevance

Substitutes relate to exchange rates to the extent that new technologies and processes affect the traditional cost structures. New cost structures may have different currency exposures, as inputs may be used from new global sources and new competitive relationships develop.

2.4 The Construction Firm's Decision to Manage Foreign Exchange Risks

Construction firms involved in international projects are faced with the fundamental decision of establishing corporate policies regarding the management of their foreign exchange risks. Such corporate policies can range from "never hedge" to "always hedge". A variety of intermediate options is possible, including, for example, "hedge selectively", "maximum exposure to be hedged" and combinations. The levels of managing a contractor's exposure are at the strategic, operational and financial planning levels.

The literature of finance theory contains positions both in favor of (Dufey et al., 1983), as well as against (Shapiro, 1976) exchange risk management. The following subsections summarize the underlying assumptions and arguments of the debate, with focus on their applicability in construction projects and operations. It is proposed that, due to real-world imperfections, including information and transaction costs, construction firms should manage foreign exchange risks and selectively hedge their currency exposure.

2.4.1 Purchasing Power Parity

The theorem of purchasing power parity (PPP) has already been discussed in section 2.2 of this thesis. The finance literature provides reviews of the validity and applications of PPP in international operations. PPP is often used to argue against the management of foreign exchange risks.

PPP implies that foreign exchange rates move proportionately but in opposite direction with inflation. Therefore, price changes are reflected in exchange rate changes, and no real price change occurs. As a result, it is argued, hedging against foreign exchange risks is redundant, simply because there is no real foreign exchange risk.

In reality, PPP's validity in the context of construction projects is a function of the time frame, and of the relevance of construction industry and project related price trends to those of the national economy. In specific:

(a) General empirical evidence shows that PPP tends to hold better as the planning horizon increases. The adjustment between prices and exchange rates in not necessarily automatic. As a result, construction projects with relatively short planning horizons are subject to these fundamental deviations from PPP.

(b) Even when PPP does hold at the national economy level (i.e., exchange rate changes are consistent with price differentials measured by some aggregate price index such as the Wholesale Price Index), a construction project and firm may be exposed to real exchange rate risks, if the input and output price changes facing the construction industry differ from the average price changes of the national economy. This is also true if the price trends relevant to a project type are different from those of the construction industry as a whole.

The implication is that construction firms face real exchange risk due to deviations from PPP when any of the above situations applies, i.e., when the time horizon of the exposure does not provide for the fulfillment of PPP and when relevant prices simply never reach a PPP equilibrium. Persistent deviations from PPP can have a substantial (positive or negative) impact on the competitiveness of the firm.

As a result, construction firms should plan to deal with deviations from PPP and their impact on the firm's short-term cash flow and long-term competitiveness. While relevant to a construction firm's business PPP may hold in the long run, deviations from it justify the management of foreign exchange risks.

2.4.2 The Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) is also being used to question the need of hedging exchange risks. The CAPM analyzes a firm's risk in two components: the systematic (nondiversifiable) and the systematic (diversifiable) risk. The two basic arguments against hedging exchange risks evolve around this classification:

(a) If the exchange risk is systematic (nondiversifiable) and forward contracts reflect that, hedging does not reduce the firm's risk, therefore it does not add value to the firm. It simply moves the firm along the security market line.

(b) If the exchange risk is unsystematic (diversifiable), then the investors (shareholders) can diversify it away, when they decide, on their portfolio structure. The financial manager does not need to worry about it.

The essence of the above arguments is that, in the absence of imperfections, such as transaction costs and default risks, the value of forward currency contracts is zero. However, international construction financial managers often operate in countries with volatile exchange rates. The variability of cash flows can be high enough to stimulate perceptions of default risk.

Such perceptions of default risk carries at minimum two implications. First, potential investors are less inclined to invest in the project or firm. Second, the perceived relative riskiness of the project's cash flows decreases its debt capacity. In both cases, there is an upward trend in the cost of capital, whether it is equity or debt. Hedging against exchange risk to avoid bankruptcy appears to be in the interest of both the shareholders and the managers, although from different perspectives.

2.4.3 The Modigliani-Miller Theorem

The Modigliani-Miller theorem states that, in the absence of taxes, the corporate borrowing and hedging decisions are irrelevant to the firm's value. Investors can and should be allowed to do what the firm can do as far as borrowing and hedging is concerned. In the international field, investors can borrow or lend foreign currencies to hedge themselves against foreign exchange risks. Financial managers do not need to concern themselves with such transactions that are irrelevant to a project's value.

The relevance of this theorem in international construction is reduced by the size and structural barriers facing individual shareholders, as well as the information gaps between them and corporate managers. International construction firms typically have access to financial markets and instruments available only to customers of certain size and with international operations. In addition, construction firms have access to public organizations providing insurance instruments and financing that are not available to individual investors. Very often international projects are in one way or another subsidized and contractors protected by government agencies.

Most important, the individual shareholder can not hedge as effectively as the construction financial manager, because of the lack of information about a firm's exposure in a given project. Such information should include detailed cash flow projections and cost/currency integration with a critical path method based schedule. Such critical for the hedging decision information is often not available beyond the project managers and executives of a project and are typically subject to frequent changes. It is clear that the firm maintains superior information about its currency exposure.

Given these conditions, the MM theorem's indifference between corporate and individual hedging is questionable. Construction financial executives have better knowledge of the exposure and risks associated, as well as better access to lower cost financial instruments to hedge against them.

2.4.4 Market Efficiency

Market efficiency has been cited as reason for not managing foreign currency exposure (Shapiro, 1976). In specific, it has been argued that in the absence of market imperfections, hedging does not work in the long run, because of the associated costs of hedging. For example, forward contracts will be priced to reflect all available information. Similarly, soft currency borrowing will have higher interest rates associated with it (Interest Rate Parity). According to these arguments, a construction treasurer will not earn consistent profits from managing foreign exchange exposure with hedging instruments, unless imperfections exist and persist in international capital markets. Gains and losses will cancel each other over a long period of time and multiple international projects.

There are two reasons why this reasoning does not apply in international construction operations. First, construction firms often operate in less developed countries with substantial market imperfections. Such imperfections include restricted access to domestic capital markets and currency controls. Second, and most important, a construction treasurer's primary motivation for hedging would not be the possible gains from such transactions, but rather the maintenance of risk-return levels in line with corporate expectations and policies. Hedging foreign currency risks reduces the cash flow variances to those due only to construction related activities, i.e., those relevant to the firm's competitive advantage.

Unreasonable variability of construction cash flows due to currency fluctuations has a negative impact on the performance evaluation of cost engineers and financial managers. It reflects poor cash flow forecasting and can wipe the firms profits away. Therefore, construction managers have strong incentive to reduce any variance due to exchange risks. Stockholders may also be interested in reducing such variance, as excess profits from currency hedging in international projects may be subject to special taxes. Finally, bankers may have a stake in the reduction of cash flow variances, since it reduces the default risk (although, in the perfect world of no information and transaction costs bank shareholders can diversify on their own). Accordingly, the debt capacity of the project increases.

2.4.5 Purchasing Power Parity and the Shareholder Consumption

Assuming that purchasing power parity holds in the long run, and that shareholders consume goods from countries whose currencies are present in the construction cost/revenue structure, it can be argued that construction firm shareholders would (in the long run) be indifferent to exchange rate related nominal losses of wealth. The justification is that prices of foreign goods will reflect exchange rate changes, and, therefore, consumption (the ultimate goal of wealth) would not change.

There is no indication that construction firm shareholders' consumption bundle corresponds to the firm's exposure in its international projects. For instance, if the average shareholder is represented by the average US consumer, it is possible that its consumption bundle is more influenced by Japanese or other imports from Southeast Asia, while the firm's exposure may be in Middle Eastern or Latin American currencies. PPP relevant price changes are irrelevant to import consumption.

By the very nature of the industry, construction firms do not have the flexibility to match the geographic distribution of their projects with the consumption bundle of their shareholders. Construction project services and products are generated where the demand for them is. Shareholders may consume french wines, although there may be no significant construction activity in France for US firms. Even when construction and consumption bundling opportunities are substantial, restrictive host country policies limit the possibility of matching foreign currency exposure with shareholders' consumption. The obvious current example is the inability of US contractors to participate in Japanese projects (Wall Street Journal, 3/31/1988).

The legitimate conclusion is that construction firms can not effectively hedge the consumption bundle of their shareholders. The pragmatic alternative is to manage their foreign exchange exposure (unless, of course it can be shown that they can manage it themselves).

2.4.6 Uncertainty of Hedging Instruments

Construction projects often last longer than the term of hedging financial instruments. Therefore, it is possible that, under a hedging corporate policy, the construction financial manager will have to engage in sequential hedges over time until the period covered. In such a case, the cost of hedging may be as difficult to forecast as the future spot rates themselves. A possible difference in the variance of hedging costs and future spot rates further increases the uncertainty. Does it then help to hedge?

The answer for the construction firm appears to be positive, at least to the extent that the specific cash flow horizon is the same with the maturity of the hedging instruments considered. If these periods match, then the financial manager knows in advance its cash flow and can make financial planning (e.g. working capital) decisions. Therefore, it is important to distinguish between variances of hedging cost and future spot rates for the immediately hedged period (i.e., within the maturity period of the used hedging instruments) from such variances over periods beyond the instruments' maturities.

Chapter 3 : Modeling Foreign Exchange Exposure in International Construction

To understand foreign exchange exposure in international construction projects, models of the cash flows and of the key economic variables that determine them are required. The models of this section capture the nominal and real foreign exchange exposure in international construction projects. They are incrementally developed as follows:

- First, a construction cost, revenue and cash flow model is developed in section 3.1.
- Second, the model is expanded to incorporate multiple currencies in section 3.2.
- Third, the noncontractual economic exposure is analyzed in section 3.3.
- Fourth, deviations from foreign exchange equilibrium are defined and their impact on competitiveness analyzed in section 3.4.

3.1 Cost, Revenue and Cash Flow in Construction

The constructed facility life cycle consists of project formulation, planning, engineering-design, construction, use-management and disposal phases. Although foreign exchange risks affect the economics and value of the project to its owners in the long run, we will limit our analysis to the construction phase.

The construction phase consists of three subphases: bidding, acceptance and construction. The bidding period starts with the decision to bid the job and commit resources to the estimating process, and ends with the determination of markup and the resulting bid price. The acceptance period that follows includes the bid evaluation, notice of award and development of formal contract. Finally, the construction phase implements the constructed facility design and ends with the final acceptance of the facility by the owner.

Key to the management of any construction project is its cash flow (CF) model. In construction, the CF model is derived from integrated cost, revenue and schedule systems. As such it is capable of reflecting the dynamics of schedule changes, construction scenarios and progress-to-date. The dynamic integration of time and financial information is more important in international projects, which often tend to be larger in scale and with more complexities.

The key benefits from maintaining integrated cash flow information are:

(a) The ability to quickly determine project value distributions under a variety of schedule scenarios, including changes affected by exogenous factors, such as strikes and weather, or contractor operational and economic decisions, such as time-cost tradeoffs.

(b) Following (a), the ability to support the bid/no bid decision by modeling the relationship between markup and probability of winning a competitively bid job (Carr, 1982),

(c) The establishment of a time oriented budget framework for effective cost control with direct reference to the physical construction output (earned value analysis, Moder et al., 1983, p.133),

(d) The analysis and determination of construction financing requirements and the use of overdraft, loan, or other financing facilities (Halpin, 1983, p. 231),

(e) The effective integration of multiple projects at the construction firm level for the identification of cross-project construction financing effects at the firm level.

In international construction, time-based budgeting and cash flow models are expanded to account for multiple currencies and provide the time-based framework for foreign exchange exposure analysis, project valuation and exposure management decisions. The following subsections provide an overview of the cost and revenue components of construction project cash flows and lead to the discussion of the multiple currency dimension.

3.1.1 Cost Model

The cost model includes the field cost and markup variables as follows (elements of the following structure are discussed in Halpin, 1983, Adrian, 1982 and Jackson et al., 1981):

(1) Field Costs

(1a) Direct Costs: They include primarily labor (payroll), materials and equipment costs, i.e. costs associated with the physical placement of a construction unit.

Labor costs consist of the salaries and associated burden. They are determined from the units of work to be performed, crew productivity and the relevant labor rate pay.

LABOR COSTS = [(NO.OF UNITS/UNITS PER HOUR) * (HOURLY RATE)] * BURDEN FACTOR

BURDEN FACTOR = f (INSURANCE + WORKMEN'S COMPENSATION + UNEMPLOYMENT + PROPERTY DAMAGE + PUBLIC LIABILITY + FRINGES + OTHER)

Material Costs are determined from the quantity of construction units, material requirements per construction unit, and material unit prices.

MATERIAL COSTS = (NO.OF CONSTRUCTION UNITS) * (MATERIAL UNITS PER CONSTRUCTION UNIT) * (MATERIAL UNIT PRICE)

Equipment Costs consist of ownership, operation and maintenance costs. Ownership costs are fixed and include amortization (for the replacement of the equipment), insurance, interest on financing, taxes, transportation and storage. Operation and maintenance costs are variable and include fuel, oil, lubrication, preventive and corrective maintenance and operator salary.

EQUIPMENT COSTS = OWNERSHIP + OPERATION + MAINTENANCE

(1b) Subcontracts: They include subcontractor bids plus a management fee.

SUBCONTRACT COSTS = (SUB.BID) + (MANAGEMENT FEE)

(1c) Field Overhead: Includes project staff salaries and burden, office and site costs.

SUBCONTRACT COSTS = (SUB.BID) + (MANAGEMENT FEE)FIELD OHD = (SALARIES+BURDEN) + OFFICE COSTS + SITE COSTS

(1d) Special Conditions

Safety, licences, permits, etc.

(2) Markup

Consists of fixed overhead and required profit.

(2a) Fixed Overhead: Includes main office overhead, estimating and proposal costs, insurance, bonds and interest on borrowed money.

FIXED OHD = MAIN OFFICE OHD + INSURANCE + BOND COSTS + FINANCING COSTS

(2b) Profit: A percentage function of total costs.

PROFIT = (K%) * (FIELD COST + FIXED OHD)

Figure 3.1 presents graphically the cost model components. The contractor's costs along the categories outlined here will vary with the project type. Tables 3.1 and 3.2 illustrate this variation for selected construction activities in building and public works construction in the United States. The data suggests a wide range of possible ratios of labor to materials cost. For example, in building construction, the labor to materials cost ratio can be as high as 1.5:1.0 for concrete wall foundations to as low as 1.0:4.5 for exterior wall construction. In general, it is safe to assume that public works projects will have higher labor vis a vis materials costs, as a percentage of total costs. These distinctions may be important for understanding a contractor's foreign exchange exposure, given the owner and/or sponsor input sourcing requirements from local, home country, and/or international markets.

3.1.2 Revenue Model

The contractor's revenue comes from periodic (usually monthly) progress payments based on work performed. A retainage as a percentage of the value of completed work is deducted by the owner.

PAYMENT = (1+MARKUP)*(DIRECT COSTS+INDIRECT COSTS) - (RETAINAGE %)*(DIRECT COSTS+INDIRECT COSTS)

FIGURE 3.1

CONSTRUCTION PROJECT COST STRUCTURE

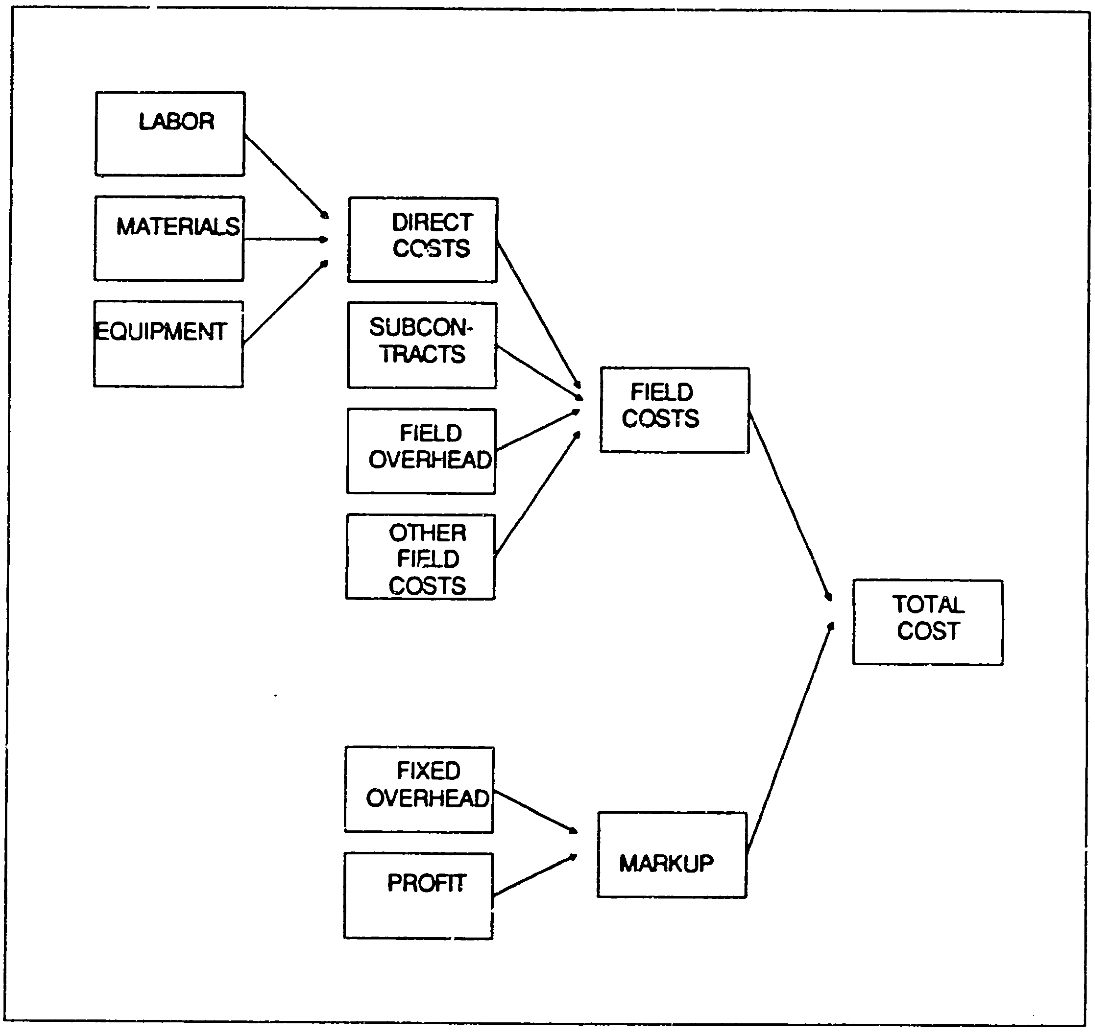


TABLE 3.1

COST VARIANCES IN BUILDING CONSTRUCTION SYSTEMS, U.S.A.

1. Cost in $/unit	Cost Range	Activity Description	Labor	Materials	Total
Excavation	High	Slab Exc.& Fil	2.82	4.22	7.04
	Medium	95% Compaction	2.01	2.18	4.19
	Low	Min.Compaction	1.33	1.79	3.12
Concrete Footings	High	10x10x4	823.00	1107.00	1930.00
	Medium	5x5x2	173.80	187.70	361.50
	Low	Strip Footing	9.74	10.94	20.68
Concrete Found.Walls	High	12"	5.22	4.41	9.63
	Medium	6"	4.78	3.05	7.83
	Low	4"	3.81	2.45	6.26
Superstructure	High	Laminated Wood	1.13	3.31	4.44
	Medium	Str. Steel	0.94	1.56	2.50
	Low	Wood Timber	0.14	0.12	0.26
Exterior Walls	High	Curtain Wall	5.21	24.1	29.31
	Medium	Masonry	9.15	10.02	19.17
	Low	Metal	0.58	0.67	1.25
Floor Finishes	High	Tile	2.65	2.66	5.31
	Medium	Wood	2.03	1.98	4.01
	Low	Concrete	1.01	0.68	1.69
2. Cost Contribution %					
Excavation	High	Slab Exc.& Fil	40	60	100
	Medium	95% Compaction	48	52	100
	Low	Min.Compaction	43	57	100
Concrete Footings	High	10x10x4	43	57	100
	Medium	5x5x2	48	52	100
	Low	Strip Footing	47	53	100
Concrete Found.Walls	High	12"	54	46	100
	Medium	6"	61	39	100
	Low	4"	61	39	100
Superstructure	High	Laminated Wood	25	75	100
	Medium	Str. Steel	38	62	100
	Low	Wood Timber	54	46	100
Exterior Walls	High	Curtain Wall	18	82	100
	Medium	Masonry	48	52	100
	Low	Metal	46	54	100
Floor Finishes	High	Tile	50	50	100
	Medium	Wood	51	49	100
	Low	Concrete	60	40	100
	Minimum		18	39	
	Maximum		61	82	
	Average-not weighted		46	54	

Source : Dodge Construction Cost Information System, Construction System Costs, McGraw-Hill, 1989.

TABLE 3.2

COST VARIANCES IN PUBLIC WORKS CONSTRUCTION SYSTEMS - U.S.A.

		Labor	Materials	Equipment	Other	Total
1. Cost in $/unit						
Excavate	High	2.46	2.25	5.76		13.71
	Medium	1.24	2.25	2.83		8.17
	Low	0.43	0.00	1.31		2.30
Drains and Sewers	High	50.24	926.54	50.59		1264.39
	Medium	18.60	481.43	19.08		636.01
	Low	2.17	5.94	1.26		12.27
Utilities	High	17.33	230.72	19.99		331.68
	Medium	14.96	106.67	17.18		173.39
	Low	4.24	4.13	4.87		17.56
Structures	High	294.45	125.00	145.70		808.54
	Medium	155.48	96.30	78.74		465.77
	Low	21.78	49.59	14.37		112.97
2. Cost Contribution %						
Excavate	High	18	16	42	24	100
	Medium	15	28	35	23	100
	Low	19	0	57	24	100
Drains and Sewers	High	4	73	4	19	100
	Medium	3	76	3	18	100
	Low	18	48	10	24	100
Utilities	High	5	70	6	19	100
	Medium	9	62	10	20	100
	Low	24	24	28	25	100
Structures	High	36	15	18	30	100
	Medium	33	21	17	29	100
	Low	19	44	13	24	100
Minimum		3	0	3	18	
Maximum		36	76	57	30	
Average-not weighted		17	40	20	23	100

Source : Dodge Construction Cost Information System, Public Works and Heavy Construction Costs, McGraw-Hill, 1989.

The contract defines how long the retainage deduction is maintained in a given project and the conditions of its release to the contractor after completion of the project. The released retainage is then:

RETAINAGE = SUM [(RETAINAGE %) * (DIRECT COSTS+INDIRECT COSTS)]

3.1.3 Cash Flow Model

The following table summarizes the synthesis and profile of construction project cash flows. Cash outflow is based on direct and indirect costs (Ct). Cash inflow is based on revenue from owner payments (Rt). The model supports construction finance and capital budgeting decisions. The difference between revenues and costs determines the amount of construction finance required. Construction finance can be in varying forms of overdraft, loan or other methods of financing. Construction financing adds interest and fee expenses to the cash outflows.

		End of Period m Before Payment	End of Period m After Payment
Direct Cost		1 (m)	
Indirect Cost		2 (m)	
COSTS	C_t	3 (m) = 1 (m) +2 (m)	
Markup		4 (m)	
TOTAL BILLED		5 (m) = 3 (m) +4 (m)	
Retainage Withheld		6 (m) = k_1*5 (m)	
PAYMENT RECEIVED	R_t		7 (m)
Total Cost To Date		8 (m) = 8 (m-1) +3 (m)	
Total Billed To Date		9 (m) = 9 (m-1) +5 (m)	
Total Paid To Date			10 (m) = =10 (m-1) +7 (m)
Overdraft End of Mo.		11 (m) = 13 (m-1) + +3 (m) + +7 (m-1)	
Interest (Overdr.Bal.)	I_{ot}	12 (m) = i_o*11 (m)	
Total Amt. Financed		13 (m) = 11 (m) +12 (m)	

3.1.4 Present Value of Construction Cash Flows

In addition to supporting construction financing decisions, the cash flow model supports project investment and capital budgeting decisions. The investment decisions of the construction firm are based on present value measures of expected project and firm cash flows. Earned value models supply up-to-date cash flow term structure information (Fleming, 1983). They also provide the basis for sensitivity analysis.

Present value measures are based on after-tax cash flows, computed using the corporate marginal tax rate.

$CF_t = (R_t - C_t) - T * (R_t - C_t)$, where

CF_t = Cash Flow

R_t = Total Revenue

C_t = Total Cost

T = Corporate Marginal Tax Rate

The present value of a cash flow component is then:

$PV(CF_t) = (CF_t)/(1+r)^t$, where

r = appropriate risk-adjusted discount rate.

The project value is affected substantially by the actual timing of costs, revenues, tax payments and other cash flows. A difference in the actual timing of cash flows implies that t can shift to $t+d_1$ for costs, $t+d_2$ for revenues, $t+d_3$ for tax payments etc., where d_i are positive or negative time increments (Warszwaski, 1982).

The method of construction financing also affects the project present value with the resulting interest and fee payments over time. The impact of construction financing costs on the firm's profitability is neglected in the construction management literature, although such costs can quickly turn a project's profit into loss (Au et al., 1986). In international projects, the cost of foreign exchange management instruments is added to traditional domestic construction financing costs.

Inflation considerations also need to be made, and an explicit determination of whether project cash flows are considered in nominal or real terms. Nominal cash flows should be discounted at nominal rates and real cash flows at real rates. In a fixed price contract, inflation will affect only the nominal construction costs of the project.

3.2 Multicurrency Cash Flow in Construction

The review of international financial management literature suggests that cash flow management in multiple currency environments is the dominant and often critical issue facing international financial managers (Lessard, 1985; Shapiro 1986). Construction is no exception. Foreign cash flows are subject to market and industry specific risks that affect the home currency value of international contractors exposed in foreign curreries.

The risks facing international contractors and affecting construction cash flows in a multicurrency environment can be categorized as follows:

(a) Business risks, reflecting construction industry and industry segment unique conditions, as they are compunded by international business environments,

(b) Political risks, reflecting man-made, willful actions of government agents (political), or country risks resulting from macro- and microeconomic policies and developments, that affect international contractor's foreign investments, and

(c) Foreign exchange risks, reflecting the denomination of construction project transactions in multiple currencies other than the home ("functional" according to international accounting definitions).

3.2.1 Sources of Foreign Cash Flow Variability

Home currency values of foreign currency cash flows are affected in two ways by international construction risks. First they are affected by changes in exchange rates and the resulting differentials between projected and actual exchange rates. Second they are affected by changes in the foreign currency based cash flows and the differentials between projected (i.e. estimated) and actual foreign currency cash flows.

Considering the possible changes in foreign cash flow CF_f and exchange rate e between time t=1 and t=2, we can define the change in cash flows as follows:

$$
\begin{aligned}
CF_{1h} &= e_1 * CF_{1f} \\
CF_{2h} &= e_2 * CF_{2f} \\
\Delta CF_{12} &= CF_{2h} - CF_{1h} = (e_1+de) * (CF_{1f}+dCF_f) - CF_{1h} = \\
&= e_1 * CF_{1f} + e_1 * \Delta CF_f + \Delta e * CF_{1f} + \Delta e * \Delta CF_f - \\
&\quad - e_1 * CF_{1f} = \\
&= e_1 * \Delta CF_f + \Delta e * CF_{1f} + \Delta e * \Delta CF_f
\end{aligned}
$$

or, for small changes in exchange rates and cash flows,

$$
\begin{aligned}
dCF_{12} &= e_1 * dCF_f + de * CF_{1f} + de * dCF_f \\
&(\cong e_1 * dCF_f + de * CF_{1f})
\end{aligned}
$$

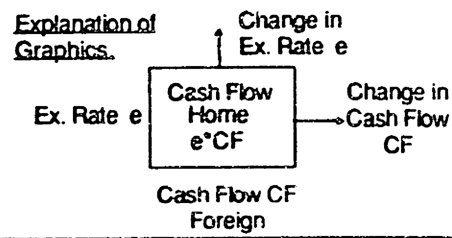
The pitfall with measuring foreign exchange exposure in international construction, as suggested by the field study and literature review (Joiner, 1987), is that it focuses exclusively on the impact of foreign exchange changes (de) on home currency based cash flow, while ignoring changes in foreign currency cash flows (dCF_f). Changes in foreign currency cash flows can be attributed to general market, as well as specific exchange rate factors. The impact of such changes in cash flows can be substantial and contribute negatively or positively to the contractor's exposure. In some cases it may offset the impact of exchange rate changes.

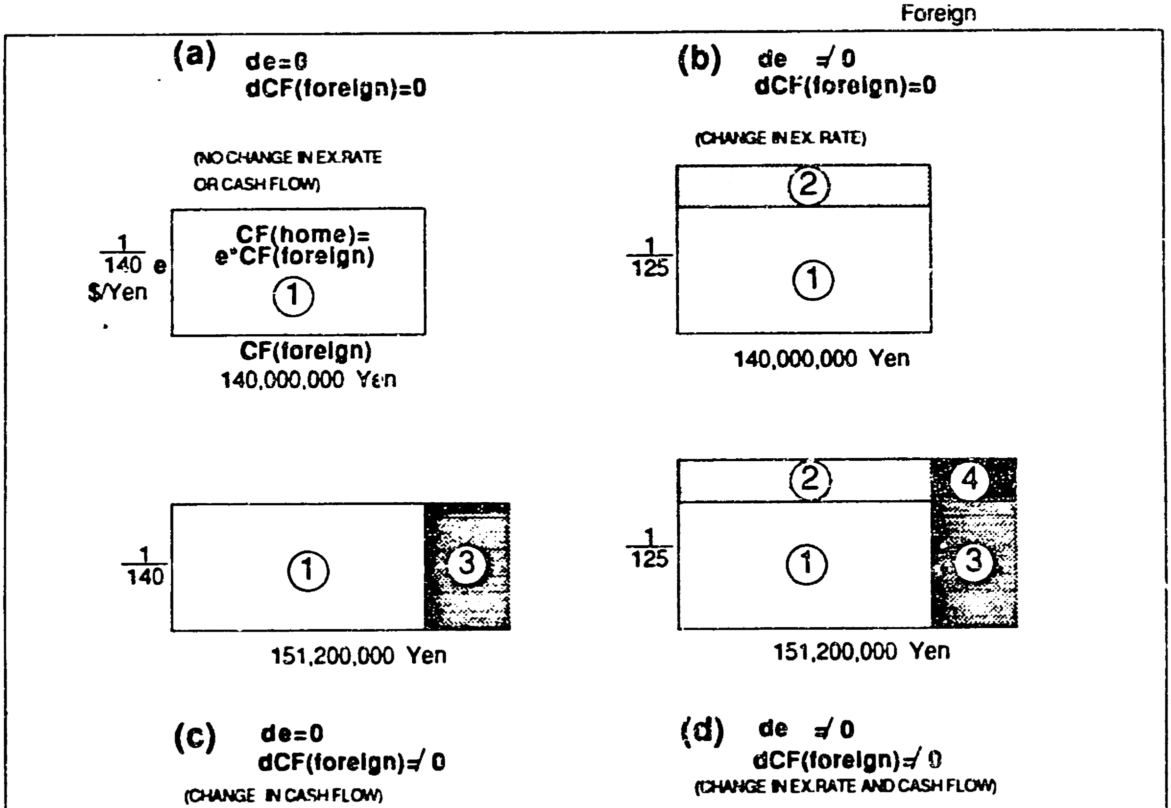
Business, political and exchange risks have a currency impact in international projects. Figure 3.2 illustrates a few possibilities of construction cash flow exposure. The example assumes that a contractor may have budgeted in 1987 equipment purchases of 140,000,000 Yen for 1988 from Japan at a forecasted rate of 140 yen per US dollar. The US dollar value of the equipment is estimated equal to 140,000,000 Yen / 140 (Yen/$)= $1,000,000 (figure 3.2a).

Figure 3.2b illustrates the risk from exchange rate changes. The purchase from Japan may be possible at the estimated prices, but at a different exchange rate, such as $1 = 125 Yen. Assuming that this is still going to be the minimum cost alternative, the US dollar actual cost will be 140,000,000 Yen / 125 (Yen/$)= $1,120,000. The contractor will realize a $120,000 cost overrun, due to currency forecast error.

Next, figure 3.2c illustrates the possibility that the purchase from Japan may be possible at the forecasted exchange rate, but at different prices in Japanese yen. For example, a new tax policy, such as a sales or value-added tax, may increase equipment prices by 8 percent. The cost will be 1.08 * 140,000,000 Yen = 151,200,000 Yen, or 151,200,000 Yen / 140 (Yen/$)= $1,080,000. The contractor will realize an $ 80,000 cost overrun, that can be attributed to country / macroeconomic policy risk sources.

FIGURE 3.2
SOURCES OF HOME CURRENCY CASH FLOW EXPOSURE





		HOME CURRENCY COST	CHANGE IN HOME CURRENCY COST	
(a)	①	= 140,000,000Yen/140 = $1,000,000	+$0	(+0%)
(b)	①+②	= 140,000,000Yen/125 = $1,120,000	+$120,000	(+12.0%)
(c)	①+③	= 151,200,000Yen/140 = $1,080,000	+$80,000	(+8.0%)
(d)	①+②+③+④	= 151,200,000Yen/125 = $1,209,600	+$209,600	(+20.9%)

Finally, figure 3.2d combines the effects of both exchange rate and nominal foreign cash flow changes. The cost overrun will be $209,600, i.e. $9,600 more than the sum of (b) and (c) overruns, to account for the combined effect of the two events (de * dCF(foreign)).

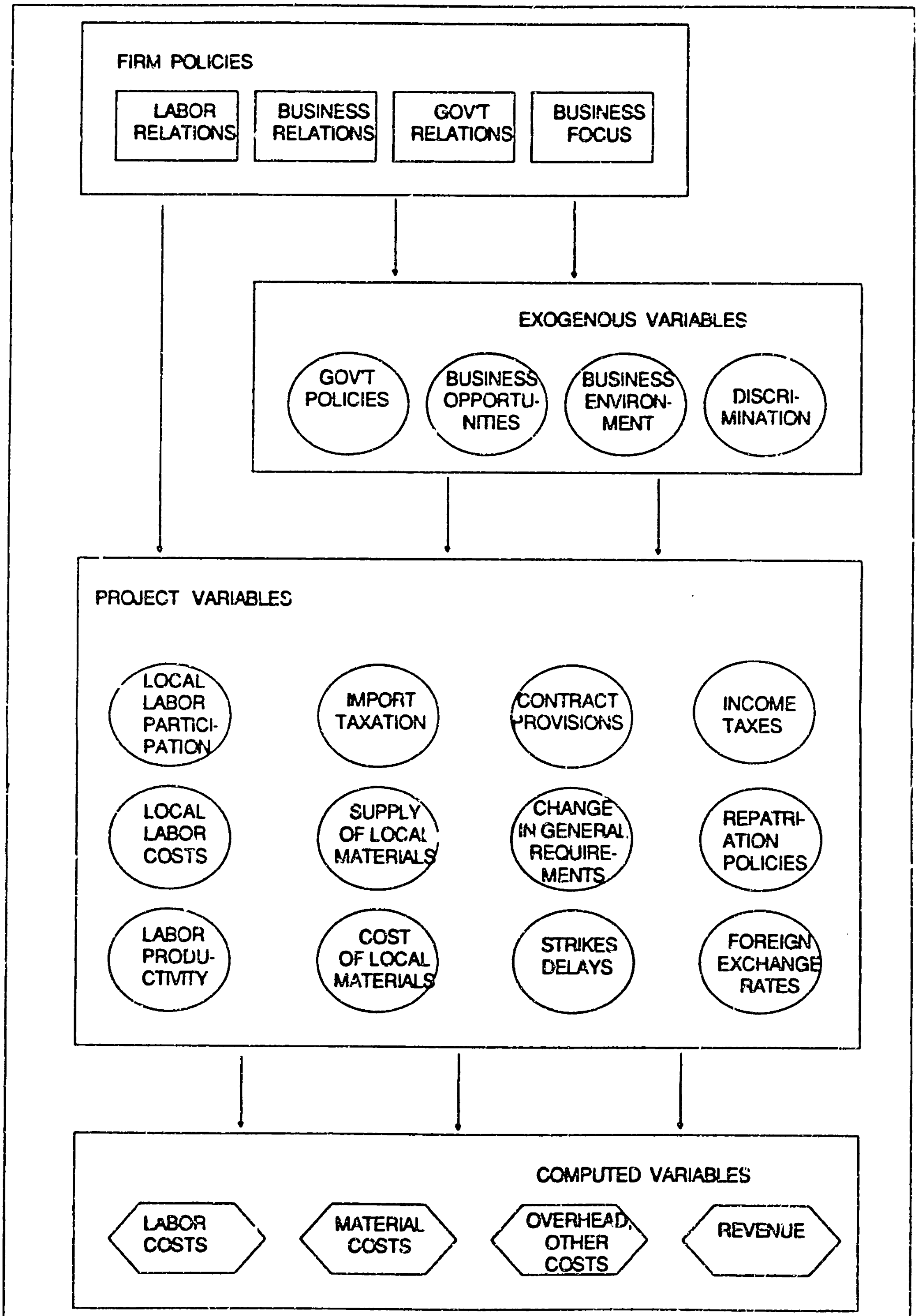
Of course, a common business risk is that the equipment may not be available from Japanese vendors at the time of purchase. Instead, the equipment might have to be purchased from Germany, at DM 2,400,000 with 1US$=1.90DM. The US dollar cost is then 2,400,000 DM/1.90(DM/$) = $1,263,157. A budget overrun of $263,157 attributed to common business risk source would be realized.

The examples illustrate the complexity of foreign exchange exposure analysis and the need for a comprehensive currency based cash flow model. Figure 3.3 shows a variety of business, political/ country and exchange risks affecting foreign currency construction costs and revenues. The current thesis recognizes the impact of variable business and political source risk factors on foreign currency cash flows, and, therefore, on the exposure and value of the project and firm. However, its explicit focus and contribution is in understanding and evaluating the contribution of foreign exchange factors to the exposure and competitiveness of the international contractor.

3.2.2 Construction Project Cost / Revenue Structures in Multiple Currencies

Exposure in a given foreign currency is the home (functional) currency based value of unmatched costs or revenues in the foreign currency. The value of exposed cash flow can go either way, up or down, depending on the direction of cash flow and exchange rate changes. Given that, it may be in general irrelevant whether the contractor has a long, or short position in a currency, as the cash flow and/or currency may shift in

FIGURE 3.3
INTERNATIONAL CONSTRUCTION CASH FLOW RISK ENVIRONMENT



either direction. (Of course, having a long position in a currency likely to depreciate is relevant, because of the expectation regarding the currency's future value.) As such, the exposure of a contractor in a currency i can be defined as the absolute value of, translated in home currency, foreign cash flow:

$$E_i = e_i * | CF_i | = | e_i * CF_i |$$

The first step towards understanding foreign exchange exposure is the detailed definition of cash flows by currency of denomination, and the adoption of currency rate forecasts for the translation of future cash flows. This analysis reveals the extent of unmatched inflows and outflows in multiple currencies and provides the basis for first rough measures of currency risk.

For example, the US Government pays US contractors in US dollars for overseas construction of government facilities, although the contractor may have to subcontract part of the work or otherwise procure locally. The following simple, two-currency unmatched cost/revenue structure has been found to be typical of such projects (FC = Foreign Currency):

	Revenues	Costs
US$	100%	40%
FC		60%

In dollar figures, assuming a $21,000,000 project (home currency), that includes a 5 percent profit (i.e. $1,000,000), the corresponding revenues and costs are (the time value of money is not incorporated for simplicity):

	Revenues	Costs	
US$	$21,000,000	$8,000,000	(=0.40*20,000,000)
FC		$12,000,000	(=0.60*20,000,000)
	$21,000,000	$20,000,000	
Expected Profit	$1,000,000		

The table implies that the amount of unmatched foreign currency costs (FC) to equal $12,000,000. If the foreign currency appreciates on average by 20 percent, i.e. if the foreign currency unit requires 20 percent more US dollars to buy, then the US dollar value of foreign costs increases by 0.20*12,000,000 = 2,400,000. The actual revenue/cost structure will then be:

	Revenues	Costs
US$	$21,000,000	$8,000,000
FC		$14,400,000
	$21,000,000	$22,400,000
Actual Loss		($1,400,000)

By contrast, if the foreign currency depreciates by 20 percent, the company will realize a much larger profit:

	Revenues	Costs
US$	$21,000,000	$8,000,000
FC		$9,600,000
	$21,000,000	$17,600,000
Actual Profit	$3,400,000	

In summary, foreign exchange exposure for the international contractor arises when cash inflows and outflows do not match equally in the multiple currencies of their denomination, so as to exactly offset movements in the exchange rates. The contractor has to evaluate the exposure's impact and then manage it with project based methods or financial instruments.

To measure its foreign currency exposure, the contractor needs to expand the domestic cash flow model by breaking the project cash flows outlined in the previous subsection by their currency of denomination. In the discussion that follows, the subscripts f and h refer to foreign and home currency cash flows.

(a) Single Period t Foreign Currency Cash Flow Breakdown Matrix:

$$CF_{ft} = [\ CF_{fti}\ ] = [\ CF_{ft1} \\ CF_{ft2} \\ CF_{fti} \\ CF_{ftN}\ ],$$

where i=1,2, N the currencies of cash flow denomination.

(b) Single Period Home Currency Cash Flow Value Matrix:

$$CF_{ht} = [\ CF_{hti}\ ] = \begin{bmatrix} CF_{ht1} \\ CF_{ht2} \\ \cdots\cdots \\ CF_{hti} \\ \cdots\cdots \\ CF_{htN} \end{bmatrix} = \begin{bmatrix} e_1 * CF_{ft1} \\ e_2 * CF_{ft2} \\ \\ e_i * CF_{fti} \\ \\ e_n * CF_{ftN} \end{bmatrix}$$

where

i = 1,2, N are the currencies of denomination,

e_i are the forecasted exchange rates, and

CF_{hti} are the cash flows in home currency.

(c) Intertemporal Distribution

The intertemporal distribution has project value and risk management implications. Investors in the project and firm are interested in the time value and variability of cash flows. Financial managers are interested in the project value, but also have to understand the details of their exposure in order to make risk management decisions. For this analysis, the time distribution of cash flows in foreign currencies is required. This can be accomplished with earned value analysis, i.e. with models that provide the value of completed and remaining project over time. Such models integrate in ways that allow for the determination of project value earned based on actual progress to-date, with accurate time and cost variance estimates and realistic cash flow and schedule forecasts for the remaining parts of a project.

These features make the use of earned value analysis critical for international construction. The analysis can be expanded to provide up-to-date information on time and currency cash flow integration. This analysis is appropriate at the bid, acceptance and construction phases in the project cycle. It provides the needed information for accurate single and multiple project cash flow profiles, for cross-project cash flow exposure analysis, and, therefore, for exposure management. Finally, it provides the necessary input for project valuation and sensitivity analysis, and for mean-variance analysis of existing and candidate project portfolios.

Using time-cost integration in a multiple currency context, the columnar home currency cash flow matrix becomes an TxN matrix, where T is the number of time periods and N the number of currencies:

```
CFht = [ CFhti ] = [CFh11  CFh21          CFhT1
                    CFh12  CFh22          CFhT2
                    .....
                    CFh1i  CFh2i          CFhTi
                    .....
                    CFh1N  CFh2N          CFhTN ]
where
```

$t=1,2,...T$ are the time periods, and

$i=1,2, \; N$ are the currencies of denomination.

The above matrix provides the basis for firm-level simple exposure analysis measures, such as :

(i) Total exposure in a given currency in a given time period:

$$Eit = \sum_{j=1}^{M} |Eitj|$$

Eitj: Exposure in currency i, translated in home currency, across M projects in time period t.

(ii) Total exposure in a given currency over a time period t=1 to T:

$$Ei = \sum_{t=1}^{T} \sum_{j=1}^{M} |Eitj|$$

(d) Construction Cost Account Breakdown

The understanding of foreign exchange exposure is further enhanced by a detailed construction cost breakdown. The level of detail in the breakdown should be a function of the relative to the budget order of magnitude of the analyzed cash flows. The cost account reference is an economically significant third dimension to the currency and time dimensions of international construction project cash flows. It facilitates the identification and analysis of noncontractual cash flows (i.e., cash flows that are not fixed in nominal terms, but rather fluctuate in response to market conditions) by construction resource and industry segment.

The construction cost breakdown expands the previously described simple exposure analysis measures within cost categories of the budget. For example, the total exposure in currency i, with cost categories k=1,..K, can be written as:

$$E_i = \sum_{k=1}^{K} E_{ik} = \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{j=1}^{M} |E_{itjk}|$$

$$= \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{j=1}^{M} | e_i * CF_{f,itjk}| .$$

The contractor's total exposure E will be:

$$E = \sum_{i=1}^{N} E_i$$

The cost breakdown structure is important, because the weight of cost components varies across project types. As a result, foreign exchange exposure will, in general, differ across project types. The variation in cost structure is reflected in the computation of construction industry cost indexes. For example, Engineering News Record (March 19, 1987) suggests a 14 percent contribution of structural steel to its average construction cost index. The same source, suggests a 24 percent contribution of structural steel in its building cost index. Similarly, Moavenzadeh (1985) shows the variation in materials inputs as percentage of total expenditure for residential buildings, non-residential buildings and civil engineering projects in developing countries.

Tables 3.3 and 3.4 illustrate the variability in the contribution of construction systems to total construction costs across a diverse sample of project types. For example, it is implied that computer, research and other high-technology facilities have relatively higher HVAC and electrical systems costs than residential buildings. Likewise, steel and/or concrete superstructure costs are relatively higher in office and manufacturing buildings.

TABLE 3.3

COST STRUCTURE, AVERAGE BUILDING COSTS - U.S.A.

(percent)

	High-Rise Apartment Building	Office Building	Research High Technology	Laboratory
Foundations	4.2	1.5	2.2	4.0
Floors on Grade	0.5	0.5	1.2	2.5
Superstructure	25.3	23.3	10.1	12.1
Roofing	0.4	0.3	4.6	2.1
Exterior Walls	9.4	9.1	18.3	6.5
Partitions	10.7	7.0	0.9	6.5
Wall Finishes	6.2	3.7	2.2	4.6
Floor Finishes	4.3	4.6	2.1	3.0
Ceiling Finishes	4.6	2.3	2.2	2.2
Conveying Systems	2.1	11.3	1.0	0.0
Specialties	1.5	1.5	3.0	3.2
Fixed Equipment	6.8	3.7	13.0	8.8
HVAC	8.9	16.0	18.2	18.5
Plumbing	6.3	5.7	4.3	10.9
Electrical	8.8	9.5	16.7	15.1
Total	100.0	100.0	100.0	100.0

Source : Dodge Construction Cost Information System,
Public Works and Heavy Construction Costs,
McGraw-Hill, 1989.

TABLE 3.4

COST STRUCTURE, AVERAGE BUILDING COSTS - EUROPE

1. France

Project Cost Structure, Percent

	Computer	Hotel	Manufa-cturing	Hi-Rise Office	Lo-Rise Office	Ware-house
Sitework	1.9	2.7	6.1	2.7	4.5	9.5
Foundation	1.7	1.2	6.1	1.9	2.7	8.3
Floor Systems	1.1	1.9	5.7	1.7	1.8	10.5
Interior Column Syst	10.6	10.2	26.8	13.2	18.0	20.0
Roof Systems	1.9	2.7	4.1	1.3	2.6	15.4
Exterior Wall System	13.7	9.7	21.9	15.6	13.5	16.8
Partitions	2.9	4.8	3.6	4.4	7.4	2.1
Finishes	13.1	14.2	10.8	15.2	14.5	2.1
Specialties	5.6	4.1	0.3	1.5	2.1	0.4
Equipment	5.3	10.1	0.0	3.3	4.1	0.0
Conveying Systems	2.1	2.9	0.0	3.9	0.0	0.0
Plumbing Systems	2.1	8.9	1.8	2.5	2.8	1.3
HVAC	22.9	14.5	6.9	20.1	15.9	8.9
Electrical System	15.1	12.1	5.9	12.7	10.1	4.7
Total Building Costs	100.0	100.0	100.0	100.0	100.0	100.0

2. Belgium

Project Cost Structure, Percent

	Computer	Hotel	Manufa-cturing	Hi-Rise Office	Lo-Rise Office	Ware-house
Sitework	2.4	4.6	10.4	3.5	3.7	13.9
Foundation	1.4	1.0	4.2	1.6	2.2	6.9
Floor Systems	1.0	2.1	4.6	1.9	1.5	9.3
Interior Column Syst	11.4	9.3	19.4	11.6	17.7	18.1
Roof Systems	2.3	4.0	4.9	1.7	3.7	14.0
Exterior Wall System	14.6	9.8	24.0	17.1	15.3	16.0
Partitions	2.5	5.3	3.2	4.6	3.8	4.1
Finishes	11.3	18.1	15.6	15.5	13.2	3.8
Specialties	5.4	3.9	0.0	3.0	4.1	0.0
Equipment	5.4	14.1	0.0	4.8	4.3	0.0
Conveying Systems	2.4	2.7	0.0	4.4	3.8	0.0
Plumbing Systems	2.2	6.1	1.7	2.1	3.5	2.3
HVAC	23.3	8.8	7.0	17.0	15.9	7.4
Electrical Systems	14.4	10.3	5.0	11.3	7.4	4.1
Total Building Costs	100.0	100.0	100.0	100.0	100.0	100.0

Source : Computed from Engineering News Record, December 18, 1988

As with the distinction between labor, material and equipment costs suggested in the previous subsection 3.1.1, the construction system breakdown of costs allows for a transparent view of a contractor's exposure by specific construction input category. It also provides the basis for sensitivity analysis with respect to price movements of specific resources. Its importance is in that it recognizes that different groups of construction cash flows respond differently to exchange rate fluctuations and market conditions. For example, prices of construction inputs traded internationally, such as cement or structural steel, will have different response than nontraded inputs for high technology construction.

The quantification of price responses to exogenous economic changes is accomplished through elasticity measures of prices. The elasticity of construction input prices will normally vary across such inputs. If P_i is the price of a given good i, then its elasticity of price ($E(P,X)_i$) with respect to changes of an independent economic variable X_i is:

$$E(P,X)_i = (dP_i/dX_i)/(P_i/X_i)$$

$$dP_i = (P_i/X_i) * E(P,X)_i * dX_i$$

Microeconomic theory determines such elasticities of price as a function of the competitive structure of the industry, i.e., the number of competing firms and the product differentiation. The variety of materials, labor, equipment and other inputs can be studied individually with respect to their individual unique elasticities of price, based on their contribution to total project cost.

Substituting exchange rates ei for the generic economic variable Xi, we introduce the concept of foreign exchange elasticity of input prices, and, therefore, the sensitivity of noncontractual costs on exchange rates and their changes:

$$E(P,e)_i = (dP_i/de_i)/(P_i/e_i)$$

$$dP_i = (P_i/e_i) * E(P,e)_i * de_i$$

3.2.3 Foreign Exchange Exposure Measures in Construction

Construction project foreign exchange measures are useful in absolute, project specific, as well as in relative, firm related, terms. In absolute, project specific terms, they report in home currency the exposure on a period by period basis, as well as of the project as a whole. In relative terms, they provide ratios of contribution to corporate exposure or significance of project exposure in the context of the firm's revenue, equity or other financial measure. The measures listed below provide a sense of the variety of simple and risk-adjusted approaches to quantifying foreign exchange exposure in absolute monetary and relative to the firm's size terms.

(a) Simple Exposure Measures

The cash flow model outlined in section (reference) provides a structure for the establishment of project specific exposure measures in home currency terms. Given the project status at a given time t, and the projected cash flow profile from earned value analysis, the projected exposure viewed at time t of a future period X is:

$$E_{t,X} = \sum_{i=1}^{N} | e_{i/t,X} * NCF_i(t,X) |$$

The total exposure for the remaining T-X periods of the project over N currencies of exposure is expressed as:

$$E_t = \sum_{i=1}^{N} \sum_{x=X}^{T} | e_{i/t,x} * NCF_i(t,x) |$$

where

$E_{t,X}$: Exposure in future period X as projected in period t

E_t : Total exposure between time X and project completion time T, as projected at time t.

$e_{i/t,X}$: Projected at period t spot exchange rate in future period X.

$NCF_i(t,X)$: Projected at period t net cash flow exposure in future period X and currency i.

The above project exposure, expressed in nominal home currency terms, provides a useful basis for managing project exposure, but can not provide a sense of relative magnitude, in the context of the firm size and operations. For example, the same nominal exposure in dollar terms has different impact on a firm with \$100 million versus a firm with \$10 million of international revenue. A better measure of its significance for the firm is derived by firmwide ratios, such as the exposure's ratio to shareholder's equity:

$$\text{Exposure Ratio} = \frac{\text{Project Exposure}}{\text{Shareholders Equity}}$$

$$\text{Exposure Ratio} = \frac{\sum_{i=1}^{N} \sum_{x=X}^{T} | e_{i/t,x} * NCFi(t,x) |}{\text{Shareholders Equity}}$$

These values and ratios of exposure can be sufficient first measures of the potential gains or losses from currency rate changes in currency terms, as well as relevant to the firm's size of operations. However, they do not account for the risk profile of contributing cash flows. As such, they may underestimate or overestimate the potential gains or losses

(b) Risk-Adjusted Exposure Measures

Risk-adjusted measures of construction cash flow exposure reflect the variability of exposed cash flow in absolute home currency terms, or the ratio of this variability to the variability of firmwide financial measures, such as shareholder equity. They have also been suggested in a more general context by Bergqvist (1982).

Portfolio Risk

The portfolio theory developed by Markowitz (1952) implies that construction firm shareholders are not only interested in maximizing their returns (and therefore in the simple exposure of future cash flows) by selecting securities and preferring projects with positive net present value. Risk-averse investors are also interested in reducing the risks associated with the security and project payoffs. The basis of portfolio selection is then the maximization of expected utility of investors in the context of risk-return tradeoff. The efficient portfolio is defined as the locus of points on the risk/return plane that minimize risk for a given expected return.

The mean-variance analysis employed in portfolio selection is the formal expression of diversification. It is based on correlations among security returns and provides an approach to constructing efficient portfolios. The portfolio theory implies that projects should be evaluated and selected in ways similar to those of securities.

The portfolio variance (measure of risk) is equal to the weighted sum of covariances among all portfolio entries (securities, projects):

$$\text{Portfolio Variance} = v = \sigma^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} [w_i * w_j * Cov(NPV_i, NPV_j)]\}$$

$$\sum_{i=1}^{N} \sum_{j=1}^{N} (w_i * w_j * \rho_{ij} * \sigma_i * \sigma_j)$$

ωηερε σ_i and σ_j are the standard deviations of projects i and j, ρ_{ij} the correlation coefficient between i and j, and w_i and w_j the weights of value of assets i and j.

Following these clarifications, a risk-adjusted measure of construction cash flow exposure should account for the variability of the exposed cash flow. To derive the portfolio exposure measure at a given time t (the subscript t is removed from the following formulation for simplicity) we define:

Currency risk: σ_i (currency rate standard deviation)

Shareholder equity risk: σ_e (equity standard deviation)

Project currency portfolio risk: σ_p (portfolio standard deviation)

Currency correlations: ρ_{ij}

Currency weight $w_i = (E_i*e_i)/ \Sigma(E_i*e_i)=(E_i*e_i)/ E_t$,

Total Exposure at time t: $E_t = \Sigma(E_i*e_i)$

Then, the portfolio risk based exposure is quantified by the combination of simple project exposure defined above and project currency portfolio risk (standard deviation):

$$\sigma_p^2 = \sum_i \sum_j w_i * w_j * \sigma_{ij}$$

$$= \sum_i \sum_j \frac{(E_i*e_i)*(E_j*e_j)}{[E_t]^2} * \sigma_{ij}$$

where $\sigma_{ij} = \rho_{ij} * \sigma_i * \sigma_j$

Following the rationale used in simple exposure analysis, appropriate ratio measures suggest the significance of a given project's exposure in the context of firmwide activity. For example, project currency portfolio risk can be compared to shareholder equity risk as follows.

$$\text{Exposure Ratio} = \frac{\sigma_P}{\sigma_{SE}} \qquad \text{(risk ratio)}$$

(SE : shareholders equity)

or even

$$\text{Exposure Ratio} = \frac{\sigma_P * E_t}{\sigma_{SE} * SE} \qquad \text{(home currency ratio)}$$

Systematic Risk

The Capital Asset Pricing Model (CAPM) decomposes total portfolio risk into two components: the unique risk that can be reduced and eventually eliminated through diversification, and the market risk (associated with the market portfolio) that can not be reduced through further diversification (reference previous section).

In construction projects, the CAPM implies that project risk can be decomposed to exogenous, macroeconomic that can not be diversified, and project specific risks that can be diversified by engaging in a large enough number of projects. The contribution of a project's risk to total portfolio risk is measured by the covariance ("beta") of individual project returns with the returns of the market portfolio of all assets (Sharpe, 1964).

Using the fundamental concepts underlying the CAPM as they are defined in section (reference previous section) we can define exposure measures for construction project cash flows. The following definitions are used:

Market risk : σ_m (currency rate standard deviation)

Project currency portfolio risk: s_p (portfolio standard deviation)

Equity beta : β_{SE}

Project currency portfolio beta : β_p

Currency-market correlations ρ_{pm}

Then, the systematic risk based exposure is quantified by the project currency systematic risk (beta) relative to the market risk:

$$\beta_p = \sigma_{pm}/\sigma_m^2 = \sigma_p * \sigma_m * \rho_{pm}/\sigma_m^2$$

This measure is different from the portfolio measure, because it excludes market risks that are common to all investments and are affected by exogenous to all firms macroeconomic variables. Similarly to the definition of portfolio risk based exposure ratio, we can also define a relative to the firm's equity risk ratio:

$$\text{Exposure Ratio} = \frac{\beta_p}{\beta_{SE}} \qquad \text{(risk ratio)}$$

(SE : shareholders equity)

or even

$$\text{Exposure Ratio} = \frac{\beta_p * E_t}{\beta_{SE} * SE} \qquad \text{(home currency ratio)}$$

Of the two classes of ratios, the risk-adjusted measures provide better information about the potential gains or losses, as they account for the variability of cash flows translated in home currency. Among the risk-adjusted measures, the CAPM based measures provide more accurate information in the context of systematic, diversifiable construction industry risks rather than total risks. In other words, they do not mix market, undiversifiable risks, which are not affected by a contractor's operational and financial choices.

(c) Project Exposure Determination

The development of reliable foreign exchange exposure measures relies on accurate home currency cash flow forecasts. Consequently, it is based on:

(1) project performance data at the time of exposure measurement, including the

actual cost for worked performed (ACWP),
budgeted cost for worked performed (BCWP), and
budgeted cost for work scheduled (BCWS).

(2) estimated time and costs to complete the project based in part on data under (1) above and on evaluation of the remaining tasks,

(3) projected foreign exchange rates to determine the future (then current) value in home currency, and

(4) projected interest rates to define discount rates for present value measures of future exposure.

3.2.4 Time Path of Construction Cash Flow Exposure

Let us now consider, how the expected exposure in a given future period X, and a given currency i, can vary with time. It is sufficiently general to examine this variation with simple exposure measures. The exposure at times t and t+1 will be:

$$E_{t/X,T} = \sum_{i=1}^{N} \sum_{x=X}^{T} | e_{t/ix} * NCF_{t/ix} |$$

$$E_{t+1/X,T} = \sum_{i=1}^{N} \sum_{x=X}^{T} | e_{t+1/ix} * NCF_{t+1/ix} |$$

Between t=t and t=t+1, changes will take place in

(1) the expectations about future spot exchange rates, with:

$e_{t+1/ix} = e_{t/ix} + de_i$, and

(2) the expectations about future cash flows, based on project performance data, as well as macroeconomic (exogenous) price change data with:

$NCF_{t+1/ix} = NCF_{t/ix} + dNCF_{ix}$

Therefore,

$$E_{t+1/X,T} = \sum_{x=X}^{T} \sum_{i=1}^{N} e_{t+1/ix} * |NCF_{t+1/ix}|$$

$$= \sum_{x=X}^{T} \sum_{i=1}^{N} (e_{t/ix} + de_{ix}) * (|NCF_{t/ix}| + d|NCF_{ix}| =$$

$$= \sum_{x=X}^{T} \sum_{i=1}^{N} [e_{t/ix} * |NCF_{t/ix}| + e_{t/ix} * d|NCF_{t/ix}| + de_{ix} * |NCF_{t/ix}| + de_{ix} * d|NCF_{ix}|] =$$

$$= \sum_{x=X}^{T} \sum_{i=1}^{N} [E_{t/ix} + e_{t/ix} * d|NCF_{t/ix}| + de_{ix} * |NCF_{t/ix}| + de_{ix} * d|NCF_{t/ix}|] =$$

$$= \sum_{x=X}^{T} \sum_{i=1}^{N} (E_{t/ix} + dE_{t/ix})$$

$$\text{with } dE_{t/ix} = e_{t/ix} * d|NCF_{t/ix}| + de_{ix} * |NCF_{t/ix}| + de_{ix} * d|NCF_{ix}|$$

The time path of exposure is then dependent on the time path of exchange rates and project cash flows. Considering a set of future time periods, their projected net cash flow in a currency NCF_i, and an appropriate exchange rate e_i, the time path of the projected net exposure E_i can be expressed by the equation:

$$\frac{dE_{t/ix}}{dt} = e_{t/ix} * \frac{d|NCF_{t/ix}|}{dt} + |NCF_{t/ix}| * \frac{de_{t/ix}}{dt} + \frac{d|NCF_{t/ix}|}{dt} * \frac{de_{t/ix}}{dt}$$

Therefore, the time path of the construction cash flow exposure in one or a group (including all) of currencies in any given time period (or range of time periods) will depend on the time path of:

(1) the foreign currency based cash flows, which in turn will be affected by:

(1a) the schedule dynamics of the project, determined through earned value analysis, that defines how many units of which work package will be produced in future project periods based on progress-to-date updates and/or schedule revisions, and

(1b) the time path of of foreign currency prices applied to the units of construction output under above (1a)

(2) the exchange rate time path of the currencies of denomination of future cash flows.

Construction units by work package define the resource utilization (with cost impact) and the project completion rate (with revenue impact). The term structure of future cash flows is affected by actual progress vis a vis a baseline schedule, and by management decisions affecting project activities with float, i.e. activities whose possible delay does not have an impact on the completion date of a project or part of it.

Management decisions include time-cost tradeoffs, when construction activity costs are not constant but rather a function of the activity's duration. Elmaghraby (1977) discusses how time-cost tradeoffs are made using linear, as well as nonlinear cost-duration curves. The interesting implication for international construction is that, in addition to the cash flow impact of such tradeoffs, the float of construction activities can be used as a tool to manage exposure.

Application

The following application illustrates the time path of foreign exchange exposure. Figure 3.4 summarizes the key concepts. The application describes the foreign exchange exposure between a future dates X=t+3 and the project completion date T=t+10 or other, depending on projected schedule, as estimated on a prior date t. First the projected exposure is computed with projected at t exchange rates (figure 3.4a). The exposure is indicated by the sum of shaded areas (note that we are adding absolute values of cash flows). If the projected cash flows and exchange rates do not change between t=t and t=X, the exposure is stable (figure 3.4b). However, the exposure may be increasing (figure 3.4c) or decreasing (figure 3.4d), due to change in cash flow and/or exchange rate projections.

Application with Figure 3.4

EXPOSURE TIME PATH ANALYSIS (discrete time)
(Single Currency i)

(A) At time t = t

Time (A)	Projected Net Cash Flow in For.Curr. (B)	Projected Exchange Rate (C)	Projected Exposure (Absolute) Base Curr. (D=C*|B|)
t+ 1	-15	10.00	150.00
t+ 2	-10	9.95	99.50
t+ 3	5	9.90	49.50
t+ 4	10	9.85	98.50*
t+ 5	5	9.80	49.00*
t+ 6	-5	9.75	48.75*
t+ 7	-10	9.70	97.00*
t+ 8	-15	9.65	144.75*
t+ 9	-20	9.60	192.00*
t+10	-5	9.55	47.75*

Projected Exposure for t=t+3 to t+10,
starred exposures (*) are added : E_{t+3} = 677.75

Stable Exposure

(B) At time t = t+3
Assuming no exchange rate or foreign cash flow changes,
we have stable exposure

Time (A)	Projected Net Cash Flow in For.Curr. (B)	Projected Exchange Rate (C)	Projected Exposure (Absolute) Base Curr. (D=C*|B|)
t+ 4	10	9.85	98.50*
t+ 5	5	9.80	49.00*
t+ 6	-5	9.75	48.75*
t+ 7	-10	9.70	97.00*
t+ 8	-15	9.65	144.75*
t+ 9	-20	9.60	192.00*
t+10	-5	9.55	47.75*

Projected Exposure for t=t+3 to t+10,
starred exposures (*) are added : E_{t+3} = 677.75

Increasing Exposure

(C1) At time t = t+3
Assuming changes in foreign cash flow forecasts, but no changes in exchange rate we may have increased exposure

Time (A)	Projected Net Cash Flow in For.Curr. (B)	Projected Exchange Rate (C)	Projected Exposure (Absolute) Base Curr. (D=C*|B|)	
t+ 4	5	9.85	49.25*	
t+ 5	-5	9.80	49.00*	
t+ 6	-10	9.75	97.50*	
t+ 7	-15	9.70	145.50*	
t+ 8	-15	9.65	144.75*	
t+ 9	-20	9.60	192.00*	
t+10	-15	9.55	143.25*	
t+11	-10	9.50	95.00*	} schedule
t+12	-5	9.45	47.25*	} slippage

Projected Exposure for t=t+3 to t+10,
starred exposures (*) are added : E_{t+3} = 963.50

Increasing Exposure

(C2) At time t = t+3
Assuming changes in foreign cash flow and exchange rate forecasts, we may again have increased exposure:

Time (A)	Projected Net Cash Flow in For.Curr. (B)	Projected Exchange Rate (C)	Projected Exposure (Absolute) Base Curr. (D=C*|B|)	
t+ 4	5	9.85	49.25*	
t+ 5	-5	9.79	48.95*	
t+ 6	-10	9.73	97.30*	
t+ 7	-15	9.67	145.05*	
t+ 8	-15	9.61	144.15*	
t+ 9	-20	9.55	191.00*	
t+10	-15	9.49	142.35*	
t+11	-10	9.43	94.30*	} schedule
t+12	-5	9.37	46.85*	} slippage

Projected Exposure for t=t+3 to t+12,
starred exposures (*) are added : E_{t+3} = 959.20

Decreasing Exposure

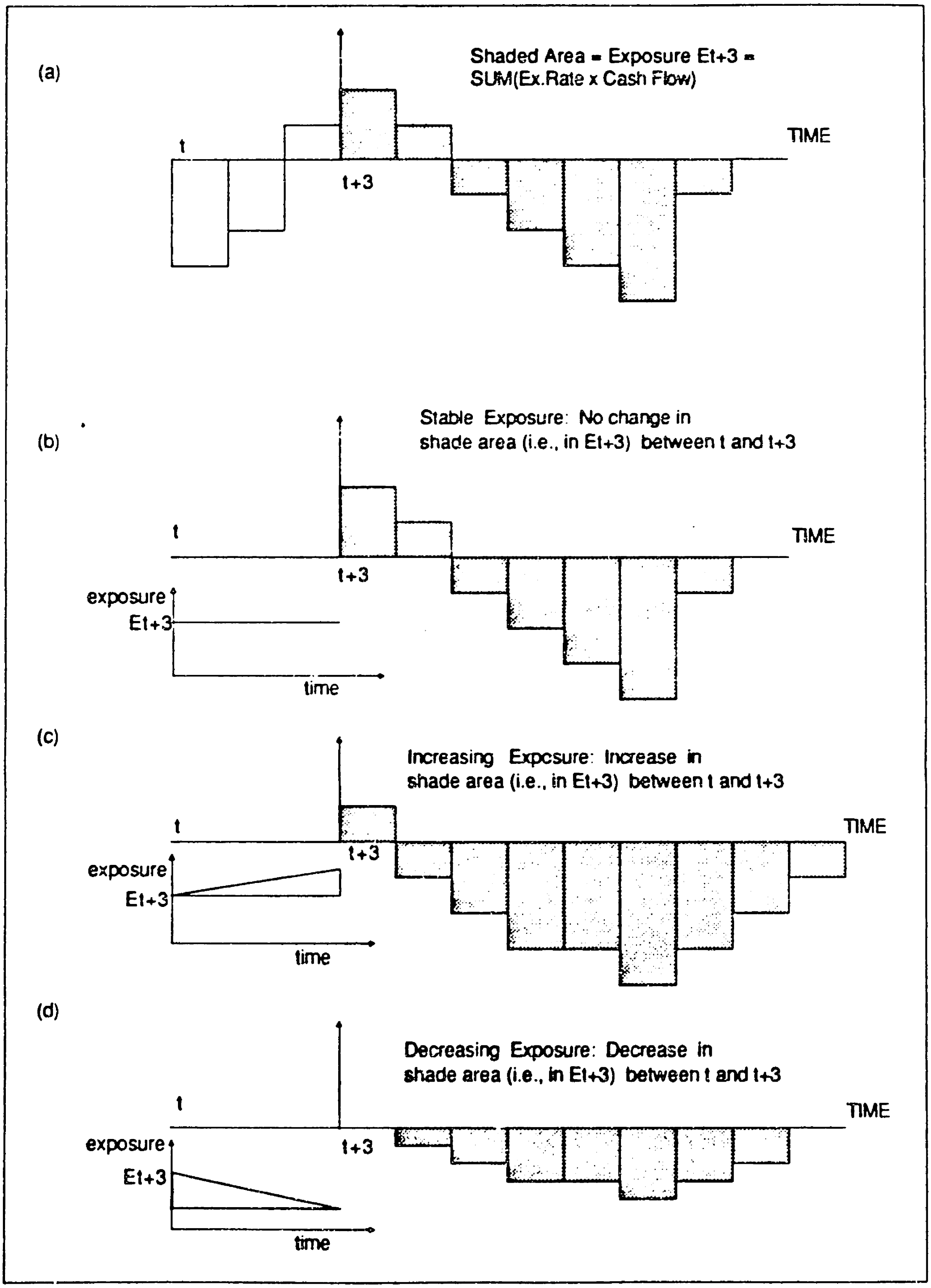
(D) At time t = t+3
Assuming changes in foreign cash flow and exchange rate forecasts, we may have decreased exposure:

Time (A)	Projected Net Cash Flow in For.Curr. (B)	Projected Exchange Rate (C)	Projected Exposure (Absolute) Base Curr. (D=C*|B|)	
t+ 4	0	9.85	0.00*	
t+ 5	-4	9.82	39.28*	
t+ 6	-6	9.79	58.74*	
t+ 7	-8	9.76	78.08*	
t+ 8	-8	9.73	77.84*	
t+ 9	-10	9.70	97.00*	
t+10	-8	9.67	77.36*	
t+11	-6	9.64	57.84*	} schedule slippage

Projected Exposure for t=t+3 to t+11,
starred exposures (*) are added : E_{t+3} = 486.14

FIGURE 3.4

EXPOSURE CHANGES OVER TIME



3.3 Noncontractual Exposure of Multiple Currency Construction Cash Flows

Following the breakdown of construction cash flows by currency, time and cost account, we can now review how microeconomic techniques can enhance the international contractor's understanding of individual noncontractual cash flow exposure in multiple currency environments. (Contractual cash flows are defined as those that are fixed in nominal foreign currency terms. By contrast, noncontractual cash flows fluctuate in nominal foreign currency terms as a function of exogenous market conditions.)

Noncontractual cash flows are affected by multiple factors including political, country and business risks. For example, the nature of contractor business, its relationship with the government, the power of local labor and business interests, and the macroeconomic environment and policies are political and country sources of economic risk. They affect the nominal value of cash flows denominated in foreign currencies.

This section suggests a methodology for understanding how prices, on the cost and revenue sides, respond to currency fluctuations. The resulting exchange rate elasticity of construction cash flows describes expectations about changes in the nominal value of cash flows and suggests a new layer of foreign currency exposure, in addition to the traditionally considered translation exposure.

The traditional approach, as implied by the limited literature (Joiner, 1987) and industry interviews, recognizes foreign exchange gains/losses due to shifts in currency rates only in accounting terms:

$$CF_i(\text{home}) = CF_i(\text{foreign}) * e_i$$

$$\frac{dCF_i(\text{home})}{de_i} = CF_i(\text{foreign})$$

A complete approach recognizes the sensitivity of noncontractual cash flows to currency rate movements, i.e.

$$CF_i(\text{home}) = CF_i(\text{foreign}) * e_i \Rightarrow$$

$$\frac{dCF_i(\text{home})}{de_i} = CF_i(\text{foreign}) * \frac{de_i}{de_i} + \frac{dCF_i(\text{foreign})}{de_i} * e_i \Rightarrow$$

$$\frac{dCF_i(\text{home})}{de_i} = CF_i(\text{foreign}) + \frac{dCF_i(\text{foreign})}{de_i} * e_i$$

The analysis of this section helps understand the neglected in the construction literature and practice second component [dCF_i(foreign)/de] * e of home currency exposure. As such, it uncovers the layer of noncontractual exposure associated with the sensistivity of input prices and, therefore, foreign currency cash flows. The origin, magnitude and implications of such noncontractual exposure for the international contractor is analyzed. Exchange rate changes are considered exogenous events to the construction industry and firms. In other words, we are not concerned with the determination of exchange rates at the macroeconomic level.

Flood (1983; 1985) analyzed the economic factors which determine the way prices, cash flows and production are affected by exchange rate changes. Appendix B develops a relevant part of the approach suggested by Flood. This section summarizes and interprets the same results for the construction industry. The methodologies applied are based on the Marshallian partial equilibrium approach which studies one market at a time. As such, they do not consider the interaction of the market under study with the rest of the economy, which is the centerpiece of general equilibrium analysis.

International and domestic prices of construction goods are the result of exchange rate equilibrium trends that apply to their industry structure. Overall, when a currency depreciates, prices of construction inputs sold to buyers in the depreciating currency's country will rise, in terms of their depreciating currency. At the same time, prices for buyers of appreciating currencies will fall, in terms of their appreciating currency. The extent of price changes reflects the competitive structure of the industry, the proportion of domestic and international producers and consumers, and the elasticities of supply and demand. The microeconomic analysis is performed here for perfect and monopolistic competition, including price discrimination.

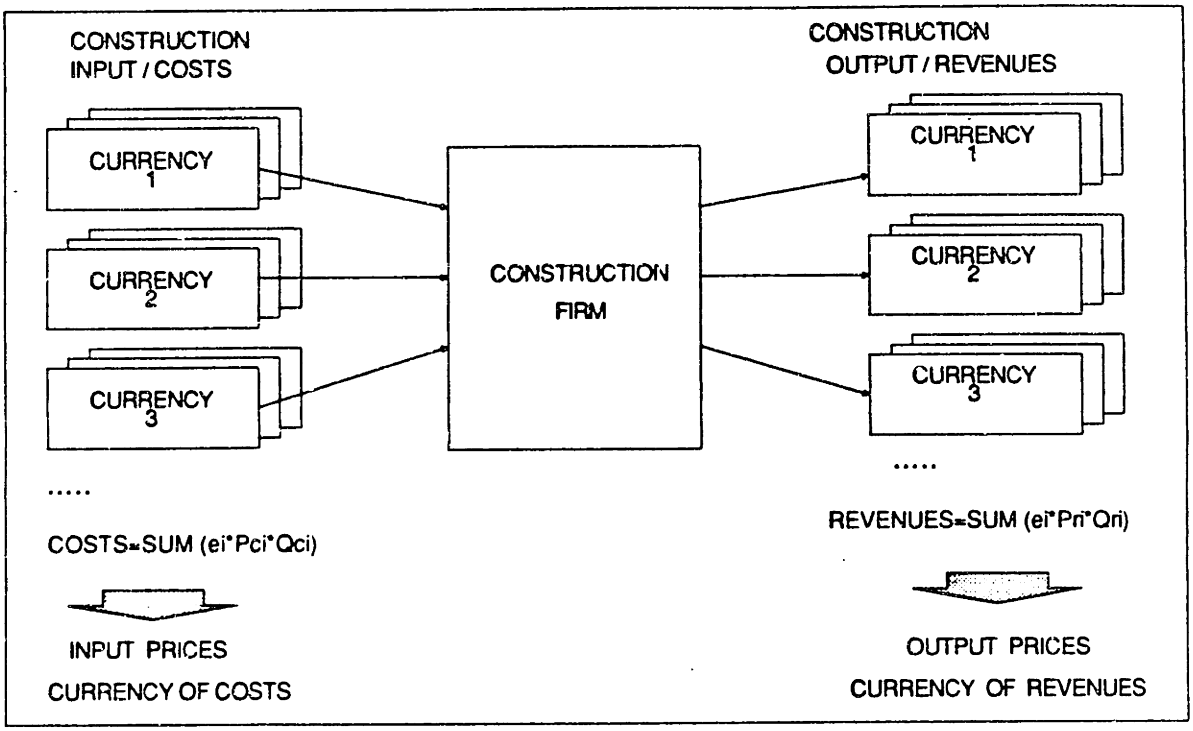
The implication is that costs and revenues of a construction project are exposed to exchange rate changes. The international contractor that is interested to reduce its overall cash flow exposure at the project and firm levels could shift its sourcing to markets such that domestic currency translated revenues and costs move in the same direction when exchange rates change.

3.3.1 International Construction Industry Structures

The international contractor can utilize a variety of inputs from many countries in order to deliver different types of constructed facilities to its world clients. As such, it stands between a host of upstream industries and its clients. Figure 3.5 summarizes graphically the relationship. The economic decisions affecting the contractor's costs relate to construction input prices, their currency of denomination and their availability. On the revenue side, they relate to the contractor's markup, its output prices and the currency of denomination of its revenue. These factors are influenced by (a) the competitive structure of the economic environments of upstream industries and of the

FIGURE 3.5

CONSTRUCTION FIRM UPSTREAM AND DOWNSTREAM RELATIONSHIPS



international construction industry, and (b) the contractual obligations to the owner and/or project financing arrangements.

On the cost side, input prices and availability are determined by the international competitive environment of the industry providing the inputs. The prices of construction materials depend on the number of producing firms and the existing product differentiation in the relevant market. The relevant market is largely defined by the sourcing obligations of the international contractor to the owner and sponsor of the project. If the contractor has agreed to source construction inputs from a local foreign market, then the local industry structure is the relevant environment. In the absence of such sourcing obligations, the relevant industry structure may be defined internationally.

Within the relevant market, technical and legal factors determine the existence of barriers to entry and the level of competition, from perfect competition to monopoly. Technical factors establish the existence of decreasing marginal costs over wide ranges of output, and therefore the potential for monopoly power. They may result in different industry structures for the same construction input in different markets. For example, a construction input may not exhibit decreasing marginal costs at the national US or international level, which suggests the absence of technical barriers to entry. This implies, according to microeconomic theory, that many firms can operate in a competitive environment. However, in a particular small foreign market, decreasing marginal costs may be exhibited. Such is the case of ready mix concrete, where high transportation costs tend to isolate small foreign local markets and create monopoly power. This industry is most often competitive in large metropolitan US markets, but monopolistic in isolated local US markets (for similar reasons that apply to foreign local markets). Legal factors affecting the industry structure are due to government-granted monopoly positions in the form of legal protection of a productive technique and/or to the awarding of exclusive franchises to serve local markets. Prices in such monopolies may be regulated by the government.

The international contractor needs to understand (a) its contractual obligations regarding input sourcing, and (b) the competitive structure of the industry it is sourcing its inputs from (whether required by the owner or sponsor, or decided by the contractor). Owners will often require input sourcing from local markets to support local industries. Sponsors (such as foreign aid agencies) will often require sourcing from markets of the sponsoring ageny's country. In the absence of such requirements, owners will source in ways that minimize their base currency costs. Therefore, the currency of denomination of construction inputs can be determined by the owner (foreign local currency), sponsor (sponsor's home currency - typically contractor's home currency), or by the contractor (contractor's currency choice). The input prices and availability from any of the above sources will at large be determined exogenously, as a function of the industry structure. Therefore, noncontractual costs are directly affected by the currency of denomination and industry structure.

The same approach to understanding the competitive environment applies to the revenue side of international construction. International contractors will determine their markup based on the competition they face, which will be subject to the number of contractors competing and product differentiation. International construction activity data suggest that the segment of building and heavy construction, characterized by more participating firms and relatively homogeneous product, are more competitive than process plant construction (Engineering News Record, 7/15/1982). In less competitive environments, a contractor has more control over pricing. The more competitive the environment, the more its markup will be defined by the competition.

The currency of denomination of revenue may be defined by the owner or sponsor of the project. Less developed country owners, which represent the majority of international construction, (reference to data in other section) will tend to favor payment in their own currency, often characterized as "weak" or "soft". Sponsors are typically not willing to take foreign exchange positions and prefer to finance international projects with their own currency (contractor's home currency), whether the project is constructed in a country with "weak" or "strong" currency. For example, the State Department pays its contractors in US dollars for US embassy construction work, whether in Egypt or W.Germany. Of course, in the absence of owner or sponsor restrictions, the contractor can negotiate the currency of denomination of its revenue.

3.3.2 Perfect Competition

Perfect competition assumes the existence of many firms selling homogeneous construction products to international contractors (Nicholson, 1982). The analysis is based on two-country settings, with a fixed number of domestic and foreign firms, sourcing their own inputs in domestic markets and selling to both countries. In other words, the contractor can source its inputs from its home country, or a foreign country (that could be the project owner's).

The following symbols are used in the analysis:

P_d Domestic Price

P_f Foreign Price

S_d Domestic Supply

S_f Foreign Supply

D_d Domestic Demand

D_f Foreign Demand

N_{dd} Number of Domestic Customers

N_{df} Number of Foreign Customers

N_{sd} Number of Domestic Firms

N_{sf} Number of Foreign Firms

e Exchange Rate, i.e., the price of the foreign currency unit in US dollars, i.e., the direct quote from U.S. perspective.

Assumption:

$P_d = e*P_f$, i.e., Purchasing Power Parity (PPP) holds.

In perfect competition, the firm is a profit maximizer, but it can't influence prices. Instead, it will produce the output for which its marginal costs will equal price, which is equal to marginal revenue. Prices are exogenously determined by the market supply and demand dynamics. The market (partial) equilibrium at any time t requires that:

Supply (Foreign+Domestic) = Demand (Foreign+Domestic)

$$\Rightarrow \quad N_{sd}*S_d*(e*P_f) + N_{sf}*S_f*(P_f)=N_{dd}*D_d*(e*P_f) + N_{df}*D_f*(P_f)$$

The differentiation of both sides of this equation with respect to e yields (see appendix B):

$$\frac{dP_f}{de}*\frac{e}{P_f} = \frac{e*[N_s*\frac{dS_d}{d(e*P_f)} - Nd*\frac{dD_d}{d(e*P_f)}]}{[e*N_d*\frac{dD_f}{dP_f} - N_s*\frac{dS_f}{dP_f}]-e*[N_s*\frac{dS_d}{d(e*P_f)} - Nd*\frac{dD_d}{d(e*P_f)}]}$$

or

$$\frac{dP_f}{de}*\frac{e}{P_f} = \frac{A_1}{B_1 - A_1} \quad (= K_1)$$

where

$$A_1 = e*N_s*\frac{dS_d}{d(e*P_f)} - e*Nd*\frac{dD_d}{d(e*P_f)}$$

and

$$B_1 = e*N_d*\frac{dD_f}{dP_f} - N_s*\frac{dS_f}{dP_f}$$

and

$$P_d = e * P_f \Rightarrow$$

$$\Rightarrow \quad \frac{dP_d}{de} = P_f + e * \frac{dP_f}{de} \Rightarrow$$

$$\Rightarrow \quad \frac{dP_d}{de}*\frac{e}{P_d} = 1 + \frac{dP_f}{de}*\frac{e}{P_f} \quad (= L_1)$$

Assuming negative slopes for the domestic and foreign industry demand curves (dD_d/dP_d and $dD_f/dP_f < 0$, $P_d = e * P_f$) and positive slopes for the supply curves (dS_d/dP_d and $dS_f/dP_f > 0$, $P_d = e*P_f$), the exchange rate elasticity of foreign price K_1 is less than 0 and greater than -1, while the exchange rate elasticity of domestic price L_1 is less than 1 and greater than 0:

$$0 < \frac{dP_d}{P_d}*\frac{e}{de} < 1 \ , \quad -1 < \frac{dP_f}{P_f}*\frac{e}{de} < 0$$

The conclusion is that, when the domestic currency depreciates, ($de/e>0$) prices to domestic buyers will tend to rise ($dP_d/P_d>0$) in terms of their domestic currency, while prices to foreign buyers will tend to fall ($dP_f/P_f<0$) in terms of their foreign currency. The extent of price changes will depend on the slope of the demand and supply curves (dD/dP, dS/dP).

The international contractor sourcing some of its competitively priced inputs from domestic markets will be faced with increasing domestic prices (i.e., prices in domestic currency in the domestic market) of domestic and foreign goods, when the domestic currency depreciates, while foreign prices to competitors (i.e., prices in the foreign currency, in the foreign country) will be decreasing. If the contractor expects its home currency to depreciate, it should favor fixing in nominal terms the costs of inputs it may be obliged to source from domestic and foreign markets. Similarly, it should pursue fixing its nominal costs contractually, if it is contractually commited to sourcing competitively traded goods from a host country whose currency is likely to depreciate.

Appendix B shows that production of goods in perfect competition may increase or decrease, depending on the relative flow of trade between countries. When the country whose currency depreciates is closer to being an all-exporter, production increases. When it is closer to being an all-importer, production decreases (Flood, 1985). This observation leads to an interesting implication for international contractors: if the contractor is dependent on competitively priced inputs from a country that is close to being an all-exporter, there is a likelihood of shortage of these inputs, with possible implications on the contractor's schedule, in case of depreciation of the producing country's currency.

The international contractor's pricing decision and bidding strategy is similarly affected from exchange rate fluctuations in a competitive environment. The analysis implies that, in a construction industry segment with many competing firms and no tangible product differentiation, contractors with depreciating home currency will tend to have increased fixed overhead costs, and therefore higher bid prices.

3.3.3 Monopolistic Competition

The symbols and definitions used in the section on perfect competition are maintained in this section too. As in perfect competition, the firm is interested in maximizing its profits. However, in monopolistic competition, the firm has some control over the prices of its outputs.

Profit = Revenues - Costs, or $P_r = R - C$

where,

Revenue(dom.currency)= Domestic Revenue + Foreign Revenue =>

$$R = P_d*D_d + (e*P_f)*D_f =$$
$$= e*P_f*D_d + e*P_f*D_f =$$
$$= e*P_f*(D_d+D_f) = e*P_f*D$$

for $P_f=P_f*(D_d+D_f)$, $D=D_d+D_f$ (PPP holds, i.e., $P_d=e*P_f$, and Pf is a function of ex.rate and total demand D)

Costs $C = C(D) = C(D_d+D_f)$

Therefore,

$$\text{Profit} = P_r = e*P_f(e,D)*D - C(D)$$
$$= e*P_f*D_d + e*P_f*D_f - C(D)$$

In monopolistic competition, the firm has some control over the prices it charges. For example, it can increase or decrease the foreign price P_f of its product, i.e., the price a foreign buyer will have to pay for it, so that its profit is maximized. In microeconomic terms, the price P_f is one of the firm's choice variable (Flood, 1985; Chiang 1984). The first order condition for profit maximization is then:

$$\frac{dP_r}{dP_f} = 0$$

Using the above expression for profit Pr, we differentiate and derive the following expression:

$$\frac{dP_r}{dP_f} = e^2P_f*\frac{dD_d}{d(e*P_f)} + e*D_d + e*P_f*\frac{dD_f}{dP_f} + e*D_f - e*\frac{dC}{dD_d}*\frac{dD_d}{d(e*P_f)} - \frac{dC}{dD_f}*\frac{dD_f}{dP_f} = 0 \qquad (1)$$

Next, we get an expression for dP_f/de by differentiating (1) with respect to e. Following the calculus of appendix B, the exchange rate elasticity of foreign price is:

$$\frac{dP_f}{de}*\frac{e}{Pf} = \frac{-2*e^2*P_f*\frac{dD_d}{d(e*P_f)} - \frac{dC}{dD_f}*\frac{dD_f}{dP_f}}{2*e^2*P_f*\frac{dDd}{d(e*Pf)} + 2*e*P_f*\frac{dDf}{dPf}}$$

or

$$\frac{dP_f}{de}*\frac{e}{P_f} = \frac{-A_2 - B2*C2}{A_2 + D_2} \quad (= K_2)$$

where

$$A_2 = -2*e^2*P_f*\frac{dDd}{d(e*P_f)}, \quad B_2 = \frac{dC}{dD_f}, \quad C_2 = \frac{dDf}{dP_f}, \text{ and}$$

$$D_2 = 2*e*P_f*\frac{dD_f}{dP_f}$$

Assuming again negative slopes for the demand curves and positive curves for the supply curves, we have $A_2<0$, $B_2>0$, $C_2<0$ and $D_2<0$, therefore $K_2<0$. It is also shown in appendix B that $K_2>-1$, i.e., that $-1<K_2<0$, or:

$$-1 < \frac{dP_f}{de}*\frac{e}{P_f} < 0$$

In addition, following that $P_d = e * P_f$ we have (as shown):

$$\frac{dP_d}{de}*\frac{e}{P_d} = 1 + \frac{dP_f}{de}*\frac{e}{P_f}$$

$$= \frac{2 \cdot e \cdot P_f \cdot \frac{dD_f}{dP_f} - \frac{dC}{dD_f} \cdot \frac{dD_f}{dP_f} \cdot \frac{dD_f}{dP_f}}{2 \cdot e^2 \cdot P_f \cdot \frac{dD_d}{d(e \cdot P_f)} + 2 \cdot e \cdot P_f \cdot \frac{dD_f}{dP_f}} \quad (= L2),$$

with $0<L_2<1$, or:

$$0 < \frac{dP_d}{de} \cdot \frac{e}{P_d} < 1$$

Similarly to the analysis of perfect competition, the conclusion is that when the domestic currency depreciates, ($de/e>0$) prices to domestic buyers will tend to rise ($dP_d/P_d>0$) in terms of their domestic currency, while prices to foreign buyers will tend to fall ($dP_f/P_f<0$) in terms of their foreign currency. However, the extent of price changes will be different, given the different contribution of demand, supply and cost curve slopes (dD/dP, dS/dP, dC/dP) to the exchange rate elasticity formulae, because the monopolistic producer has some effect on price.

As a result, an international contractor sourcing some of its inputs from monopolistically competitive markets should be fixing its costs in currencies likely to depreciate, where the unit prices will tend to rise. As a matter of fact, the analysis suggests that the international contractor should be fixing such costs more often for inputs sourced from monopolistic rather than from perfectly competitive markets. The reason is that, unlike perfect competition where price equals marginal cost, in monopolistic competition price is greater than marginal cost. As a consequence, the foreign exchange elasticity formula implies that foreign prices are more sensitive in monopolistic than in competitive environments, resulting in higher variations of exposed cash flows. The conclusion is consistent with the intuitive expectation that exposure in inputs sourced from monopolies is riskier than exposure in inputs sourced from competitive markets.

With reference to output trends, it can be shown (appendix B) that, in monopolistic competition, when the producer's currency depreciates, overall production of goods increases, production for domestic markets decreases, and production for foreign markets increases. The international contractor should expect fluctuations in the supply and availability of its inputs in the domestic and international markets and plan accordingly, in order to avoid delivery and schedule delays. Again, the general conclusion is consistent with the intuitive expectation that monopolistic producers will have more influence in their quantity and location of production than competitive producers.

Finally, the international contractor's markup and pricing decisions and strategy are affected by exchange rate fluctuations in ways similar to those discussed for perfect competition. Fixed overhead cost in domestic currency will be likely to increase due to home currency depreciation, because the overhead costs of a general contractor (domestic currency priced salaries, services and other expenses) will tend to follow the rising domestic price indexes. If the revenue is fixed in nominal domestic currency terms, an exposed contractor is likely to face losses in domestic currency.

In brief, the contractor is expected to make such responses for two primary reasons. First, because it is assumed to be a profit maximizer. Second, because it is also assumed to have an exposure in foreign currencies. When a foreign exchange change takes place, prices change and, as a result, cash flows in foreign currency terms change. Given the new exposure that the contractor is faced with, it has to make operational adjustments, shifts in sourcing, in order to reduce its exposure to acceptable levels, for the associated risk.

By reassessing and restructuring, whenever possible, its foreign exchange exposure with such responses, the international contractor effectively manages its exposure with operational hedging. This is a cost-effective first step towards exposure management, without resorting to financial hedging instruments, such as currency forward, futures and options contracts. If operational hedging is not possible, the contractor will not maximize its domestic profits. Instead, it will have to decide whether to bear the risk of the new exposure, or hedge with financial instruments, trading part of the risk with the instruments' cost. This may or may not be possible, depending on the availability and cost of financial instruments. For example, a long position in a likely to depreciate currency of a developing country may be more difficult to manage with financial instruments (that will probably not be available) than a similar position in a widely traded currency, such as the sterling pound. The feasibility of, typically short-term, financial instruments, which can be appropriate in international commodity trading, is also more difficult in medium- and long-term international construction projects.

3.3.4 Price Discrimination

Until now it has been assumed that Purchasing Power Parity (PPP) holds, i.e., that exchange rates fluctuations are offset by price changes. The mathematical expression explicitly used in sections 3.3.2 and 3.3.3 has been:

$$P_d = e * P_f$$

For example, on the cost side, this relationship implies that the effective price of construction inputs are the same internationally, excluding transportation and other costs. In reality, legal barriers, quotas, tariffs and other institutional reasons make it possible that some of the contractor's suppliers can segment their markets and charge different prices across markets.

Of course, the contractor may be able to source its inputs internationally, in order to minimize its costs. Still, international suppliers having monopoly positions allowing them to practice price discrimination across national borders and currencies can affect a contractor's noncontractual costs, especially when markets are sufficiently separated from each other. In addition, contractual requirements to source domestically can result in cost, and therefore competitive, advantage or disadvantage when PPP does not hold (reference later section).

The notation assumptions are the same as in the previous sections. The firm is still a profit maximizer. However, compared to monpolistic competition, in price discrimination, the firm has more control over prices and production. The essential new element in the analysis is that purchasing power parity does not hold, i.e., P_d is not equal to e^*P_f. Profit in domestic currency is given by the expression:

Profit = Revenue(Domestic Currency)+
Revenue(Foreign Currency)-
Costs

or

$$Pr = P_d{}^*D_d + e^*P_f{}^*D_f - C(D), \text{ where } D=D_d+D_f$$

The first and second order condition for profit maximization are now:

First order conditions:

$$\frac{dPr}{dD_d} = 0, \quad \frac{dPr}{dD_f} = 0$$

Second order conditions:

$$\frac{d^2Pr}{dD_d^2} < 0, \quad \frac{d^2Pr}{dD_f^2} < 0, \text{ and}$$

$$\left(\frac{d^2Pr}{dD_d^2}\right)*\left(\frac{d^2Pr}{dD_f^2}\right) - \left(\frac{d^2Pr}{dD_d\, dD_f}\right)^2 > 0$$

The conditions imply that the firm chooses the amounts it produces for domestic and foreign buyers, i.e, that domestic and foreign output are choice variables in microeconomic terms. Following the analysis of appendix B, we have:

$$\frac{dD_d}{de} = \frac{[P_f + D_f*\frac{dP_f}{dD_f}] * \frac{d^2C}{dD^2}}{[2*\frac{dP_d}{dD_d} + Dd*\frac{d^2P_d}{dD_d} - \frac{d^2C}{dD^2}]*[2*e*\frac{dP_f}{dD_f} + e*Df*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}]-[\frac{d^2C}{dD^2}]^2}$$

with $dP_d/de = (dP_d/dDd)*(dD_d/de)$, and

$$\frac{dD_f}{de} = \frac{-[P_f + D_f*\frac{dP_f}{dD_f}] * [2*\frac{dP_d}{dD_d} + Dd*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}]}{[2*\frac{dP_d}{dD_d} + Dd*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}]*[2e*\frac{dP_f}{dD_f} + e*Df*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}]-[\frac{d^2C}{dD^2}]^2}$$

with $dP_f/de = (dP_f/dD_f)*(dD_f/de)$.

Given the profit maximization first and second order conditions, it can be shown (see appendix B) that domestic currency depreciation (de>0) is followed by reduction in output for domestic markets ($dD_d/de<0$) and an increase in domestic currency prices for domestic buyers ($dP_d/de>0$). It is also shown that a domestic currency depreciation (de>0) is followed by increase in output for foreign markets ($dD_f/de>0$) and a decrease in foreign currency prices for foreign buyers ($dP_f/de<0$).

For the international contractor, this observation leads to conclusions similar to those reached under the assumption that the law of one price holds. However, a close examination of the formulae reveals that the exchange rate elasticity of foreign and domestic prices is lower for the price discriminator than for the monopolistic competitor. In other words, the variability of costs facing the international contractor will tend to be lower from price discriminating sources.

This can be seen by assuming, for simplicity, but without loss of generality, linear demand and cost curves for a contractor's inputs, i.e., that $d^2P_f/dD_f^2 = d^2P_d/dD_d^2 = 0$, and $d^2C/dD^2 = 0$. The adjustment of the price discrimination formulae derived in the current section, results in a simpler expression of elasticity of P_f:

$$\frac{dP_f}{de} * \frac{e}{P_f} = \frac{e}{P_f} * \frac{dP_f}{dD_f} * \frac{dD_f}{de} = \frac{-\left[Pf + Df * \frac{dP_f}{dD_f}\right] * \left[2 * \frac{dP_d}{dD_d}\right]}{\left[2 * \frac{dP_d}{dD_d}\right] * \left[2e * \frac{dP_f}{dD_f}\right]} * \frac{e}{P_f} * \frac{dP_f}{dD_f} =$$

$$= \frac{-\left[P_f + D_f * \frac{dP_f}{dD_f}\right]}{2 * e} * \frac{e}{P_f} = \frac{-\left[P_f + D_f * \frac{dP_f}{dD_f}\right]}{2 * P_f} = \frac{-MR_f}{2 * P_f}$$

Under the same assumptions of linear demand and cost curves, with the additional assumption, for simplicity, of perfectly inelastic domestic demand (i.e., $dD_d/dP_d = 0$), which reduces the exchange rate elasticity of price, the monopolistic competition formula of the previous section is simplified as follows:

$$\frac{dP_f}{de} * \frac{e}{P_f} = \frac{-\frac{dC}{dD_f} * \frac{dD_f}{dP_f}}{2*e*P_f*\frac{dD_f}{dP_f}} = \frac{-\frac{dC}{dD_f}}{2*e*P_f} = \frac{-MC_f}{2*P_f}$$

Since the firm is a profit maximizer, $MR_f = MC_f$, therefore the two exchange rate elasticities are equal. In other words, in the special case of inelastic domestic demand, prices in price discrimination are as responsive as prices in monopolistic competition. Consequently, in the more general case of elastic demand, prices in price discrimination will be less responsive than prices in monopolistic competition, or, equivalently, the exchange rate elasticity of prices is lower in price discrimination.

Therefore, the international contractor that sources inputs from price discriminating environments will have higher exposure due to the higher prices it has to pay, compared to competitive environments, but will also have reduced variability of its cash flows due to foreign exchange changes. In other words, part of the contractor's foreign exchange risk (i.e., variability of its cash flows) is traded off with the higher price it pays to the price disciminating producer. Of course, the higher costs associated with price discriminating industries can contribute positively or negatively to exposure in a given currency, depending on the overall short or long, respectively, position that the contractor may have in it.

3.4 International Construction Competitivencss and Deviations from Purchasing Power Parity (PPP)

A key consideration in the preceding analysis is the validity of purchasing power parity (PPP) in international construction and its upstream industries. Economy wide measures of deviations from PPP are overall useful indicators of international cost trends and their impact on competitiveness. However, specific industry price trends typically differ from national price trends. This is true for the construction industry and its subsegments.

Table 3.5 shows these differences in price trends by comparing economy wide indicators, such as the consumer and producer price indexes, with composite construction, as well as highway and power plant construction in particular. These differences within the construction industry are due to the observed varying cost structure among project types, as indicated in section 3.2 (see tables 3.3, 3.4). For example, for the most part of the past 30 years, highway construction costs have been increasing faster than average construction costs, which have in turn been increasing faster than producer and consumer prices. Given the observed differences in rates of cost changes, it is critical to differentiate PPP for the construction industry and, if possible, for specific project types.

At the economy level, when the PPP condition holds, changes in exchange rates exactly offset price changes, as they are reflected by national inflation rates. If P_d is the domestic price level, P_f the foreign country price level, and e the exchange rate among the two countries (i.e., the price of one unit of foreign currency in domestic currency), PPP holds when:

TABLE 3.5

PRICE TRENDS: US ECONOMY, CONSTRUCTION INDUSTRY

Year	Producer Price Index	Consumer Price Index	Composite Construction Cost Index	Highway Construction Cost Index	Power Plant Construction Cost Index
SUMMARY OF INDEXES					
1960	98.9	93.7	96.3	88.7	97.6
1965	100.0	100.0	100.0	100.0	100.0
1970	114.0	123.0	130.3	139.1	134.6
1975	177.8	170.5	204.8	231.9	195.3
1980	284.9	261.1	328.4	390.9	287.6
1985	339.4	336.7	387.2	412.6	348.8
ANNUALIZED PRICE CHANGES, PERCENT					
1960-65	0.2	1.3	0.8	2.5	0.5
1965-70	2.8	4.6	6.1	7.8	6.9
1970-75	11.2	7.7	11.4	13.3	9.0
1975-80	12.1	10.6	12.1	13.7	9.4
1980-85	3.8	5.8	3.6	1.1	4.3

Sources :

1 Federal Reserve Bulletin, var. issues (1968-1986).
2 US Dept. of Commerce, various issues (1968-1986).
3 Construction Review, July/August 1983.
4 Construction Review, September/October 1984.
5 Construction Review, May/June 1988.

$$e = \frac{P_d}{P_f} \quad \text{("absolute version" of PPP)} \qquad (1)$$

3.4.1 PPP in Construction

Assuming that the price level for construction inputs are $P_{d,c}$ and $P_{f,c}$, PPP holds for the relevant construction prices when:

$$e = \frac{P_{d,c}}{P_{f,c}} \quad \text{("absolute version" of PPP in construction)} \ (2)$$

In general, the ratio $P_{d,c}/P_{f,c}$ will not equal P_d/P_f. So, while PPP may hold at the national economy level, it may not hold at the construction input level and vice versa, or may not hold differentially in both. For example, in March 1983, the price of reinforcing bars was about $430.00 ($P_{d,c}$) per metric ton in Dallas, while the exchange rate between the US dollar and the Korean won was about 800 Yen per US dollar, i.e., e = 0.00125 US $/won. If PPP holds, the price of the same item in Korea should have been 344,000.00 won (= $ 430.00 * 800 won/$). Deviation from this price would result in advantage or disadvantage for the relevant industry and affect the competitiveness of the construction industries, if they had to source domesticallly. The actual price in Seoul was about 304,000.00 won, (or about $380.00), i.e., PPP did not hold, and Korean contractors had a price advantage. By contrast, the price of cement in Dallas was about $64.00 per metric ton, or $64.00 * 800 won/$ = 51,200 won, while the price in Korea was about 52,000 won; i.e., PPP practically held and no competitive advantage was observed.

Deviations from PPP may display increasing or decreasing trends over time, if the rates of change of domestic construction costs vs. national economy prices, and/or foreign construction costs are different. A "relative version" of PPP implies that trends in foreign exchange rates are offset by trends in the rates of inflation.

The relative version of PPP for construction is developed by comparing exchange rates and prices over time. In the following definition, we denote $f_{d,c}$ and $f_{f,c}$ the domestic and foreign construction industry inflation rates respectively.

At $t=0$ $\quad e_0 = P_{d,c0}/P_{f,c0}$

At $t=1$ $\quad e_1 = P_{d,c1}/P_{f,c1}$

Then, the change in the exchange rate will be:

$$e_1 - e_0 = \frac{P_{d,c1}}{P_{f,c1}} - \frac{P_{d,c0}}{P_{f,c0}} =$$

$$= \frac{(1+f_{d,c})*P_{d,c0}}{(1+f_{f,c})*P_{f,c0}} - \frac{P_{d,c0}}{P_{f,c0}} =$$

$$= \frac{(1+fd,c)*P_{d,c0} - (1+ff,c)*P_{d,c0}}{(1+f_{f,c})*P_{f,c0}} =$$

$$= \frac{(f_{d,c}-f_{f,c})*P_{d,c0}}{(1+f_{f,c})*P_{f,c0}} = \frac{(f_{d,c}-f_{f,c})}{(1+f_{f,c})}*e_0$$

$$\frac{e_1 - e_0}{e_0} = \frac{(f_{d,c}-f_{f,c})}{(1+f_{f,c})} \cong (f_{d,c}-f_{f,c}) \qquad (3)$$

The above relationship (3) implies that, if PPP holds for the construction industry, changes in exchange rates will be offset by relative construction price changes, i.e., they will be reflected by the relevant to the industry inflation rates. For example, a domestic currency depreciation of 1 percent should be accompanied by domestic inflation of about 1 percent higher than the foreign inflation. Since most construction economic statistics are reported using construction index trends, the relative version of PPP is an easier tool for determining changes over time in the competitive position of internationally competiting contractors.

3.4.2 Competitive Advantage Associated with PPP

Deviations from PPP have impact on the international contractor's competitiveness and real profitability. To understand the impact of PPP on competitiveness, we consider the bids of two contractors with different base currencies. We assume that both firms source the same percentage of their direct costs in base currency (to account, for example, for contractual obligations to sponsor), while the rest of direct costs are based on international prices. We also assume that the markup detemination in guided by base currency return on investment requirements. Finally, for comparison purposes we assume that both contractor bids are denominated in a third currency FC.

The notation used is as follows:

B_i	bid of contractor i
DC_i	direct costs of contractor i
M_i	markup of contractor i
FO_i	fixed overhead of contractor i
Pr_i	profit of contractor i
$e_{i,FC}$	exchange rate between currency i and third currency of bid denomination FC
$DC_{i(d,FC)}$	direct costs in home (domestic) currency
$DC_{i(intl,FC)}$	direct costs sourced internationally
$FO_{i(d,FC)}$	fixed overhead in home (domestic) currency
$Pr_{i(d,FC)}$	profit in home (domestic) currency
Subscript $_d$	home(domestic) currency or home country

Subscript $_{intl}$ internationally sourced input

Subscript $_{FC}$ foreign currency of bid denomination

The contractor's bid is the sum of direct costs, in home and foreign currencies, fixed overhead and profit (see figure 3.1):

$$B_i = DC_i + FO_i + Pr_i =$$

$$= DC_{i(d,FC)} + DC_{i(intl,FC)} + FO_{i(d,FC)} + Pr_{i(d,FC)} =$$

$$= e_{i,FC}*DC_{i,d} + \Sigma\ (e_{j,FC}*DC_{j,intl}) + e_{i,FC}*FO_{i,d} + e_{i,FC}*Pr_{i,d} \quad (4)$$

In the above equation (4),

(a) The term $DC_{i,d}$ accounts for direct costs of inputs sourced from the home country of contractor i. As such, it is affected by the competitiveness of the contractor's home country upstream to construction industries.

(b) The term $FO_{i,d}$ accounts for fixed overhead costs of the contractor. As such, it is affected by the costs and overall competitiveness of the contractor organization.

(c) Finally, the term Pr_i accounts for the profit requirement of the contractor. As such it is affected by the contractor shareholders' consumption needs and pricing of risk in capital markets, which are influenced by the purchasing power of their currency.

For the two competing contractors 1 and 2 we have:

$$B_1 = e_{1,FC}*DC_{1,d} + \Sigma\ (e_{j,FC}*DC_{1j,intl}) + e_{1,FC}*FO_{1,d} + e_{1,FC}*Pr_{1,d}$$

$$B_2 = e_{2,FC}*DC_{2,d} + \Sigma\ (e_{j,FC}*DC_{2j,intl}) + e_{2,FC}*FO_{2,d} + e_{2,FC}*Pr_{2,d}$$

Assuming for simplicity that the two competing contractors have equal access to international construction input markets, the internationally sourced inputs should contribute equally to both contractors' cost estimates. We can denote the sum of costs of internationally sourced inputs, translated in the currency of bid denomination, as DC_{intl}:

$$DC_{intl} = \Sigma\ (e_{j,FC}*DC_{1j,intl}) = \Sigma\ (e_{j,FC}*DC_{2j,intl})$$

From the definition of exchange rates we have $e_{2,FC} = e_{1,FC}*e_{1,2}$. Therefore, the two bids of the competing contractors, denominated in the third currency FC are:

$$B_1 = e_{1,FC}*DC_{1,d} + DC_{intl} + e_{1,FC}*FO_{1,d} + e_{1,FC}*Pr_{1,d} \quad (5)$$

$$B_2 = e_{1,FC}*e_{1,2}*DC_{2,d} + DC_{intl} + e_{1,FC}*e_{1,2}*FO_{2,d} + e_{1,FC}*e_{1,2}*Pr_{2,d} \quad (6)$$

One of the two international contractors will have a competitive advantage resulting from exchange rates, if one or more of its cost components in the currency of bid denomination FC is less than its competitor's. In other words, contractor 1 will have a competitive advantage if $B_1 < B_2$. The conditions for such advantage are discussed under holding of PPP, as well as following deviations from PPP.

<u>PPP Holds</u>

To understand the impact of PPP, we examine the bid components in expressions (5) and (6) of the contractors' bids B_1 and B_2. If the following three conditions (a), (b) and (c) hold, then the two contractors do not possess a competitive advantage due to exchange rates.

(a) $DC_{1,d} = e_{1,2}*DC_{2,d}$,

i.e., both contractors can buy the same inputs from each other's markets after translating their home currency funds to each other's currency. No competitive advantage provided by any of the contractors' upstream industries.

(b) $FO_{1,d} = e_{1,2}*FO_{2,d}$,

i.e., both contractors have the same fixed overhead in real currency terms. No competitive advantage provided by the contractors' organizations.

(c) $Pr_{1,d} = e_{1,2}*Pr_{2,d}$,

i.e., both contractors have the same profit requirement in real currency terms. No competitive advantage is provided by shareholder consumption requirements and/or the purchasing power of shareholders' currency.

Given the conditions (a), (b) and (c), the difference B_1-B_2 between the two bids is:

$$
\begin{aligned}
B1-B2 &= e_{1,FC}*(DC_{1,d}-e_{1,2}*DC_{2,d}) + e_{1,FC}*(FO_{1,2}-e_{1,2}*FO_{2,d}) + \\
&\quad + e_{1,FC}*(Pr_{1,d}-e_{1,2}*Pr_{2,d}) = \\
&= e_{1,FC} * (0) + e_{1,FC} * (0) + e_{1,FC}*(0) = \\
&= 0
\end{aligned}
$$

This means that when PPP hold across the different components of international contractors' bids, and real costs are the same, there is no apparent competitive advantage, regarding the ability of any contractor to win projects on the basis of exchange rates, unless they choose a different profit margin. In the case that we analyzed, the two bids will be equal to:

$$B_1 = B2 = e_{1,FC}*DC_{1,d} + DC_{intl} + e_{1,FC}*FO_{1,d} + e_{1,FC}*Pr_{1,d}$$

<u>Deviations from PPP</u>

The violation of one or more from the above conditions (a), (b) and (c) results in bid differential and competitive advantage equal to:

$$B1-B2 = e_{1,FC}*(DC_{1,d}-e_{1,2}*DC_{2,d}) + e_{1,FC}*(FO_{1,2}-e_{1,2}*FO_{2,d}) +$$

$+ e_{1,FC}*(Pr_{1,d}-e_{1,2}*Pr_{2,d})$

The difference between the two bids is a function of

(a) Upstream industry competitiveness. The measure of competitiveness is the difference ($DC_{1,d}-e_{1,2}*DC_{2,d}$), i.e., the difference in the costs of domestically sourced inputs.

(b) Contractor organization competitiveness. The measure of competitiveness is the difference ($FO_{1,2}-e_{1,2}*FO_{2,d}$), i.e., the difference in the fixed overhead costs.

(c) Contractor shareholder consumption and purchasing power. The measure of competitiveness is the difference ($Pr_{1,d}-e_{1,2}*Pr_{2,d}$), i.e., the difference in profit required, which in turn reflects the shareholders' consumption needs and purchasing power of their currency in their domestic market.

3.4.3 Application

The following example illustrates how PPP affect an international contractor's competitiveness. We consider a simplified project requiring:

10,000 units of DC_i's priced domestically at PDC_i

10,000 internationally priced units worth FC 2,000/unit

1,000 units of FOis priced domestically at PFO_i, and

Pr_i the contractor's profit

The simplified bid formula is:

Bi =	$e_{i,FC}*10,000*PDC_i$ +	(direct costs from domestic markets)
	+ $DC_{intl,FC}$ +	(internationally sourced input costs)
	+ $e_{i,FC}*1,000*PFO_i$ +	(fixed overhead costs)
	+ $e_{i,FC}*Pr_i$	(profit)

The exchange rates are:

$e_{1,FC}$ = 10.00
$e_{2,FC}$ = 5.00 => $e_{1,2}$ = 0.50

The input units are:

DC_d units	10,000		
DC_{intl} units	10,000	at PDC_{intl} in FC	2,000
FO_d units	15,000		

The input unit prices for Contractor 1 are:

PDC_1 = 10,000
PFO_1 = 20,000
Pr_1 = 10,000,000

Scenario 1: PPP holds (Prices 1 = Ex. Rate * Prices 2)

The input unit prices for Contractor 2 are:

PDC_2 = 5,000 (= $0.5*PDC_1$)
PFO_2 = 10,000 (= $0.5*PFO_1$)
Pr_2 = 5,000,000 (= $0.5*Pr_1$)

Contractor Bids:		B_1		B_2
	DC_1	= 10,000,000	DC_2	= 10,000,000
	DC_{intl}	= 20,000,000	DC_{intl}	= 20,000,000
	FO_1	= 30,000,000	FO_2	= 30,000,000
	Pr_1	= 1,000,000	Pr_2	= 1,000,000
		61,000,000		61,000,000

The two bids are equal: $B_1 = B_2 = 61{,}000{,}000$

Scenario 2: PPP does not hold for Direct Costs

Assume that the direct costs for contractor 2 are out of PPP by 20%. Then, the input unit prices for Contractor 2 are:

PDC_2 = 6,000 (= $1.2*0.5*PDC_1$)
PFO_2 = 10,000 (= $0.5*PFO_1$)
Pr_2 = 5,000,000 (= $0.5*Pr_1$)

Contractor Bids:

	B_1		B_2
DC_1 =	10,000,000	DC_2 =	12,000,000
DC_{intl} =	20,000,000	DC_{intl} =	20,000,000
FO_1 =	30,000,000	FO_2 =	30,000,000
Pr_1 =	1,000,000	Pr_2 =	1,000,000
	61,000,000		63,000,000

Contractor 2's bid is higher by 3.28 percent due to its higher real direct costs. Contractor 2 has a competitive disadvantage.

Scenario 3: PPP does not hold for Direct Costs, Fixed Overhead and Profit

Now let us assume that all of DCs, FOs and Prs out of line with PPP by 20%

The input unit prices for Contractor 2 are:

PDC_2 = 6,000 (= 1.2*0.5*PDC_1)
PFO_2 = 12,000 (= 1.2*0.5*PFO_1)
Pr_2 = 6,000,000 (= 1.2*0.5*Pr_1)

Contractor Bids:

	B_1		B_2
DC_1 =	10,000,000	DC_2 =	12,000,000
DC_{intl} =	20,000,000	DC_{intl} =	20,000,000
FO_1 =	30,000,000	FO_2 =	36,000,000
Pr_1 =	1,000,000	Pr_2 =	1,200,000
	61,000,000		69,200,000

Contractor 2's bid is higher by 13.44 percent (even hogher than under scenario 1) due to its overall higher real costs and profit requirements. Contractor 2 has a competitive disadvantage (B_2>B_1).

Scenario 4: PPP does not hold for Direct Costs, Fixed Overhead, and Profit. DCs, FOs and Prs out of line with PPP by -40%, 5% and 5% respectively

The input unit prices for Contractor 2 are:

PDC_2 = 3,571
PFO_2 = 10,500
Pr_2 = 5,250,000

Contractor Bids:

		B1			B2
DC_1	=	10,000,000	DC_2	=	7,142,857
DC_{intl}	=	20,000,000	DC_{intl}	=	20,000,000
FO_1	=	30,000,000	FO_2	=	31,500,000
Pr_1	=	1,000,000	Pr_2	=	1,050,000
		61,000,000			59,692,857

Contractor 2's bid is lower, as its real direct cost advantage compensates for the higher fixed overhead and profit requirement. Contractor 2 has a competitive advantage ($B_2<B_1$).

In addition to the impact of contractual agreements on the cost/revenue structure by currency, the project type and the weight of construction costs determines the total impact of real costs on the contractor's competitiveness. Deviations from PPP persisting in one direction over time can result in permanent shifts of competitive advantage with the practical result of forcing the contractors with high real costs out of international markets. This can be seen from the above numerical examples, where a contractor facing consistently higher costs due to deviations from PPP (such as in scenario 3) is unlikely to win jobs and, therefore, risks losing market share in the short run, and possibly its access to given markets in the long run.

Recapturing the market share (following return to PPP equilibrium) is not as easy or quick as the exchange rate adjustments taking place. This is especially true if the contractor is already out of the market, since the business development expenses of reestablishing one's presence in an international market can be very high. The negative impact of higher relative costs of US services and goods on winning international jobs was cited by the Office of Technology Assessment's report on the US construction industry's competitiveness in 1984.

The popular engineering literature and field interviews also confirm the negative long-term impact of high real construction costs on US construction firms' competitiveness during the years of "strong" US dollar in the first half of the 1980s. Three years after the beginning in mid-1985 of the US dollar's steady decline in real and nominal value by as much as 30 percent, the Wall Street Journal reported on March 21, 1988 that "...Construction was hurt by the strong dollar earlier in the decade and has yet to rebound...". The decrease of US construction firms' market share was also attributed to a tightening market, due to reduced purchasing power of value of decreasing dollar revenues in oil producing countries, and the emergence of technologically advanced newly industrialized country competitors.

Of course, with the recent weakening of the US dollar (in real and nominal terms), and the relative strengthening of other industrialized country currencies, non-US contractors have been under similar pressures. Engineering News Record (3/5/87) reported that Japanese and European contractors were shifting their attention to domestic or low risk markets (such as those of industrial countries), or were diversifying their activities to other industries.

On the positive side, a strong economy and a strong in purchasing power currency can buy more construction for developing countries when foreign aid offered in that currency. The OECD reported in 1988 that Japan will surpass the United States in foreign aid in 1989. Japan's foreign aid is primarily targeted towards infrastructure projects and the reported strategy is to combine the effects of foreign aid with US's reduced market share in order to build a lasting leadership for Japanese contractors.

3.4.4 Real Exchange Rate

The above example introduces the concept of the "Real Exchange Rate" RX, defined as one plus the percentage by which exchange rates deviate from parity with prices. The absolute definition is given by the relationship:

$$e = RX * \frac{P_d}{P_f} \Rightarrow RX = e * \frac{P_f}{P_d}$$

When PPP hold, Pd = e*Pf and then RX=1. If Pd>e*Pf, then RX<1 (higher real costs) and the contractor has a disadvantage. By contrast, if Pd<e*Pf, then RX>1 (lower real costs) and the contractor has a competitive advantage. The definition implies that the relevant RX is specific to the project's cash flow components. In the simplified example given above, there is an RX for direct construction costs, an RX for fixed overhead and an RX for the required return.

The focus and level of detail in RX analysis will normally depend on the cost structure of a project. It is important to notice that the relevant RX will not necessarily reflect the overall RX at the wholesale (WPI) or consumer price index (CPI) levels. It will rather reflect a combination of construction industry and national economy price indexes. More specifically, it will reflect the cost structure of a given project type and the relative weight of cost components in the overall budget. Direct construction costs will relate to upstream industries' RX measures. Fixed overhead will relate to relevant RX measures of contractor organizations. Finally, the required profit will be close to national economy RX measures (relevant for example to the WPI and CPI), to the extent that construction firm shareholders are representative of the average consumer.

Finally, as the analysis implies, a construction firm with high real costs can be competitive in the short run by reducing its real profit margins. However, given the small profit margins of international construction firms, reduced real profitability may not be sufficient to offset high real costs in the long run, and the firm may start losing market share.

3.4.5 Empirical Data

We have already seen how construction industry cost indexes display different trends compared to economy wide price indexes, as well as compared to each other. We have also shown how cross-border differences in construction costs provide advantage in international competition. In this subsection we illustrate the existence of such competitive advantage in international construction.

The first set of data provide implicit measures of real exchange rate through aggregate cost data by project type and construction cost systems for selected pairs of potential international competitors. The real exchange measures are suggested to be implicit because they do not reflect unit prices of construction input, but rather unit prices of construction output in local currency. Table 3.6 provides a snapshot of the relative costs of construction systems for concrete office facilities in the United Kingdom and West Germany in March 1987. The real exchange rate is :

$$RX_{UK,GE} = e_{UK,GE} * \frac{P_{GE}}{P_{UK}}$$

or, using the column descriptions of table 3.6,

$$(C) = 0.35135 * \frac{(B)}{(A)}$$

TABLE 3.6

REAL EXCHANGE RATES, STEEL MANUFACTURING CONSTRUCTION
UNITED KINGDOM vs. WEST GERMANY, APRIL 1987

Construction Cost/ SF
Nominal Ex. Rate
e(UK,GE) = 0.35135 St.Pound/DM

	UK Sterl. Pound	WEST GERMANY DM	REAL EX.RATE RX(UK,GE)	UK US$ eUS,UK= 1.5385 $/UK	WEST GERMANY US$ eUS,GE= 0.5405 $/DM
Total Building Costs	29.49	94.41	1.12	45.37	51.03
Sitework	1.29	3.92	1.07	1.98	2.12
Foundation	1.46	4.81	1.16	2.24	2.6
Floor Systems	2.78	8.64	1.09	4.28	4.67
Interior Column Syst	0.42	1.37	1.14	0.65	0.74
Roof Systems	5.84	19.70	1.18	8.99	10.65
Exterior Wall System	3.25	9.99	1.08	5.00	5.4
Exterior Glazed Open	0.06	0.17	1.00	0.09	0.09
Interior Wall System	0.81	2.55	1.10	1.25	1.38
Doors	0.31	0.89	1.02	0.47	0.48
Specialties	0.30	1.05	1.24	0.46	0.57
Equipment	3.28	13.14	1.41	5.05	7.1
Conveying Systems	1.03	4.40	1.50	1.59	2.38
Plumbing Systems	3.67	10.25	0.98	5.65	5.54
HVAC	1.77	4.85	0.96	2.73	2.62
Electrical System	3.14	8.45	0.95	4.83	4.57
Special Electrical	0.07	0.22	1.09	0.11	0.12

Source : Engineering News Record, April 19, 1987

The data demonstrate that the competitive advantage belonged to German contractors, as the aggregate real exchange rate $RX_{UK,GE}$ is 0.74 < 1, which, according to the definition of section 3.4.4 implies that relative costs are higher in the United Kingdom. As expected, real exchange rates differ across construction systems.

Similarly, table 3.7 illustrates the advantage provided by real exchange rate to Belgian vis a vis French contractors. In this case the aggregate $RX_{FR,BE}$ is 0.92 for steel office facilities and 0.88 for steel industrial facilities in 1986. Interestingly enough, we observe similar trends in RX between the construction systems across the two project, i.e., the competitive advantage by construction system is maintained across project types. In addition, we observe that the competitive advantage may be with either contractor for individual construction systems, despite the dominance of one at the aggregate level. For example, French contractors retain a competitive advantage, among other systems, in HVAC, plumbing and equipment, where the relevant $RX_{FR,BE}$'s are greater than 1. Table 3.8 provides a similar comparison of implicit construction real exchange rates between France and Belgium for a variety of project types during the last quarter of 1988. The data imply that the Belgian contractors have maintained their competitive advantage vis a vis the French between 1986 and 1988.

The next set of data provides more explicit real exchange rate information over time, regarding the construction materials costs facing US and South Korean contractors in their home markets. The comparison is notably interesting, because of the already discussed dominance in recent years of Korean contractors in international building construction. During the past 20 years, Korean construction material prices have increased faster than US prices, both considered in the domestic markets and denominated in domestic currency. This is demonstrated by the construction material price index trends in the two countries, displayed in figure 3.6a. Despite that, due to

TABLE 3.7

REAL EXCHANGE RATES, STEEL OFFICE BUILDING CONSTRUCTION
FRANCE vs. BELGIUM, JUNE 1986

Construction Cost/ SF
Nominal Ex. Rate
e(FF,BF) 0.15378 FF/BF

	France French Franc	Belgium Belgian Franc	REAL EX.RATE RX(FR,BE)	France US$ eUS,Fr= 6.9200 FF/$	Belgium US$ eUS,Be= 45.0000 BF/$
Total Building Costs	543.01	3236.40	0.92	78.47	71.92
Sitework	3.53	9.00	0.39	0.51	0.20
Foundation	11.14	75.60	1.04	1.61	1.68
Floor Systems	115.91	605.70	0.80	16.75	13.46
Interior Column Syst	14.60	53.55	0.56	2.11	1.19
Roof Systems	89.41	517.05	0.89	12.92	11.49
Exterior Wall System	19.72	105.30	0.82	2.85	2.34
Exterior Glazed Open	17.65	245.25	2.14	2.55	5.45
Interior Wall System	17.99	135.00	1.15	2.60	3.00
Doors	1.80	26.10	2.23	0.26	0.58
Specialties	17.65	79.20	0.69	2.55	1.76
Equipment	0.69	7.65	1.70	0.10	0.17
Conveying Systems	24.08	118.35	0.76	3.48	2.63
Plumbing Systems	9.90	95.85	1.49	1.43	2.13
HVAC	38.34	343.35	1.38	5.54	7.63
Electrical System	33.08	73.35	0.34	4.78	1.63
Special Electrical	3.74	8.55	0.35	0.54	0.19
Markup	123.66	737.10	0.92	17.87	16.38

Source : Engineering News Record, June 19,1986

TABLE 3.8

REAL EXCHANGE RATES
FRANCE vs. BELGIUM, DECEMBER 1988

Construction Cost/ SF
Nominal Ex. Rate
e (France, Belgium) = 0.1525 FF/BF

	Computer	Hotel	Manufacturing	Hi-Rise Office	Lo-Rise Office	Warehouse
Total Building Costs	0.85	0.86	0.87	0.86	0.88	0.88
Sitework	1.06	1.45	1.47	1.12	0.72	1.30
Foundation	0.70	0.75	0.60	0.71	0.71	0.74
Floor Systems	0.79	0.97	0.69	0.96	0.75	0.78
Interior Column Syst	0.91	0.79	0.63	0.75	0.87	0.80
Roof Systems	1.05	1.27	1.04	1.09	1.23	0.80
Exterior Wall System	0.91	0.87	0.95	0.94	0.99	0.84
Partitions	0.74	0.95	0.77	0.91	0.45	1.74
Finishes	0.73	1.10	1.25	0.87	0.80	1.60
Specialties	0.82	0.82	na	1.71	1.70	na
Equipment	0.86	1.20	na	1.24	0.93	na
Conveying Systems	0.98	0.81	na	0.97	na	na
Plumbing Systems	0.90	0.59	0.84	0.72	1.09	1.53
HVAC	0.86	0.53	0.88	0.73	0.88	0.74
Electrical Systems	0.81	0.74	0.74	0.76	0.65	0.78

Source : Engineering News Record, December 15, 1988

FIGURE 3.6A

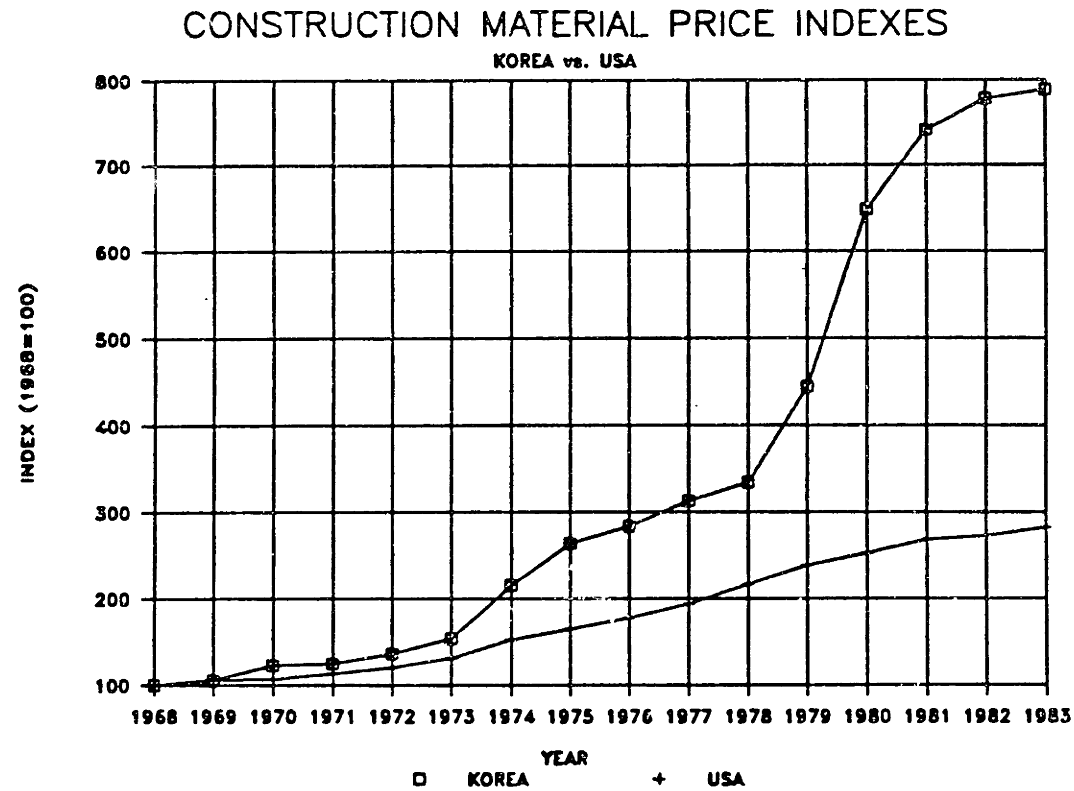
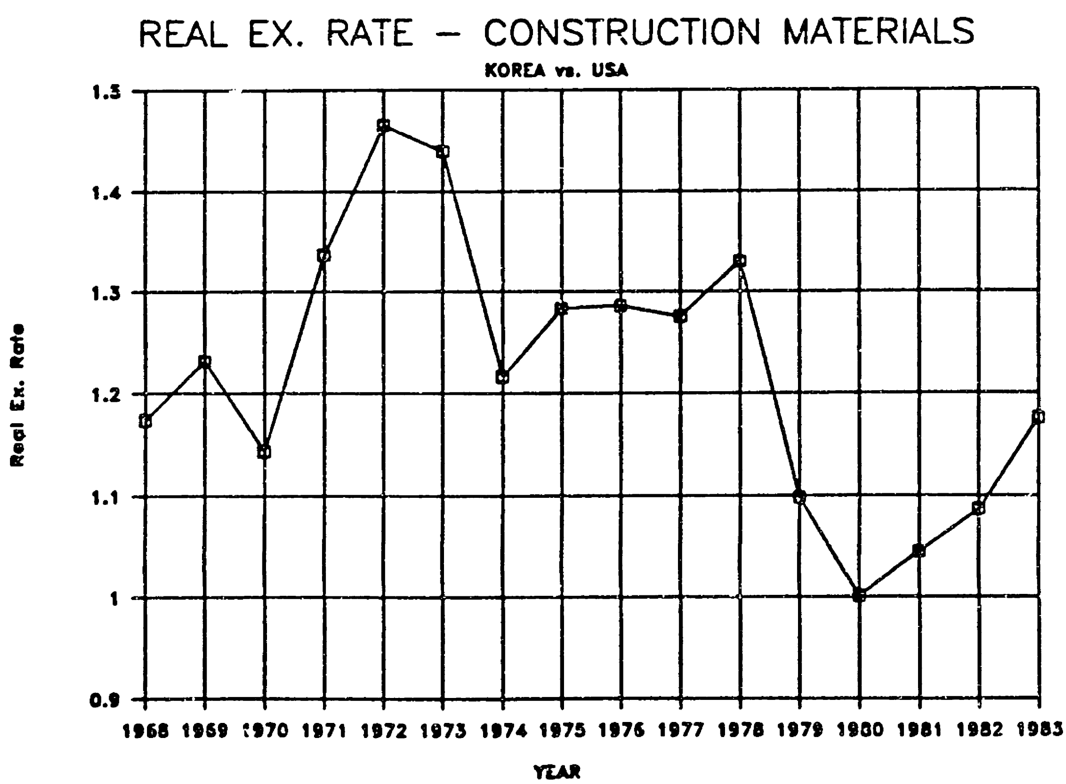


FIGURE 3.6B



currency rates between the Korean won and the US dollar, the real exchange rate of Korean construction materials has been consistently greater than 1 (figure 3.6b) providing Korean contractors with a competitive advantage, when US contractors are required to source materials from the US market. Table 3.9 provides the backup data for figures 3.6a and 3.6b.

The real exchange rate index IRX_i in year i (column E of table 3.9) is computed using the definition of real exchange rate in section 3.4.4:

$$RX_{1968} = e_{1968} * \frac{P_{US1968}}{P_{KO}1968} \quad \text{and} \quad RX_i = e_i * \frac{P_{USi}}{P_{KO}}$$

Therefore, and since $RX_i/RX_{1968} = IRX_i/IRX_{1968}$,

$$IRX_i = IRX_{1968} * \frac{e_i}{e_{1968}} * \frac{P_{USi}}{P_{KO}i} * \frac{P_{KO1968}}{P_{US1968}}$$

The price ratios will equal the price index ratios in a given currency, and it will be

$$\frac{P_{USi}}{P_{US1968}} = \frac{IP_{USi}}{IP_{US1968}}, \quad \text{and} \quad \frac{P_{KO}i}{P_{KO1968}} = \frac{IP_{KOi}}{IP_{KO1968}}$$

Therefore,

$$IRX_i = IRX_{1968} * \frac{e_i}{e_{1968}} * \frac{IP_{USi}}{IP_{KO}i} * \frac{IP_{KO1968}}{IP_{US1968}}$$

To develop the real exchange index series, we arbitrarily assign $IRX_{1968} = 100$, as well as $IP_{US1968}=100$ and $IP_{KO1968}=100$. In addition, we have $e_{1968}=276.65$. We finally have:

$$IRX_i = 100 * \frac{e_i}{276.65} * \frac{IP_{USi}}{IP_{KO}i},$$

or using the column descriptions of table 3.9,

TABLE 3.9

CONSTRUCTION MATERIALS PRICE TRENDS AND REAL EXCHANGE RATES
KOREA vs. UNITED STATES, 1968-1983

Year A	Construction Materials Price Index Korea 1968=100 B	Construction Materials Price Index US 1968=100 C	Nominal Ex.Rate e Won/US$ D	Real Ex. Rate RX Index E	Real Ex. Rate RX F
1968	100.0	100.0	276.65	100.0	1.17
1969	105.2	106.0	288.16	104.9	1.23
1970	122.7	106.5	310.56	97.4	1.14
1971	124.7	113.2	347.15	113.9	1.34
1972	136.4	119.9	392.89	124.9	1.47
1973	153.9	131.2	398.32	122.7	1.44
1974	214.9	152.4	404.47	103.6	1.22
1975	263.6	164.8	484.00	109.3	1.28
1976	283.8	177.7	484.00	109.6	1.29
1977	312.3	194.0	484.00	108.7	1.28
1978	333.8	216.2	484.00	113.3	1.33
1979	444.8	238.1	484.00	93.6	1.10
1980	649.4	252.3	607.43	85.3	1.00
1981	740.9	268.0	681.03	89.0	1.04
1982	777.9	272.6	731.08	92.6	1.09
1983	789.0	281.9	775.75	100.2	1.18

Sources :Construction Review, July/August 1985
Construction Review, March/April 1987
Construction Association of Korea, Statistics Yearbook of Construction Industry, 1984
International Monetary Fund, International Financial Statistics, 1989
Hong, W., Krueger, A.O., Trade and Development in Korea Korea Development Institute, 1975

$$(E) = 100 * \frac{(D)}{276.65} * \frac{(C)}{(B)},$$

The real exchange rate index should be interpreted carefully for a number of reasons. First, the base period (1968=100) is not necessarily an equilibrium period as far as purchasing power parity is concerned. In other words RX_{1968} does not equal 1. Second, the available US and Korean construction material indices may not be comparable, in terms of the materials incorporated in their computation. Finally, local taxation and subsidies on exports and tariffs create de facto multiple nominal exchange rate systems (Morgan Guaranty, 12/30/1988). Nevertheless, the trend of the real exchange rate index demonstrates the direction of change in the competitive position of Korean vis a vis US contractors. For example, the competitiveness of Korean contractors has been increasing on average between 1968 and 1978 and decreasing after 1978.

To determine the competitive relationship in absolute terms, we need at least one value of the real exchange rate in the time period considered. For example, assuming that the real exchange rate of construction materials was reasonably close to the real exchange rate for the economy in 1973, and using the real exchange rate $RX_{1973}=1.44$ reported by Hong et al. (1975), we derive a list of real exchange rates consistently greater than 1, that demonstrate the strong competitive position of Korean contractors in the time period studied. It can be shown that the results are even stronger in favor of Korean contractor competitiveness if any other RX provided by Hong et al. (1975) for the time period 1968-1973 is used. Figures 3.7a and 3.7b also suggest the impact that foreign exchange rates may have had in the development of Korea's competitive position in international construction from the combination of high real exchange rates at the construction and the national economy levels. It is worth observing that the sustained foreign exchange competitive advantage of Korean contractors precedes the

FIGURE 3.7A

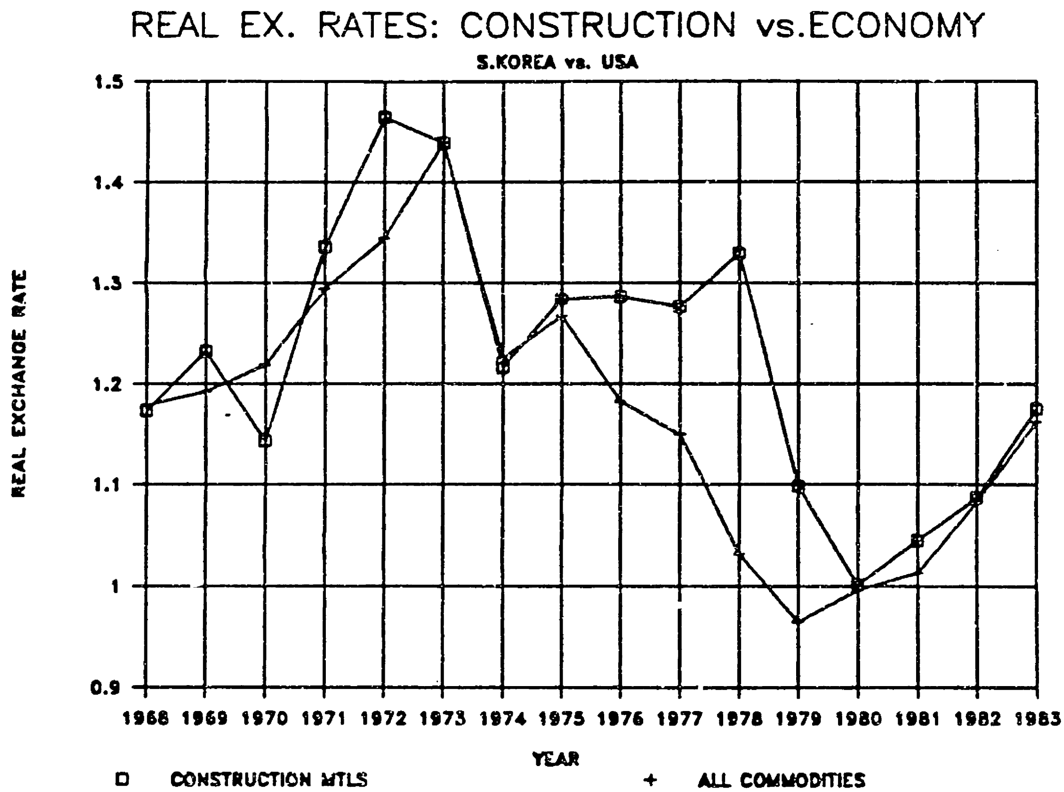
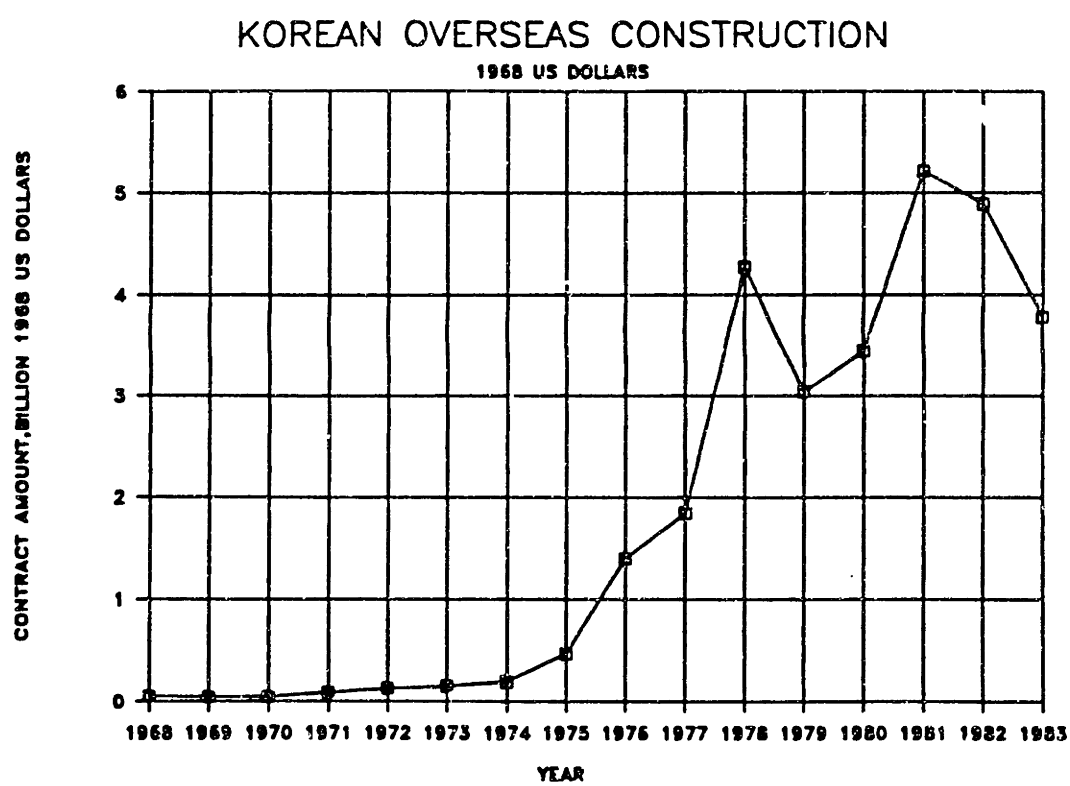


FIGURE 3.7B



extraordinary increase of their international construction work in the late 70s, that led to their large market share and dominant position in international construction.

In conclusion, RX provides a measure of deviations from PPP that depends on the observed nominal exchange rate e and the relative prices. If relative prices change while nominal rates stay the same or nominal exchange rates change while relative prices stay the same, RX will show a trend. If RX is less than 1 regarding prices and costs relevant to the international contractor, it constitutes a disadvantage in competition. US industries, including the construction industry, have been affected by such trends in real exchange rates between the US dollar and other major currencies in the early 1980s, when reference was typically made to the "strong dollar".

The empirical evidence shows that PPP tends to hold in the long run but not in the short run (Shapiro, 1983). The definition of "long run" for PPP equilibrium may go beyond a given project's duration. Prices of construction inputs traded competitively in world markets are likely to respond quickly to offset exchange rate changes. Such nondifferentiated manufactured goods are easily transported and/or produced globally (e.g., steel products). By contrast, construction inputs that are not easily substituted (differentiated goods), such as those having electronic components, are likely to respond slower, because of the monopolistic character of the industries. Nontraded goods, such as labor, also appear having slower price responses towards PPP equilibrium (Isard, 1977).

Chapter 4 : Construction Firm Cost and Revenue Structure Decisions

The function of the international contractor and its role between upstream industries and downstream clients was discussed in the previous chapter 4. Figure 4.5 summarized that relationship. In this role, the contractor is faced with cost and revenue foreign exchange exposure, which is partly the result of exogenous conditions, and partly influenced by its own actions.

The analytic framework of chapter 4 provided an understanding of how the exogenously determined prices and the availability of internationally sourced inputs are affected by exchange rate changes. It also provided a basis for assessing the influence of exchange rates on the contractor's own pricing decision. Finally, the exogenously determined competitive advantages from real exchange rate trends were defined.

In this chapter, we will attempt to analyze some of the contractor's options regarding the currency of denomination of its costs and revenues, to the extent that such options are not constrained by other project entities, such as the project owner and/or project sponsor. To facilitate the discussion, we define profit from construction operations as follows:

Profit = Revenues - Costs

with:

Revenues $= e_1*P_{R1}*Q_{R1} + e_2*P_{R2}*Q_{R2} + e_3*P_{R3}*Q_{R3} + \ldots$

Costs $= e_1*P_{C1}*Q_{C1} + e_2*P_{C2}*Q_{C2} + e_3*P_{C3}*Q_{C3} + \ldots$

where e_i's are exchange rates,

P_{Ri}'s revenue unit prices in currencies i

P_{Ci}'s input unit prices in currencies i

Q_{Ri}'s units sold in currencies i

Q_{Ci}'s units bought in currencies i.

Project owners will sometimes require that the contractor be paid in currency of the owner's preference, such as local "soft" currency. (After all, local governments have their own foreign exchange exposure to manage.) The owner may also request that the contractor source inputs from local markets. At the same time, official project sponsors, such as export-import banks, may provide their financing on conditions of the sourcing inputs from the sponsor's country.

In brief, and using the variable definitions of the profit equation, the contractor can not affect exchange rates (e_i's) and prices (P_{Ci}'s), which are exogenous variables determined by the macroeconomy. However, subject to contractual constraints, the contractor may be in a position to at least partially influence the currency of denomination of its inputs (Q_{Ci}'s), as well as the output (Q_{Ri}'s) and unit pricing (P_{Ri}'s) of its products.

In the last part of this chapter, the valuation by components (VC) methodology will be reviewed for international contractor's project selection. The explicit decomposition of cash flows into noncontractual and contractual components, as performed in the VC model, supports the definition of project value measures which can transparently incorporate results from the economic analysis of chapter 4. This is accomplished with the categorization and sensitivity analysis of cash flows by competitive structure of related industries.

4.1 Cost Structure

Expert determination of construction costs goes beyond knowing the cost of labor, materials, equipment, financing and other resources utilized. It also depends on the estimator's knowledge and choice of alternative ways and approaches to constructing a facility. For example, the construction of concrete slabs may be accomplished with different types and sizes of labor crews using different technologies, such as concrete pumps, crane and bucket, or even a conveyor system. In international construction, these choices have foreign exchange exposure impact, as the resources used by alternative technologies may have to be sourced from different countries.

The sourcing decision of the construction firm is normally noncontractual, i.e., the contractor does not have a fixed price commitment from its subcontractors or vendors regarding the delivery of construction related products, labor, materials and other inputs. In that sense, costs will fluctuate with market conditions. As far as the currency of denomination of these costs is concerned, there may be a contractual obligation to source from a given market, therefore binding the contractor to the price and exchange rate fluctuations of that market. The market can be domestic, if the project is financed by home country agencies, or local, if the project owner requires so.

In most international construction projects, governments and official agencies prefer lump-sum or fixed-price contracts (Demacopoulos et al., 1985.). Such preference is persistent, despite disadvantages such as the delay in the start of construction and the difficulty in the implementation of changes. Under a fixed price contract, the profit maximization objective translates into cost minimization. Cost minimization is also a realistic objective because the output in most construction operations is pre-demanded and, therefore, fixed in output units. Of course, in the unusual case when the output and/or unit prices are not fixed, the profit maximizing international contractor may not want to minimize costs. Finally, assuming cost minimization is pursued from a functional currency perspective (see definition in section 3.1), it is affected by exchange rates. Therefore, in minimizing its costs, the international contractor may take long or short currency positions with a resulting foreign exchange exposure.

The construction industry utilizes a large number of inputs for the production of constructed facilities. Most construction activities are interdependent, as they are in assembly line production. The use of precedence diagramming and activity network techniques in construction highlights the interdependency of construction activities. Due to this interdependency, the construction process output will, at least mathematically, be zero when a production process (activity) breaks down. In general we can assume a production function Q_0 such that :

$$Q_0 = Q(Q_{C1}, Q_{C2}, Q_{C3} \ldots Q_{CN})$$

where Q is the output rate and QC's are the inputs.

Most production functions reviewed in the microeconomic literature are of the constant returns to scale, constant elasticity of substitution (s) type. The three most common values of s are infinite, 0 and 1. It can be shown that s=infinite implies a production function dependent on only one resource, for example, only labor or capital (Nicholson, 1978). This is an unrealistic assumption overall, and specifically for construction where it is difficult to envision a production process dependent only on one input. A production function with s=0 implies a fixed proportions production function, i.e., the ratio of inputs is fixed. This is also unrealistic for construction, since it does not provide for the possible tradeoffs among technologies, including the substitution of labor for capital and vice versa (Peurifoy, 1979).

By contrast, a production function with s=1 provides a middle ground model that allows for the limited resource substitutability typical of construction processes. Such a production function, called Cobb-Douglas, has been suggested by Adrian (1982) as a more accurate representation of construction activity production. Its formal definition is:

$$Q = A * QC_1^{a1} * QC_2^{a2} * QC_3^{a3} * \ldots\ldots\ldots * QC_N^{aN},$$

where A and a_i's are constants.

The production function constants are defined by using time-series analysis of production in the construction industry over many years, or by gathering information from a number of firms in construction, or by using engineering studies for specific construction processes.

Least-Cost Combination

Given the production function, a typical objective for further analysis is cost minimization through appropriate combination of resources. The cost function can be written:

$$C = P_1{*}Q_{C1} + P_2{*}Q_{C2} + P_3{*}Q_{C3} + \quad P_N{*}Q_{CN}$$

In international construction, subject to contractual constraints, the contractor makes the least-cost combination decision with inputs priced in multiple currencies. Assuming an exchange rate e_j, and P_{ij} and Q_{ij} the unit price and quantity of input i in currency j, the total cost in home currency is:

$$\begin{aligned} C = \; & e_1{*}P_{11}{*}Q_{C11} + e_2{*}P_{12}{*}Q_{C12} + \quad + e_N{*}P_{1N}{*}Q_{C1N} + \\ & + e_1{*}P_{21}{*}Q_{C21} + e_2{*}P_{22}{*}Q_{C22} + \quad + e_N{*}P_{2N}{*}Q_{C2N} + \\ & + \ldots. \quad \ldots.. + \end{aligned}$$

$$+ e_1*P_{N1}*Q_{CN1} + e_2*P_{N2}*Q_{CN2} + \quad + e_N*P_{NN}*Q_{CNN}$$

with

$$Q_{Ci} = Q_{Ci1} + Q_{Ci2} + Q_{Ci3} + \quad + Q_{CiN},$$

the total amount of a given input i across N currencies.

It is sufficiently general to assume that all of a given input is sourced in one currency. If the law of one price holds, the home price of a given input i is e_i*P_{ij} = constant for every currency j. If the law of one price does not hold, input QC_i is sourced in the currency m for which the translated in home currency cost is minimized , i.e., e_m*P_{mj} = minimum $\{e_i*P_{ij}\}$, for all currencies i. Then,

$$C = e_1*P_1*Q_{C1} + e_2*P_2*Q_{C2} + \quad + e_N*P_N*Q_{CN},$$

where e_i can be equal to e_j for certain inputs.

For simplicity, but without loss of generality, we can reduce the cost minimization problem to a two input environment as follows:

$$\min C = e_1*P_1*Q_{C1} + e_2*P_2*Q_{C2}$$
$$\text{s.t. } Q_0 = Q(Q_{C1}, Q_{C2})$$

The Lagrangian function is:

$$Z = e_1*P_1*Q_{C1} + e_2*P_2*Q_{C2} + m * [Q_0-Q(Q_{C1}, Q_{C2})]$$

To satisfy the first order condition, for minimum cost the construction input levels Q_{C1} and Q_{C2} (choice variables), have to satisfy the following simultaneous equations:

$$dZ/dm = Q_0-Q(Q_{C1}, Q_{C2}) = 0$$

$$dZ/dQ_{C1} = e_1*P_1 - m*(\delta Q/dQ_{C1}) = 0$$

$$dZ/dQ_{C2} = e_2*P_2 - m*(dQ/dQ_{C2}) = 0$$

which leads to the condition:

$$\frac{e_1 * P_1}{dQ/dQ_{C1}} = \frac{e_2 * P_2}{dQ/dQ_{C2}} = m$$

The Lagrangian multiplier m can be interpreted as the marginal cost translated in home currency, i.e., the extra cost in home currency of producing one more unit of output. At the cost-minimizing point, each construction input provides equal marginal productivity per unit of home currency spent on it.

The marginal rate of technical substitution (MRTS) of input 1 in currency 1 for input 2 in currency 2 is then:

$$MRTS_{12} = \frac{e_1 * P_1}{e_2 * P_2} = \frac{dQ/dQ_{C1}}{dQ/dQ_{C2}}$$

We note that, to minimize costs, a marginal increase of $e_i * P_i$ is associated with a marginal increase in dQ/dQ_{Ci}. For example, assuming constant nominal prices, the MRTS implies that the international contractor will source marginally more ($dQ/dQ_{C1} > 0$) in the depreciating ($de_i > 0$) currency.

The above necessary (but not sufficient) cost minimization condition implies that the optimal combination of resources depends on exchange rates. Following the economic analysis of the previous chapter, the MRTS is affected by exchange rates in two ways:

(i) changes in foreign exchange rates (de),

(ii) changes in foreign prices due to foreign exchange rate changes (foreign exchange rate elasticities of prices, dP/de)

In addition, cost minimization requires that the second order (sufficient) condition of having a negative bordered Hessian be satisfied:

$$|H| = \begin{vmatrix} 0 & Q_{x1} & Q_{x2} \\ Q_{x1} & -m^*Q^2_{x1} & -m^*Q_{x1x2} \\ Q_{x2} & -m^*Q_{x2x1} & -m^*Q^2_{x2} \end{vmatrix} =$$

$$= \quad m^* \; (Q^2_{x1}{}^*Q_{x2}{}^2-2^*Q_{x1x2}{}^*Q_{x1}{}^*Q_{x2}+Q^2_{x2}{}^*Q_{x1}{}^2) < 0$$

The optimal value for m (marginal cost) is positive, as it represents the cost associated with an additional output unit. Therefore, the parenthesis has to be negative. Chiang (1988) shows this to be true for strictly quasiconcave production functions $Q = Q(QC_1, QC_2)$ that generate strictly convex, downward sloping indifference curves in the QC_1QC_2 plane. Such production functions include the Cobb-Douglas that we considered appropriate for the construction industry.

The applicability of least-cost construction input combinations and the selection of construction methods that minimize costs depend on the availability of resources vis a vis the project's resource requirements. Such availability is partly influenced by exchange rates and by the competitive structure of the industry, as discussed in chapter 4. Likewise, the feasibility of minimizing costs is subject to contractual agreements on matters of performance such as target dates and penalty costs for schedule delays.

Elasticity of Substitution

The least-cost combination analysis provides the direction for construction input substitution when costs and exchange rates change. The extent of substitution is measured with the elasticity of substitution (Nicholson, 1984). The home currency based minimum cost combination of construction inputs for producing Q_o units of output, is given by the tangency of isoquant curve Q_o and the isocost line $C_0 = e_1P_1QC_1 + e_2P_2QC_2$

(figure 4.1). Assuming a Cobb-Douglas production function $Q = A * Q_{C1}^{a1} * Q_{C2}^{a2}$, whose applicability for the construction industry we have already discussed, we have:

$$
\begin{aligned}
Q_{C2}/Q_{C1} &= (a_1 P_{d1}/a_2 P_{d2}) = \\
&= (a_1 e_1 P_1/a_2 e_2 P_2) = \\
&= k\ (e_1 P_1/e_2 P_2) = \\
&= k\ e*(P_1/P_2),
\end{aligned}
$$

where k a constant equal to a1/a2, P_{di}'s the base currency prices, P_i's the foreign currency prices, and e the exchange rate between currencies 1 and 2, i.e., the number of units of currency 1 required to buy one unit of currency 2 ($e=e_1/e_2$).

The foreign exchange elasticity of substitution of construction inputs is then derived from the following relationship:

$$
\frac{d[Q_{C2}/Q_{C1}]}{de} = k * \frac{P_1 + e * \frac{dP_1}{de} - \frac{dP_2}{de}}{P_2^2} \Rightarrow
$$

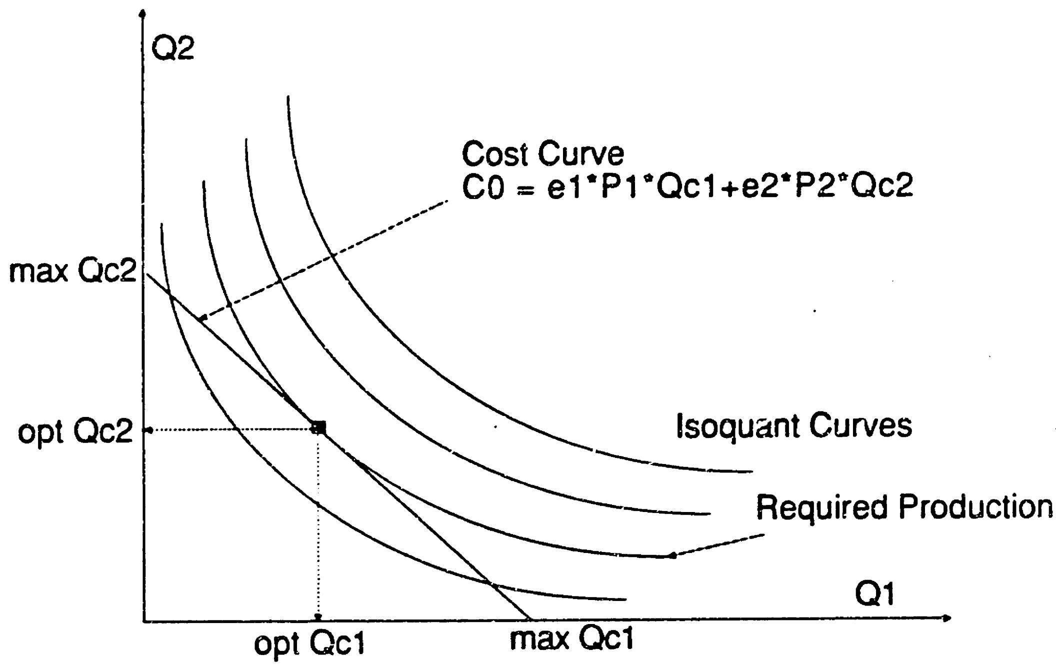
$$
\frac{d[Q_{C2}/Q_{C1}]}{de} * \frac{e}{[Q_{C2}/Q_{C1}]} = k * \frac{e*P_1 + e^2 * \frac{dP_1}{de} - e * \frac{dP_2}{de}}{P_2^2 * [Q_{C2}/Q_{C1}]}
$$

The above formula provides us with the extent of substitution of inputs and tradeoff between alternative construction technologies and inputs sourced from international markets. The exchange rate elasticity of substitution of inputs is then a function of exchange rates, as well as of exchange rate elasticities of construction input prices that have been discussed in the previous chapter.

Following that, the extent of such substitution is affected by the industry structures facing the international contractor when sourcing its inputs. In section 4.3 we saw that, under conditions of purchasing power parity, a profit maximizing environment results in higher price responses than under price discriminating conditions. As a result,

FIGURE 4.1

LEAST-COST INPUT COMBINATION



Source : Adapted from Nicholson, W., Microeconomic Theory, The Dryden Press, Hinsdale, Illinois, 1982.

the exchange rate elasticity of substitution formula can determine the extent of input substitution as follows :

Assumed Market Characteristics		
Construction Input 1	Construction Input 2	Extent of Substitution of 2 for 1.
Competitive Pricing (PPP holds)	Price Discrimination (PPP does not hold)	Relatively high
Price Discrimination (PPP does not hold)	Competitive Pricing (PPP holds)	Relatively low
Competitive Pricing (PPP holds)	Competitive Pricing (PPP holds)	Depends on relative exchange rate elasticities of prices
Price Discrimination (PPP does not hold)	Price Discrimination (PPP does not hold)	Depends on relative exchange rate elasticities of prices

4.2 Revenue Structure

The other side of a contractor's exposure to foreign exchange risks is its revenue. If the contract amount is fixed and the currency of denomination specified by the owner or competitive conditions, the international contractor is forced to exposures that may contribute to undesirable short or long foreign currency positions.

It is possible that the contractor have some room to negotiate the currency of billing at the individual project level. Even under such an unusual scenario, the lumpiness of construction projects does not provide for the flexibility to alter the currency of billings, following shifts in expectations about exchange rates, which is sometimes practiced in other exporting industries (Business International Corporation, 1982).

At best the international contractor should attempt to negotiate with the owner at least partial payment in currency of the contractor's preference. Such an agreement can be in the mutual interest of the two parties, if their respective exposures are in opposite directions. From a different perspective, the risk of contractor's financial failure due to foreign exchange exposure may affect the project value to the owner. More specifically, an exposed contractor may be forced to adopt defensive strategies, such as incorporating excessive contingencies and suboptimizing the use of technologies with costs and exposure in currency not matched by the revenue.

Regardless of the contractor's ability to negotiate its revenue structure in currencies of its preference in any given project, it may still have some of that flexibility at the firm level. Specifically, it may be able to bid work with owners who are willing and able to pay in currencies of its preference. It may also decide to shift part of its business to areas with revenue in currencies of its preference. Whatever the mode of the contractor's ability to define the currency of its revenues, it is of interest to understand how expectations about exchange rates can shape its decision making process. This section addresses analytically the revenue aspect of the contractor's exposure.

4.2.1 Two Currency Revenue Structure

Assuming a two-currency world, where revenue structure decisions are possible in two currencies, profit can be expressed as follows:

$$Pr = e_1 * R_1 + e_2 R_2 - C(Q) =$$

$$= e_1 * P_{R1} * Q_{R1} + e_2 * P_{R2} * Q_{R2} - C(Q),$$

where

Q_{R1}, Q_{R2} represent construction units sold that are priced in currency i, with

$Q = Q_{R1} + Q_{R2}$, and

$C(Q) = C(Q_{R1} + Q_{R2})$

Given these definitions, Q is the total construction work volume, or number of construction units produced by the firm priced in the two currencies.

Exchange rates changes are exogenous to the firm's decision making process. Therefore, changes in the values of the firm's choice variables do not affect exchange rates. I.e., $de_i/dX_i=0$, where X_i is any choice variable of the firm, such as the markup/price or quantity of output of the firm.

The firm is assumed to be a profit maximizer. In order to maximize its profits, the contractor can shift its output and revenue from one currency to another. In other words, it can choose its output with revenue in currency i. This decision is equivalent to choosing the business volume in a given country, if work in that country is billed in the country's currency. Of course, the geographic shift in business development is easier to be suggested than implemented, given the networking and other investment required for a contractor's establishment in a market. However, it not likely to be as difficult as the relocation of manufacturers with substantial fixed investment in plant and equipment.

The first order (necessary) conditions for profit maximization, with respect to Q_{Ri}, i.e., output priced in a given currency i are:

$$\frac{dPr}{dQ_{R1}} = 0 , \quad \frac{dPr}{dQ_{R2}} = 0,$$

The second order (sufficient) conditions for profit maximization are:

$$\frac{d^2Pr}{dQ_{R1}^2} < 0 , \quad \frac{d^2Pr}{dQ_{R2}^2} < 0,$$

$$\left[\frac{d^2Pr}{dQ_{R1}^2}\right]\left[\frac{d^2Pr}{dQ_{R2}^2}\right] - \left[\frac{d^2Pr}{dQ_{R1}dQ_{R2}}\right]^2 > 0$$

First Order Conditions

$$\frac{dPr}{dQ_{R1}} = 0 <=>$$

$$\frac{dPr}{dQ_{R1}} = e_1*P_{R1}*\frac{dQ_{R1}}{dQ_{R1}} + e_1*\frac{dP_{R1}}{dQ_{R1}}*Q_{R1} + e_2*P_{R2}*\frac{dQ_{R2}}{dQ_{R1}} +$$

$$e_2*\frac{dP_{R2}}{dQ_{R2}}*\frac{dQ_{R2}}{dQ_{R1}}*Q_{R2}+\frac{dC}{dQ_R}*\frac{dQ_R}{dQ_{R1}} = 0 \qquad (1)$$

Assumptions:

(a) The decision to propose payment in a given currency is independent to the decision to propose payment in any other currency:

$dQ_{R1} <> f(dQ_{R2})$, i.e., $dQ_{R2}/dQ_{R1} = 0$

(b) $Q = Q_{R1}+Q_{R2} => dQ_R/dQ_{R1} = 1$

Given these assumptions, the above equation (1) becomes:

$$\frac{dPr}{dQ_{R1}} = e_1*P_{R1} + e_1*\frac{dP_{R1}}{dQ_{R1}}*Q_{R1} - \frac{dC}{dQ_R} = 0 \qquad (2)$$

Similarly, after differentiating with respect to Q_{R2} we have:

$$\frac{dPr}{dQ_{R2}} = e_2 * P_{R2} + e_2 * \frac{dP_{R2}}{dQ_{R2}} * Q_{R2} - \frac{dC}{dQ_R} = 0 \qquad (3)$$

The first order conditions (2) and (3) show that the contractor's marginal revenue in a given currency, when translated in home currency, should at least equal the firm's marginal costs:

$$e_i * P_{Ri} + e_i * \frac{dP_{Ri}}{dQ_{Ri}} * Q_{Ri} = \frac{dC}{dQ_R}$$

<u>Second Order Conditions</u>

The second order conditions are:

$$\frac{d^2Pr}{dQ_{R1}^2} < 0 , \quad \frac{d^2Pr}{dQ_{R2}^2} < 0, \text{ and}$$

$$\left[\frac{d^2Pr}{dQ_{R1}^2}\right]\left[\frac{d^2Pr}{dQ_{R2}^2}\right] - \left[\frac{d^2Pr}{dQ_{R1}dQ_{R2}}\right]^2 > 0$$

In detail,

$$\frac{d^2Pr}{dQ_{R1}^2} = e_1 * \frac{dP_{R1}}{dQ_{R1}} + e_1 * \frac{dP_{R1}}{dQ_{R1}} + e_1 * \frac{d^2P_{R1}}{dQ_{R1}^2} * \frac{dQ_{R1}}{dQ_{R1}} * Q_{R1} - \frac{d^2C}{dQ_R^2} =$$

$$= \left[2e_1 * \frac{dP_{R1}}{dQ_{R1}} + e_1 * \frac{d^2P_{R1}}{dQ_{R1}^2} * Q_{R1} - \frac{d^2C}{dQ_R^2} \right] < 0$$

$$\frac{d^2Pr}{dQ_{R2}^2} = \left[2e_2 * \frac{dP_{R2}}{dQ_{R2}} + e_2 * \frac{d^2P_{R2}}{dQ_{R2}^2} * Q_{R2} - \frac{d^2C}{dQ_R^2} \right] < 0$$

$$\left[\frac{d^2Pr}{dQ_{R1}^2}\right]\left[\frac{d^2Pr}{dQ_{R2}^2}\right] - \left[\frac{d^2Pr}{dQ_{R1}dQ_{R2}}\right]^2 =$$

$$\left[2e_1 * \frac{dP_{R1}}{dQ_{R1}} + e_1 * \frac{d^2P_{R1}}{dQ_{R1}^2} * Q_{R1} - \frac{d^2C}{dQ_R^2}\right]\left[2e_2 * \frac{dP_{R2}}{dQ_{R2}} + e_2 * \frac{d^2P_{R2}}{dQ_{R2}^2} * Q_{R2} - \frac{d^2C}{dQ_R^2}\right] -$$

$$- \left[\frac{d\left(\frac{dPr}{dQ_{R1}}\right)}{dQ_{R2}}\right]^2 =$$

$$\left[2e_1 * \frac{dP_{R1}}{dQ_{R1}} + e_1 * \frac{d^2P_{R1}}{dQ_{R1}^2} * Q_{R1} - \frac{d^2C}{dQ_R^2}\right]\left[2e_2 * \frac{dP_{R2}}{dQ_{R2}} + e_2 * \frac{d^2P_{R2}}{dQ_{R2}^2} * Q_{R2} - \frac{d^2C}{dQ_R^2}\right] -$$

$$- \left[\frac{d^2C}{dQ_R^2}\right]^2 > 0$$

<u>Exchange Rate Elasticities</u>

In order to obtain expressions for the contractor's response of output priced in a given currency, due to changes in exchange rates, we need to derive the relevant foreign exchange elasticity measures. To accomplish that, we differentiate the first order conditions with respect to e_i, i=1,2. From equation (2) we have:

$$\frac{d^2Pr}{dQ_{R1}de_1} = e_1 * \frac{dP_{R1}}{dQ_{R1}} * \frac{dQ_{R1}}{de_1} + P_{R1} +$$

$$+ e_1 * \frac{dP_{R1}}{dQ_{R1}} * \frac{dQ_{R1}}{de_1} + e_1 * \frac{dP^2_{R1}}{dQ_{R1}^2} * \frac{dQ_{R1}}{de_1} * Q_{R1} + \frac{dP_{R1}}{dQ_{R1}} * Q_{R1} -$$

$$- \frac{d^2C}{dQ_R^2} * \left[\frac{dQ_R}{dQ_{R1}} * \frac{dQ_{R1}}{de_1} + \frac{dQ_R}{dQ_{R2}} * \frac{dQ_{R2}}{de_2} * \frac{de_2}{de_1} \right] = 0$$

Under the assumptions made earlier, $dQ_R/dQ_{R1} = dQ_R/dQ_{R2} = 1$. The equation becomes:

$$\left[2*e_1*\frac{dP_{R1}}{dQ_{R1}} + e_1*\frac{dP^2_{R1}}{dQ_{R1}^2}*Q_{R1} - \frac{dC}{dQ_{R2}}\right]\frac{dQ_{R1}}{de_1} + \left[-\frac{dC^2}{dQ_{R2}}*\frac{de_2}{de_1}\right]\frac{dQ_{R2}}{de_2} = -P_{R1} - \frac{dP_{R1}}{dQ_{R1}}*Q_{R1} \qquad (4)$$

or, in a more manageable format,

$$A_{11}*\frac{dQ_{R1}}{de_1} + A_{12}*\frac{dQ_{R2}}{de_2} = A_{10} \qquad (4a)$$

Similarly, from (3) we have

$$\frac{d^2P_r}{dQ_{R2}de_1} = e_2*\frac{dP_{R2}}{dQ_{R2}}*\frac{dQ_{R2}}{de_2}*\frac{de_2}{de_1} + *\frac{de_2}{de_1}P_{R2} +$$

$$e_2*\frac{dP_{R2}}{dQ_{R2}}*\frac{dQ_{R2}}{de_2}*\frac{de_2}{de_1} + e_2*\frac{dP^2_{R2}}{dQ_{R2}^2}*\frac{dQ_{R2}}{de_2}*\frac{de_2}{de_1}*Q_{R2} + \frac{de_2}{de_1}*\frac{dP_{R1}}{dQ_{R1}}*Q_{R2} -$$

$$\frac{dC^2}{dQ_R^2}*\left[\frac{dQ_R}{dQ_{R1}}*\frac{dQ_{R1}}{de_1} + \frac{dQ_R}{dQ_{R2}}*\frac{dQ_{R2}}{de_2}*\frac{de_2}{de_1}\right] = 0$$

Under the same above assumptions, $dQ_R/dQ_{R1} = dQ_R/dQ_{R2} = 1$. The equation becomes:

$$\left[-\frac{dC^2}{dQ_R^2}\right]\frac{dQ_{R1}}{de_1} + \left[2*e_2*\frac{dP_{R2}}{dQ_{R2}}*\frac{de_2}{de_1} + e_2*\frac{dP^2_{R2}}{dQ_{R2}^2}*\frac{de_2}{de_1}Q_{R2} - \frac{dC^2}{dQ_R^2}*\frac{de_2}{de_1}\right]\frac{dQ_{R2}}{de_2} = -\frac{de_2}{de_1}*P_{R2} - \frac{de_2}{de_1}*\frac{dP_{R2}}{dQ_{R2}}*Q_{R2} \qquad (5)$$

or, in a more manageable format,

$$A_{21}*\frac{dQ_{R1}}{de_1} + A_{22}*\frac{dQ_{R2}}{de_2} = A_{20} \qquad (5a)$$

The contractor's decision to shift its revenue from one currency to another should satisfy equations (4a) and (5a) in order to maximize profits. The solution of the system of equations (4a) and (5a) yields:

$$\frac{dQ_{R1}}{de_1} = \frac{\begin{vmatrix} A_{10} & A_{12} \\ A_{20} & A_{22} \end{vmatrix}}{\begin{vmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{vmatrix}} = \frac{(A_{10}*A_{22}-A_{20}*A_{12})}{(A_{11}*A_{22}-A_{21}*A_{12})} \Rightarrow$$

$$\frac{dQ_{R1}}{de_1} =$$

$$= \frac{\left\{ \overbrace{\left[-P_{R1} - \frac{dP_{R1}}{dQ_{R1}} * Q_{R1}\right]}^{a_{10}} \overbrace{\left[2e_2\frac{dP_{R2}}{dQ_{R2}} + e_2*\frac{dP^2_{R2}}{dQ_{R2}^2} Q_{R2} - \frac{d^2C}{dQ_R^2}\right]}^{a_{22}} - \overbrace{\left[-\frac{de_2}{de_1}*P_{R2} - \frac{de_2}{de_1}*\frac{dP_{R2}}{dQ_{R2}} * Q_{R2}\right]}^{a_{20}} \overbrace{\left[-\frac{d^2C}{dQ_R^2}*\frac{de_2}{de_1}\right]}^{a_{12}} \right\}}{\left\{ \overbrace{\left[2e_1\frac{dP_{R1}}{dQ_{R1}} + e_1\frac{dP^2_{R1}}{dQ_{R1}^2}Q_{R1} - \frac{d^2C}{dQ_R^2}\right]}^{a_{11}} \overbrace{\left[2e_2\frac{dP_{R2}}{dQ_{R2}} + e_2*\frac{dP^2_{R2}}{dQ_{R2}^2} Q_{R2} - \frac{d^2C}{dQ_R^2}\right]}^{a_{22}} - \underbrace{\left[-\frac{d^2C}{dQ_R^2}\right]}_{a_{21}} \underbrace{\left[-\frac{d^2C}{dQ_R^2}\right]}_{a_{12}} \right\}} \qquad (6)$$

The denominator is positive from the second order conditions. In the numerator, a_{22} is negative from the second order conditions. a_{10} is also negative, being the negative of the marginal revenue from the output of one additional construction unit paid in currency 1 (which is positive). As a result, the sign of dQ_{R1}/de_1, will depend on correlation between currencies (implicit in de_2/de_1) and on the slope of marginal cost curve (d^2C/dQ_R^2) that define the magnitude of the term $a_{20}*a_{12}$. Therefore, the contractor's decision to take projects in different countries and currencies will depend on the cost and demand functions and on the correlation between exchange rates.

Section 4.3 discusses the role of currency rate correlations and the benefits from international project and currency diversification in more detail. For now, we observe that, the larger the slope of marginal costs facing the contractor, the larger the impact of currency correlation, when the currencies are positively correlated.

A much simplified version of the equation (6) can be derived if we assume that the contractor has linear marginal cost and demand curves, i.e., $d^2C/dQ_R^2=0$, and $d^2P_{Ri}/dQ_{Ri}^2=0$. The exchange rate elasticity becomes:

$$\frac{dQ_{R1}}{de_1} = \frac{-\left[P_{R1} + \frac{dP_{R1}}{dQ_{R1}} * Q_{R1}\right]}{\left[2e_1 \frac{dP_{R1}}{dQ_{R1}}\right]}$$

Again, the numerator is the negative of marginal revenue in currency 1, which is positive, i.e., the numerator is negative. Similarly, the denominator is negative, being the slope of the demand curve in currency 1. Therefore, under linear marginal cost and demand curves, the contractor's foreign exchange elasticity of revenue in a given currency will be positive. These are reasonable assumptions for the construction industry, as the literature on construction productivity and economics (Rossow, 1974) as well as standard construction cost estimating (Means, 1988) suggest. The analysis supports the intuitive proposition that a contractor should pursue its expansion of work (increase in Q_{R1}) with revenue in currencies likely to appreciate (increase in e_1, i.e., number of other, including home, currency units required to buy one unit of currency 1) against other currencies.

4.2.2 Three Currency Revenue Structure

In a three-currency world, where revenue structure decisions are possible in three currencies, profit and its maximization conditions can be expressed as follows:

$$Pr = f(QR1, QR2, QR3)$$

First Order Conditions

To have a maximum,

$$dPr = f_{R1}*dQR1 + f_{R2}*dQR2 + f_{R3}*dQR3 = 0,$$

for arbitrary values of dQ_{R1}, dQ_{R2}, dQ_{R3}, not all zero. f_{R1}, f_{R2}, and f_{R3} are partial derivatives of the profit function with respect to the three choice variables Q_{R1}, Q_{R2} and Q_{R3}, i.e., $f_{Ri} = \partial Pr/\partial Q_{Ri}$, i=1,2,3. If dQ_{R1}, dQ_{R2} and dQ_{R3} are not all zero, then in order to have dPr=0, it has to be:

$$f_{R1} = f_{R2} = f_{R3} = 0$$

Second Order Conditions

The above first order conditions designate values of Pr as the stationary values of the objective function. Similarly to the t[illegible] variable analysis, the sufficient condition for maximum Pr at a given stationary value is that d^2Pr is negative definite (Chiang reference). The expression for d^2Pr is found by differentiating dPr:

$$dPr = f_{R1}*dQ_{R1} + f_{R2}*dQ_{R2} + f_{R3}*dQ_{R3} = 0,$$

$$d^2Pr = d(dPr) = \frac{d(dPr)}{dQ_{R1}} dQ_{R1} + \frac{d(dPr)}{dQ_{R2}} dQ_{R2} + \frac{d(dPr)}{dQ_{R3}} dQ_{R3} =$$

$$= \frac{\partial}{\partial Q_{R1}} (f_{R1}*dQ_{R1} + f_{R2}*dQ_{R2} + f_{R3}*dQ_{R3}) +$$

$$+ \frac{\partial}{\partial Q_{R2}} (f_{R1}*dQ_{R1} + f_{R2}*dQ_{R2} + f_{R3}*dQ_{R3}) +$$

$$+ \frac{\partial}{\partial Q_{R3}} (f_{R1}*dQ_{R1} + f_{R2}*dQ_{R2} + f_{R3}*dQ_{R3}) =$$

$$\begin{aligned} = \quad & f_{11}dQ_{R1}{}^2 + f_{12}dQ_{R1}dQ_{R2} + f_{13}dQ_{R1}dQ_{R3} \\ & f_{21}dQ_{R2}dQ_{R1} + f_{22}dQ_{R2}{}^2 + f_{23}dQ_{R2}dQ_{R3} \\ & f_{31}dQ_{R3}dQ_{R1} + f_{32}dQ_{R3}dQ_{R2} + f_{33}dQ_{R3}{}^2 \end{aligned}$$

where $f_{ij} = \partial^2 Pr/\partial Q_{Ri}\partial Q_{Rj}$.

The sufficient condition for maximum Pr is that d^2Pr is negative definite, i.e., that:

$$\left\{ \begin{aligned} & |H1| = |f_{11}| = f_{11} < 0 \\ & |H2| = \begin{vmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{vmatrix} = f_{11}f_{22} - f_{12}f_{21} > 0, \text{ and} \\ & |H3| = \begin{vmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & f_{33} \end{vmatrix} = \\ & = f_{11}f_{22}f_{33} + f_{12}f_{23}f_{31} + f_{13}f_{21}f_{32} + \\ & \quad + f_{11}f_{23}f_{32} + f_{12}f_{21}f_{33} + f_{13}f_{22}f_{31} < 0 \end{aligned} \right\}$$

(In using the above second order condition, one has to evaluate all principal minors |H1|, |H2| and |H3| at the stationary point where $f_{R1} = f_{R2} = f_{R3} = 0$.)

Exchange Rate Elasticities

$$Pr = e_1*R_1 + e_2R_2 + e_3R_3 - C(Q)$$
$$= e_1*P_{R1}*Q_{R1} + e_2*P_{R2}*Q_{R2} + e_3*P_{R3}*Q_{R3} - C(Q)$$

$$Q = Q_{R1}+Q_{R2}+Q_{R3}$$
$$C(Q) = C(Q_{R1}+Q_{R2}+Q_{R3})$$

Using techniques similar to the ones applied for the two-currency situation (i.e., differentiating with respect to output priced in a given currency and then with respect to exchange rates), we derive the following system of equations:

$$A_{11}*\frac{dQ_{R1}}{de_1} + A_{12}*\frac{dQ_{R2}}{de_2} + A_{13}*\frac{dQ_{R3}}{de_3} = A_{10}$$

$$A_{21}*\frac{dQ_{R1}}{de_1} + A_{22}*\frac{dQ_{R2}}{de_2} + A_{23}*\frac{dQ_{R3}}{de_3} = A_{20}$$

$$A_{31}*\frac{dQ_{R1}}{de_1} + A_{32}*\frac{dQ_{R2}}{de_2} + A_{33}*\frac{dQ_{R3}}{de_3} = A_{30}$$

where:

$$A_{11} = [2*e_1*\frac{dP_{R1}}{dQ_{R1}} + e_1*\frac{dP^2_{R1}}{dQ_{R1}^2}*Q_{R1} - \frac{d^2C}{dQ_R^2}]$$

$$A_{12} = -\frac{d^2C}{dQ_R^2}*\frac{de_2}{de_1}$$

$$A_{13} = -\frac{d^2C}{dQ_R^2}*\frac{de_3}{de_1}$$

$$A_{10} = -P_{R1} - \frac{dP_{R1}}{dQ_{R1}} * Q_{R1}$$

$$A_{21} = -\frac{d^2C}{dQ_R^2}$$

$$A_{22} = 2 e_2 \frac{dP_{R2}}{dQ_{R2}} \frac{de_2}{de_1} + e_2 \frac{dP^2_{R2}}{dQ_{R2}^2} \frac{de^2}{de_1} Q_{R2} - \frac{d^2C}{dQ_R^2} \frac{de_2}{de_1}$$

$$A_{23} = - \frac{d^2C}{dQ_R^2} \frac{de_3}{de_1}$$

$$A_{20} = - \frac{de_2}{de_1} P_{R2} - \frac{de_2}{de_1} \frac{dP_{R2}}{dQ_{R2}} Q_{R2}$$

$$A_{31} = - \frac{d^2C}{dQ_R^2}$$

$$A_{32} = - \frac{d^2C}{dQ_R^2} \frac{de_2}{de_1}$$

$$A_{33} = 2 e_3 \frac{dP_{R3}}{dQ_{R3}} \frac{de_3}{de_1} + e_3 \frac{dP^2_{R3}}{dQ_{R3}^2} \frac{de_3}{de_1} Q_{R3} - \frac{d^2C}{dQ_R^2} \frac{de_3}{de_1}$$

$$A_{30} = - \frac{de_3}{de_1} P_{R3} - \frac{de_3}{de_1} \frac{dP_{R3}}{dQ_{R3}} Q_{R3}$$

The results from solving the system of equations are similar to those of the two currency analysis in describing (a) the direction and (b) magnitude of shift in contract volume and revenue in a given currency. The shape of cost and demand curves are again the key determinants of exchange rate elasticity of contract revenue.

Given the complexity of the results, we will not pursue the detailed expressions of dQ_{Ri}/de_i for the three currency environment. However, we note that a key factor in guiding the choice of currency should be the correlations between currencies. In an environment with more than two currencies, it is possible that a third currency can contribute positively or negatively to the contractor's exposure, based on its correlation with the other currencies.

4.3 International Construction Project and Currency Diversification

The volatility of exchange rates and its impact on the cash flow and project value to the contractor is a major consideration in the project selection and bid decision. For contractors focused on, and satisfied with, domestic markets, the volatility of exchange rates may support an overall aversion towards international work (although they can still face foreign competition in their domestic markets). The risk aversion towards international work is also motivated by other than exchange rate factors, such as political and business risks. For international contractors, it generates uncertainty about the home currency value and variability of cash flows and project value.

The previous sections of this thesis show the impact of exchange rate fluctuations on the expected value of a contractor's international cash flows and foreign currency exposure. Traditional project valuation methodologies use such expected (i.e., the statistical mean) cash flow information in order to determine the project value. However, modern finance theories (see section 1.3)) propose that risk-averse investors are not only interested in maximizing their returns when making investment decisions. They are also interested in reducing the risk (i.e., the statistical variance associated with an investment's payoffs). This implies that the basis of international construction project portfolio selection is the maximization of expected value in the context of such return-risk (or, statistical mean-variance) tradeoff.

Construction firms are effectively trading off project returns for lower risk when they diversify their operations geographically (e.g., Northeastern vs. Southeastern United States) or by project type (highway vs. building construction). The explicit goal is to keep the contract volume up when a local economy's demand for construction overall, or for a given project type, are reduced. The implicit tradeoff is between return and risk. A contractor is motivated to seek new project locations and types by its perception of high risk associated with its current geographic and project type focus, even though the current operations may be highly profitable.

The same tradeoff between a contractor's return and risk takes place with international diversification. For example, a contractor with excessive activity in a profitable but risky (i.e., with volatile economic conditions, including exchange rates) foreign market, may decide to shift some of its activity to other, less profitable but safer (i.e., more stable economically) markets. Actually, as we will see in subsection 4.3.1, international diversification will tend to reduce a contractor's risk, even when riskier than the existing projects are added to a contractor's portfolio, as long as the new project risk factors (including as exchange rates) do not have high positive correlation with existing projects.

The reduction of risk that results from diversification should help reduce a contractor's overall aversion towards international work. It should also encourage the pursuit of consistent international business development strategies that manage foreign exchange exposure more often through project selection and operations management (operational hedging) before using hedge instruments of financial markets (financial hedging).

To reduce its total risk in home currency despite foreign currency volatility, while maintaining the expected returns, the international contractor needs to understand how multiple international projects interact with each other, and how this interaction affects the home currency value of its cash flows. The following subsections discuss:

(a) the fundamentals of security portfolio selection (subsection 4.3.1),

(b) the applicability and mechanics of a portfolio approach in international construction project selection (subsection 4.3.2),

(c) the foreign market and exchange rate effects resulting from international project diversification (subsection 4.3.3), and

(d) the impact of exchange rate correlations on international project selection and risk reduction (subsection 4.3.4).

4.3.1 Fundamentals of Security Portfolio Selection

The central element of portfolio theory, as it applies to financial securities, is the spreading of total portfolio risks when a large number of securities are combined. Portfolio theory explains why investors often hold sets of securities that do not necessarily maximize the expected return of available securities, because they are interested in reducing the risk of their returns.

The three steps in portfolio selection decisions are:

(a) Analysis and evaluation of return and risk of individual securities,

(b) Analysis and evaluation of return and risk of alternative security portfolios, and

(c) Selection of portfolio, based on individual return-risk preferences.

Security analysis combines information about their past performance with expectations about their future performance to predict the value and probability distribution of their returns in the future. The following three measures are critical:

(a) The mean $E(X_i)$ of the distribution,

(b) the variance $v(X_i)=v_i$ and standard deviation $\sigma(X_i)=\sigma_i$ of the distribution (where $v_i=\sigma^2_i$).

(c) The covariance σ_{ij} between the returns of securities i and j, with $\sigma_{ij} = \rho_{ij}*\sigma_i*\sigma_j$, where ρ_{ij} is the coefficient of correlation between the returns securities i and j.

The coefficient of correlation measures the statistical relationship between security returns. For example, securities with substantial industry or other similarities tend to be positively correlated, i.e., when one's returns increase, the other's returns increase too. The coefficient of correlation ranges from -1 to +1 depending on the degree and direction of correlation, including zero when no correlation exists.

In the world of divisible financial securities, individuals can invest their wealth in an infinite number of portfolios, that can be produced from the combinations of marketable securities. The expected return and variance of a portfolio combination is:

$$E(R) = \sum_{i=1}^{N} w_i * E(X_i)$$

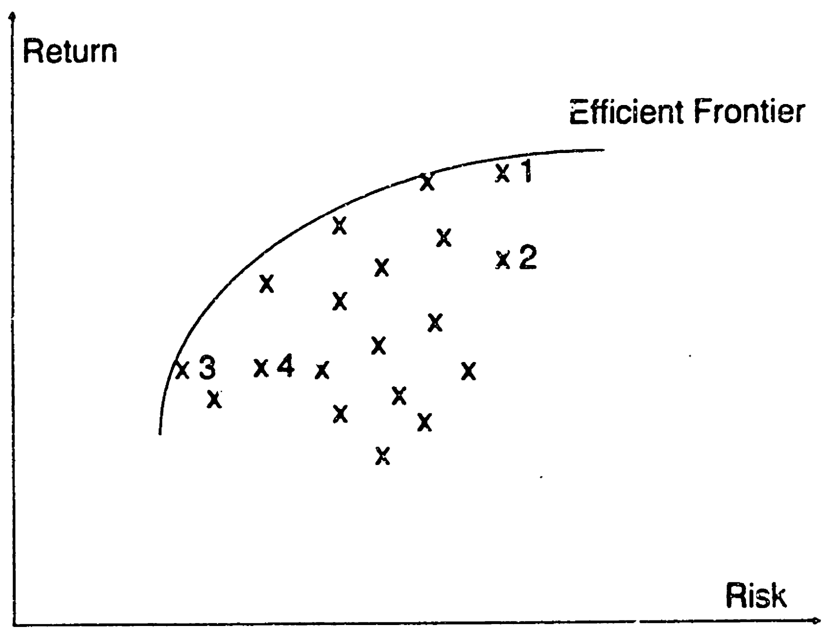
$$v(R) = \sum_{i=1} w_i^2 * \sigma_i^2 + 2 * \sum_{\substack{i,j=1 \\ i \neq j}}^{i,j=N} w_i * w_j * \rho_{ij} * \sigma_i * \sigma_j$$

The resulting standard deviation / mean (return/ risk) pairs can be plotted for visual inspection of the available options (see figure 4.2). Portfolios that have the highest expected return for a given level of risk or the lowest standard deviation for a given expected return are referred to as dominant portfolios. The locus of dominant portfolios that optimize the investor's risk/return tradeoff is called "efficient portfolio" (Brealey, 1988).

Finally, the portfolio selection decision, among the efficient set of portfolios, depends on the individual investor preferences and attitudes towards return and risk. The decision criterion then is the maximization of expected utility, rather than maximization of expected value of the portfolio returns.

FIGURE 4.2

PROJECT PORTFOLIO SELECTION



Project portfolio 1 dominates project portfolio 2
(1 has same risk with 2, but higher expected return)

Project portfolio 3 dominates project portfolio 4
(3 has same expected return with 4, but lower expected risk)

Source : Adapted from Brealey, R. and Myers, S., Principles of Corporate Finance, McGraw-Hill, New York, 1988.

4.3.2 International Construction Firm Diversification

The application of portfolio theory in international construction should be seen in the context of the uniqueness of the construction industry and projects and the difference between project versus security portfolio formation. Some major considerations are:

- Due to the substantially increased overhead associated with international operations, the construction projects pursued by international contractors are characterized by their large size, lumpiness and nondivisibility, more so than domestic projects (Seymour, 1987).

- Unlike the stock market, where securities are flexibly bought and sold over time, construction projects can not practically be sold or abandoned, once the contractor makes a commitment to them. International project abandonment can be equivalent to permanently writing off a country's market.

- Projects are added through bidding. Unlike the stock market, where a large number of securities is available on demand to choose from, international construction firms only have a finite number of projects to choose from, and suspect that other projects may be forthcoming. Therefore, their project selection strategies have longer term implications compared to investment decisions in financial assets.

- No "simple portfolio" strategy is available in international construction. Classical portfolio theory implies that investors can diversify their holdings without limitation (until their risk come close to "market risk" levels) by holding a large number of securities in proportion to their market value, and borrowing or lending to achieve a required return/ risk tradeoff (Merton, 1984). Due to the finite number of construction projects available, the international contractor does not practically have the flexibility to implement such a "passive" rule of project portfolio selection.

Despite the short-term lack of flexibility in project portfolio selection, the international contractor can benefit from a consistent, long-term international diversification strategy. Such diversification initiatives (which, in a world of perfect markets, should be made by the construction firm shareholders) can be justified by the construction market imperfections discussed in section 3.4. At the firm level, the contractor can reduce its risks by allocating optimum proportions of its operations in countries and projects that complement each other towards reducing total market risk (i.e., business, political and exchange risk) and its impact on home currency returns. At the project level, it can pursue currency of revenue and cost denominations that specifically reduce the foreign exchange exposure and its impact on home currency returns, as shown in the previous sections of this chapter.

4.3.3 Project Portfolio Selection in International Construction

A construction firm typically has a set of projects in progress, i.e., an existing portfolio of projects. These projects have individual and portfolio return / risk profiles. Unlike security based portfolios, which can be changed by selling and buying securities, the existing construction project portfolio can only be changed through addition of new projects. The construction firm does not practically have the option to abandon in-progress projects. The contractor has to decide how to select new construction projects, and how to bid on these new construction projects on the basis of their interaction with its existing project portfolio.

The adaptation of the security portfolio selection methodology implies the following steps for the developing a contractor's project portfolio:

(a) Analyze individually the projects in progress and determine their expected returns and risks over time (including exchange risks for international projects).

(b) Combine the projects in progress to determine the existing portfolio's expected total return and risk.

(c) Analyze individually the potential new projects and determine their expected returns and risks.

(d) Combine individual or groups of new projects with the current portfolio to determine the return and risks of candidate new portfolios.

(e) Choose a new project portfolio based on return/ risk preferences of the construction firm shareholders.

(f) Determine a bid price for the new project(s) accounting for the variability of costs, desired profit and competitive bidding situation (for bid decision criteria see Friedman, 1956; Gates, 1967; Rosenshine, 1972; Carr and Sandahl 1978).

The mechanics of applying a portfolio formation approach to selecting and bidding new projects should combine information about existing projects with similar information about candidate projects. For existing projects, such information can be extracted from earned value information systems and analysis models. Such models provide the progress-to-date data and probabilistic cost/schedule forecasts required to compute the present values X_{ij} of future cash flows j for the remaining N_i activities of a given project i and, therefore, define mean project values P_i and variances $v(P_i)$ of the existing portfolio of projects. Assuming that the coefficients of correlation between activities k and l are ρ_{Akl}, where the subscript A implies activity (or, activity) correlation, a project remaining activities' expected value $E(P_i)$ and variance $v(P_i)$ are defined as follows:

$$E(P_i) = \sum_{k=1}^{N_i} E(X_{ik})$$

$$v(P_i) = \sum_{k=1}^{N_i} w_i^2 * v(X_{ik}) + 2 * \sum_{\substack{k,l=1 \\ k \neq l}}^{k,l=N_i} w_{ik} * w_{il} * \rho_{Akl} * \sigma(X_{ik}) * \sigma(X_{il})$$

At the firm level, with multiple current projects M and project coefficients of correlation ρ_{Pij}, we can define the portfolio's expected value E(V) and variance v(V) as follows:

$$E(V) = \sum_{i=1}^{M} E(P_i),$$

$$v(V) = \sum_{i=1}^{M} w_i^2 * v(Pi) + 2 * \sum_{\substack{i,j=1 \\ i \neq j}}^{M} w_i * w_j * \rho_{Pij} * \sigma(P_i) * \sigma(P_j)$$

Similar to projects in progress, probabilistic cost estimates are also required to generate the return/ risk profile of candidate projects. Cost estimates for the new projects may be less accurate than those of current projects, due to the likely limited availability of information. Such lack of information will be reflected by a larger variance.

Correlation among new and current projects can be determined by disaggregating the factors contributing to it. Such factors include, but are not limited to, the project owner, geography, type, size, weather, resources, political factors, supervision, construction methods, contractual arrangements, specifications and the economy

In international construction, expected value and variance measures should reflect the risk (variance) of cash flows in home currency. This risk has two components: first, a foreign market and, second, a foreign exchange rate risk. The foreign market risk covers the variability of foreign currency project cash flows, due to different from the home country market conditions and risks. The exchange rate risk covers the variability of foreign exchange rates used in translating foreign cash flows in domestic currency. As a result, the expected value and variance of a contractor's portfolio of projects should be modified as follows:

$$E(V) = \sum_{i=1}^{M} e_i * E(P_i),$$

$$\sigma^2(V) = v(V) = \sum_{i=1}^{M} w_i^2 * v(e_i * Ei) + 2 * \sum_{\substack{i,j=1 \\ i \neq j}}^{M} w_i * w_j * \rho_{TPij} * \sigma_T(E_i) * \sigma_T(Ej)$$

where:

$E_i = E(P_i)$, expected return in foreign currency from project i,

$E_j = E(P_j)$, expected return in foreign currency from project j, and

σ_T represents total individual country/ project risk, including foreign market and foreign exchange rate risks.

Historical data on the risks associated with foreign markets demonstrate that foreign market and exchange rate risks vary widely across countries. Table 4.1 summarizes such data compiled by Solnik (1988). The statistical measures of risk used in this table data are the variance v and standard deviation σ of actual returns r_{act} from expected returns r_{exp}, i.e.,

TABLE 4.1

RISK AND RETURN FOR US DOLLAR INVESTORS, 1971-1985

Percent per year

A	Annual Return B	Capital Gain C	Dividend Yield D	Exchange Gain E	Total Risk F	Domestic Risk G	Exchange Risk H	Contribution I=F-G	Domestic/ Exchange K
Stocks									
West Germany	15.69%	7.38%	4.80%	4.51%	20.09%	15.78%	12.17%	4.31%	0.02
Belgium	19.41%	6.67%	11.30%	1.44%	20.53%	15.80%	12.14%	4.73%	0.06
Denmark	14.51%	9.32%	5.05%	0.14%	18.50%	16.67%	11.14%	1.83%	-0.16
France	14.62%	9.54%	6.19%	-1.11%	25.45%	21.60%	11.30%	3.85%	0.11
Italy	10.65%	13.01%	3.16%	-5.51%	27.80%	26.27%	9.75%	1.53%	-0.02
Norway	11.51%	7.60%	4.15%	-0.24%	28.68%	27.11%	9.73%	1.57%	-0.01
Netherlands	17.06%	6.73%	6.74%	3.59%	19.30%	17.35%	11.59%	1.95%	-0.16
United Kingdom	13.73%	11.33%	6.01%	-3.61%	28.28%	24.95%	10.32%	3.33%	0.14
Sweden	18.32%	15.43%	4.94%	-2.05%	20.84%	18.80%	9.75%	2.04%	-0.04
Switzerland	14.75%	5.01%	2.96%	6.78%	20.58%	15.75%	14.36%	4.83%	-0.07
Spain	8.24%	4.27%	8.40%	-4.43%	22.76%	19.39%	9.98%	3.37%	0.11
Australia	9.28%	8.05%	4.94%	-3.71%	26.81%	23.26%	10.10%	3.55%	0.16
Japan	24.58%	16.03%	2.42%	6.14%	20.75%	16.35%	11.16%	4.40%	0.11
Hong Kong	25.01%	17.05%	4.95%	3.01%	40.86%	43.07%	6.43%	-2.21%	-0.41
Singapore	11.30%	10.90%	2.87%	-2.48%	32.46%	32.39%	6.01%	0.07%	-0.08
Canada	10.28%	8.16%	4.32%	-2.20%	20.14%	18.47%	4.29%	1.67%	0.29
United States	9.95%	5.17%	4.78%	0.00%	15.41%	15.41%	0.00%	0.00%	
World	13.00%	8.45%	4.55%	0.00%	13.85%	13.18%			
Bonds									
West Germany	13.14%	0.40%	8.37%	4.37%	15.19%	6.91%	12.17%	8.28%	0.21
France	10.81%	-0.21%	12.09%	-1.70%	13.96%	6.69%	11.30%	7.27%	0.15
Netherlands	13.11%	0.67%	8.96%	3.47%	14.10%	6.89%	11.59%	7.21%	0.11
United Kingdom	8.37%	-0.47%	12.27%	-3.46%	16.88%	11.38%	10.32%	5.50%	0.21
Switzerland	12.34%	0.65%	5.05%	6.56%	15.22%	4.24%	14.36%	10.98%	0.06
Japan	15.68%	1.40%	8.59%	5.56%	15.22%	5.75%	11.16%	8.47%	0.41
Canada	7.20%	-1.29%	10.64%	-2.16%	10.83%	3.67%	4.29%	2.16%	0.32
United States	8.77%	-0.92%	9.68%	0.00%	9.20%	9.20%	0.00%	0.00%	
Cash									
West Germany	10.46%		6.19%	4.27%	12.10%	0.77%	12.17%	11.33%	-0.12
France	11.18%		12.25%	-1.07%	11.38%	1.34%	11.30%	10.04%	0.00
Netherlands	10.59%		7.20%	3.39%	11.67%	0.83%	11.59%	10.84%	0.06
United Kingdom	8.98%		12.44%	-3.46%	10.47%	0.95%	10.32%	9.52%	0.11
Switzerland	10.97%		4.42%	6.56%	14.41%	0.77%	14.36%	13.64%	0.04
Japan	12.90%		7.33%	5.56%	11.19%	0.70%	11.16%	10.49%	0.01
Canada	7.96%		10.12%	-2.16%	4.42%	1.00%	4.29%	3.42%	0.02
United States	9.93%		9.93%	0.00%	1.03%	1.03%	0.00%	0.00%	

Source: Solnik, B., International Investments, Addison Wesley, Reading, 1988.

$v = \sigma^2 = (r_{act} - r_{exp})^2$,

Table 4.1 provides evidence on the volatility of US dollar returns in foreign investments together with three measures of risk, represented by the standard deviations of US dollar based cash flows (total risk, σ_T), foreign currency based cash flows (market risk, σ_M) and foreign exchange rates (exchange risk, σ_E).

The data of table 4.1 show that, true to the fears of risk-averse contractors, individual foreign market risks can be larger than domestic market risks. For example, without a single exception, the US contractor is likely to face larger market risks abroad than in the US market, where the standard deviation of returns is the lowest (15.41%). The risks facing the contractor in a given country can be larger or smaller than the market risk, depending on the covariance between the contractor and market returns (represented by β beta in the capital asset pricing model (CAPM)).

The higher total foreign country risk would, at first glance, provide sufficient discouragement against internationalizing a contractor's activities. However, the addition of foreign projects to a purely domestic portfolio can reduce the total risk, provided that the added projects do not have high positive correlation with the domestic investments.(This is implied indirectly by the data of table 4.1, where the total risk of a completely internationally diversified portfolio is about 13.85%, i.e., less than that the 15.41% risk of the US market.)

To illustrate the risk reduction impact of international contractor diversification, let us consider a US contractor considering the expansion of its operations in West Germany. Let us assume for simplicity, but without loss of generality, that

- the contractor's risk is the same with the average risk observed for stocks and listed in table 4.1, (i.e., the contractor's beta equals 1.00),

- the US contractor, with domestic risk measured by $\sigma_{US} = 15.41\%$, considers investing 30% and of its assets in construction operations in West Germany (i.e., $w_{US} = 0.70$ and $w_{WG} = 0.30$) where the risk is $\sigma_{WG} = 20.09\%$, and
- the correlation coefficient between the two operations is $\rho_{US,WG} = 0.35$.

The contractor's portfolio variance will be:

$$\sigma_p^2 = (w_{US}*\sigma_{US})^2 + (w_{WG}*\sigma_{WG})^2 + 2*w_{US}*w_{WG}*\rho_{US,WG}*\sigma_{US}*\sigma_{WG}$$

$$= (0.7*0.1541)^2 + (0.3*0.2009)^2 +$$

$$+ 2*0.7*0.3*0.35*0.1541*0.2009 =$$

$$= 0.019824.$$

The standard deviation of the portfolio is then $\sigma_p = 0.1405$, or 14.05%, which is significantly lower than that of the purely domestic operations (15.41%). In other words, the investment in West Germany has reduced the total risk for the US contractor.

The numeric example of table 4.2 shows how, given appropriate correlation between country investments, a contractor can reduce its risks by investing even in the most volatile markets. This is true, for example, for Singapore, where the observed risk has been over 32%.

It can be shown that, if the correlation coefficient between two projects r_{12} is less than the ratio σ_1/σ_2, a contractor with projects in country 1 can invest up to a proportion w_2 of its assets in other projects 2, and always reduce its total risk. The proportion w_2 is given by the formula:

$$w_2 = \frac{2*\sigma_1*(\sigma_1-\rho_{12}*\sigma_2)}{\sigma_1^2+\sigma_2^2-2*\rho_{12}*\sigma_1*\sigma_2}, \text{ while } w_1 = 1-w_2$$

The condition $r_{12} < \sigma_1/\sigma_2$ guarantees that $w_2 > 0$, since the numerator is always positive:

TABLE 4.2

RISK REDUCTION THROUGH INTERNATIONAL DIVERSIFICATION

SCENARIO INDEPENDENT ASSUMPTIONS

Domestic Market Risk (standard deviation σ)

United States	:	σ_{US} =	0.1541
West Germany	:	σ_{WG} =	0.2009
Australia	:	σ_{AU} =	0.2681
Singapore	:	σ_{SI} =	0.3246

Notes: (1) Two-country portfolios with star (*) have lower risk than purely domestic investment.

(2) wd + wf = 1

SCENARIO 1

Coefficient of correlation : ρ = 1.00

Domestic Proportion wd	Foreign Proportion wf	U.States W.Germany σUS,WG	U.States Australia σUS,Au	U.States Singapore σUS,Si
1.00	0.00	0.1541	0.1541	0.1541
0.90	0.10	0.1588	0.1655	0.1711
0.80	0.20	0.1635	0.1769	0.1882
0.70	0.30	0.1681	0.1883	0.2053
0.60	0.40	0.1728	0.1997	0.2223
0.50	0.50	0.1775	0.2111	0.2394
0.40	0.60	0.1822	0.2225	0.2564
0.30	0.70	0.1869	0.2339	0.2734
0.20	0.80	0.1915	0.2453	0.2905
0.10	0.90	0.1962	0.2567	0.3075
0.00	1.00	0.2009	0.2681	0.3246

SCENARIO 2

Coefficient of correlation : ρ = 0.50

Domestic Proportion wd	Foreign Proportion wf	U.States W.Germany σUS,WG	U.States Australia σUS,Au	U.States Singapore σUS,Si
1.00	0.00	0.1541	0.1541	0.1541
0.90	0.10	0.1497 *	0.1539 *	0.1574
0.80	0.20	0.1475 *	0.1571	0.1656
0.70	0.30	0.1475 *	0.1636	0.1778
0.60	0.40	0.1498 *	0.1731	0.1934
0.50	0.50	0.1542	0.1850	0.2116
0.40	0.60	0.1605	0.1990	0.2318
0.30	0.70	0.1686	0.2146	0.2535
0.20	0.80	0.1781	0.2314	0.2764
0.10	0.90	0.1890	0.2494	0.3001
0.00	1.00	0.2009	0.2681	0.3246

(Table 4.2 cont'd)

SCENARIO 3

Coefficient of correlation : ρ = 0.35

Domestic Proportion wd	Foreign Proportion wf	U.States W.Germany σUS,WG	U.States Australia σUS,Au	U.States Singapore σUS,Si
1.00	0.00	0.1541	0.1541	0.1541
0.90	0.10	0.1469 *	0.1502 *	0.1531 *
0.80	0.20	0.1424 *	0.1507 *	0.1582
0.70	0.30	0.1408 *	0.1555	0.1687
0.60	0.40	0.1422 *	0.1643	0.1839
0.50	0.50	0.1464 *	0.1765	0.2026
0.40	0.60	0.1534 *	0.1914	0.2239
0.30	0.70	0.1627	0.2084	0.2472
0.20	0.80	0.1739	0.2271	0.2720
0.10	0.90	0.1868	0.2471	0.2979
0.00	1.00	0.2009	0.2681	0.3246

SCENARIO 4

Coefficient of correlation : ρ = 0.00

Domestic Proportion wd	Foreign Proportion wf	U.States W.Germany σUS,WG	U.States Australia σUS,Au	U.States Singapore σUS,Si
1.00	0.00	0.1541	0.1541	0.1541
0.90	0.10	0.1401 *	0.1413 *	0.1424 *
0.80	0.20	0.1297 *	0.1344 *	0.1393 *
0.70	0.30	0.1236 *	0.1346 *	0.1453 *
0.60	0.40	0.1225 *	0.1416 *	0.1594
0.50	0.50	0.1266 *	0.1546	0.1797
0.40	0.60	0.1354 *	0.1723	0.2043
0.30	0.70	0.1480 *	0.1933	0.2319
0.20	0.80	0.1636	0.2167	0.2615
0.10	0.90	0.1815	0.2418	0.2925
0.00	1.00	0.2009	0.2681	0.3246

(Table 4.2 cont'd)

SCENARIO 5

Coefficient of correlation : $\rho = -0.50$

Domestic Proportion wd	Foreign Proportion wf	U.States W.Germany σUS,WG	U.States Australia σUS,Au	U.States Singapore σUS,Si
1.00	0.00	0.1541	0.1541	0.1541
0.90	0.10	0.1298 *	0.1413 *	0.1424 *
0.80	0.20	0.1089 *	0.1344 *	0.1393 *
0.70	0.30	0.0936 *	0.1346 *	0.1453 *
0.60	0.40	0.0870 *	0.1416 *	0.1594
0.50	0.50	0.0910 *	0.1546	0.1797
0.40	0.60	0.1044 *	0.1723	0.2043
0.30	0.70	0.1241 *	0.1933	0.2319
0.20	0.80	0.1477 *	0.2167	0.2615
0.10	0.90	0.1736	0.2418	0.2925
0.00	1.00	0.2009	0.2681	0.3246

SCENARIO 6

Coefficient of correlation : $\rho = -1.00$

Domestic Proportion wd	Foreign Proportion wf	U.States W.Germany σUS,WG	U.States Australia σUS,Au	U.States Singapore σUS,Si
1.00	0.00	0.1541	0.1541	0.1541
0.90	0.10	0.1298 *	0.1413 *	0.1424 *
0.80	0.20	0.1089 *	0.1344 *	0.1393 *
0.70	0.30	0.0936 *	0.1346 *	0.1453 *
0.60	0.40	0.0870 *	0.1416 *	0.1594
0.50	0.50	0.0910 *	0.1546	0.1797
0.40	0.60	0.1044 *	0.1723	0.2043
0.30	0.70	0.1241 *	0.1933	0.2319
0.20	0.80	0.1477 *	0.2167	0.2615
0.10	0.90	0.1736	0.2418	0.2925
0.00	1.00	0.2009	0.2681	0.3246

$$\sigma_1^2+\sigma_2^2-2*\rho_{12}*\sigma_1*\sigma_2 > \sigma_1^2+\sigma_2^2-2*\sigma_1*\sigma_2 = (\sigma_1-\sigma_2)^2 > 0.$$

In our example, and since $r_{12} = 0.35 < \sigma_1/\sigma_2 = 0.1541/0.2009 = 0.76$, the maximum contractor investment in country 2 that produces reduction in total risk would be

$$w2 = \frac{2*0.1541*(0.1541-0.35*0.2009)}{0.1541^2+0.2009^2-2*0.35*0.1541*0.2009} = 0.6085,$$

or up to about 60 percent, as table 4.2 also implies. However, the optimum w_2 is shown in appendix 5 to be:

$$w2 = \frac{\sigma_1^2-\rho_{12}*\sigma_1*\sigma_2}{\sigma_1^2+\sigma_2^2-2*\rho_{12}*\sigma_1*\sigma_2}, \text{ with } w_1 = 1-w_2$$

Going back to our example, the optimum proportion of investment in country 2 should be:

$$w^2 = \frac{0.1541^2-0.35*0.1541*0.2009}{0.1541^2+0.2009^2-2*0.35*0.1541*0.2009} \cong 0.3043,$$

or up to about 30 percent of the contractor's total investment, as table 4.2 also implies. The minimum possible standard deviation would then be about 14.1 percent.

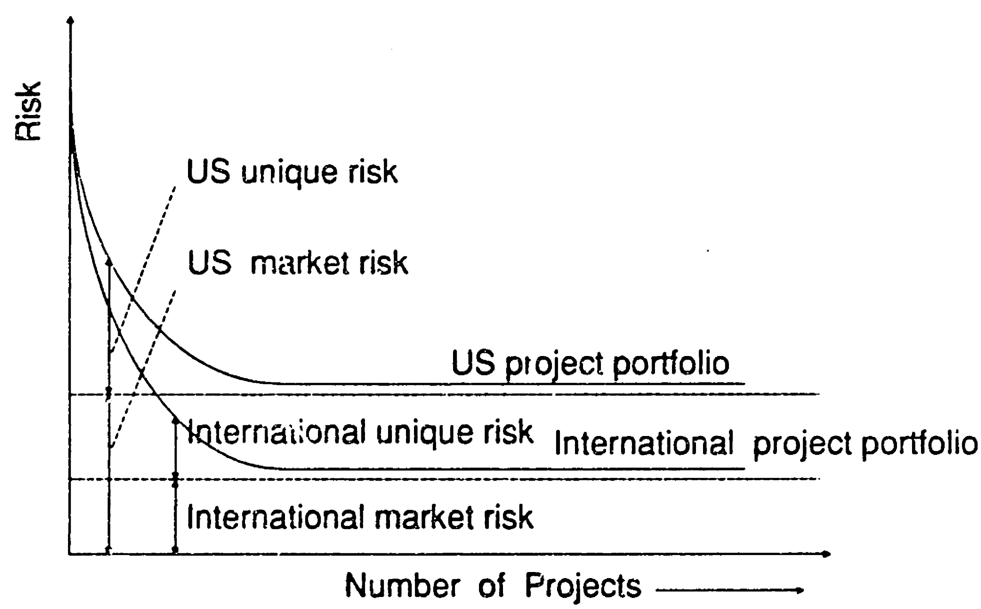
The result from internationalizing a contractor's activities is then the lowering of total market risk below the levels of domestic market risk, as the schematic of figure 4.3 suggests. The remaining market risk cannot be eliminated through diversification, as it depends on world economic conditions that affect all international firms.

4.3.4 Exchange Rate Risk and Correlations

The total risk facing the international contractor reflects not only the volatility of foreign currency based cash flows, but also the volatility of exchange rates used to translate them. Therefore, the impact of currency rate fluctuations on the volatility of home country translated cash flows can be seen from two angles:

FIGURE 4.3

CONTRACTOR'S RISK REDUCTION THROUGH INTERNATIONAL PROJECT DIVERSIFICATION



Source : Adapted from Solnik, B., "International Parity Conditions and Exchange Risk," Journal of Banking and Finance, 2, 1978, pp.281-293.

(a) the correlation between exchange rate and market movements, and, therefore, the contribution of exchange to total market risk, and

(b) the correlation between multiple exchange rates in which the contractor has net international exposure.

Correlation between exchange rate and market movements

The historical data listed in table 4.1 provide some additional inferences regarding the contribution of exchange risk to total foreign market risk. We observe that the part of total risk in home currency that can be attributed to exchange risk can be derived by subtracting the local market risk (i.e., the variability of cash flows in foreign currency, column G) from the total risk (i.e., the variability of cash flows in home currency, column F).

The subtraction (column I) reveals that the contribution of exchange risk is from significantly less to significantly higher than that of local market risk, depending on the type of investment. For example, the contribution of exchange risk to the total risk of equity investments in many industrial countries is between 3 and 4 percent of the total risk, while the exchange rate variability itself is between 10 and 12 percent. By contrast, table 4.1 shows that the contribution of exchange risk is much higher in the case of bonds and almost monopolizes the total risk in cash investments.

At this point, it is worth noting that the exchange risk contribution may actually be higher than suggested by the above empirical data. This is due to the exchange rate elasticities of noncontractual foreign cash flows, as they have been discussed in section

4.3. In other words, part of the exchange risk may be incorporated with the foreign market risk, by virtue of foreign currency prices being affected by exchange rates.

With or without such considerations, the levels of total foreign risk can vary among international contractors, depending on the individual levels of diversifiable risk, as well, as nondiversifiable risk associated with the specific project type. The data on the covariance of construction firm and market returns from Merrill-Lynch's "Security Risk Evaluation" (10/1986) suggest a wide range in the variability of contractor's risk. For example, the data show that construction firms' betas vary from 0.39 for Turner construction to 1.6 for Fluor Corporation. Some intermediate betas listed are 0.98 for Morrison-Knudsen, 0.96 for Stone & Webster and 1.22 for Perini Corporation.

Table 4.1 also implies the lack of additivity between local market and exchange risk. This suggests the low correlation between the two. The correlation coefficient of the two-component system (local market and exchange risk) can be derived from the formula (Benjamin et al., 1970):

$$\sigma_T^2 = \sigma_M^2 + \sigma_E^2 + 2*\rho_{ME}*\sigma_M*\sigma_E \Rightarrow$$

$$\rho_{ME} = (\sigma_T^2-\sigma_M^2-\sigma_E^2)/(2*\sigma_M*\sigma_E)$$

Column K of table 4.1 provides the ρ_{ME}. Excluding indirect contributions of exchange rates to local market risk, the correlation between exchange and local market risk is relatively low. Given the suggested low correlation between market and foreign exchange risk, it can be argued that exchange risk should be treated independently, and hedged with financial instruments, if their cost is appropriate for the risk it eliminates.

International contractors dealing with lumpy projects and noncontractual, long-term exposures may not find such instruments cost-effective for two primary reasons:

First, standard instruments will normally not be available for developing country currencies, where most of the international construction investment takes place. Second, the lumpiness and nondivisibility of construction projects demands longer term instruments, also not available in general and for developing countries in particular. Tailored financial instruments that suit international contractors would inevitably be more expensive than standard.

Correlation between currencies

The analysis in sections 4.1 and 4.2 demonstrated that one factor entering the foreign exchange rate elasticities of costs and revenues is the correlation between currencies. For example, we observed that, in an environment with more than two currencies, it is possible for a third currency to contribute positively or negatively to the contractor's exposure, based on its correlation with the other currencies in which the contractor is exposed. Given that, it is of interest to examine the potential benefits of foreign currency diversification in single and multiple projects.

Although many widely traded currencies (such as the US dollar, British pound, Japanese yen and Swiss franc) float independently, most countries set par values for their currencies. Table 4.3 provides the International Monetary Fund's classification of currencies based on such country policies. The intuitive observation is that pegged, fixed or otherwise linked currencies will tend to have high positive correlations with each other. However, it should be noted that currency relationships will not always provide accurate exposure management information, because of government intervention. For example, pegging and fixed currency relationships are often complemented with incremental mini-devaluations resulting in managed floating arrangements (Grabbe, 1986).

TABLE 4.3

Exchange Rate Arrangements as of March 31, 1987 [1]

Pegged						Flexibility Limited vis-à-vis a Single Currency or Group of Currencies		More Flexible		
Single currency				Currency composite				Adjusted according to a set of indicators	Managed floating	Independently floating
U.S. dollar		French franc	Other	SDR	Other	Single currency[2]	Cooperative arrangements[3]			
Antigua and Barbuda The Bahamas[4] Barbados Belize	Lao People's Democratic Rep.[4] Liberia Mozambique Nicaragua[4] Oman	Benin Burkina Faso Cameroon Central African Rep.	Bhutan (Indian rupee) Kiribati (Australian dollar)	Burma Burundi Iran, Islamic Rep. of Jordan	Algeria[4] Austria Bangladesh[4] Botswana Cape Verde	Afghanistan[4] Bahrain[5] Qatar[5] Saudi Arabia[5] United Arab Emirates[5]	Belgium[4] Denmark France Germany Ireland	Brazil Chile[4] Colombia Madagascar Portugal	Argentina China, People's Rep. of Costa Rica[4] Ecuador	Australia Bolivia Canada Dominican Republic
Djibouti Dominica Egypt[4] El Salvador Ethiopia	Panama Paraguay[4] St. Kitts and Nevis	Chad Comoros Congo Côte d'Ivoire	Lesotho[4] (SAR) Swaziland (SAR)	Kenya[6] Libya[7] Rwanda São Tomé and Principe	Cyprus Fiji Finland[8] Hungary Israel		Italy Luxembourg[4] Netherlands	Somalia[4]	Greece Guinea-Bissau Iceland India[8]	The Gambia Ghana Guinea Japan Lebanon
Grenada Guatemala[4] Guyana[4] Haiti Honduras	St. Lucia St. Vincent and the Grenadines Suriname Syrian Arab Rep.[4]	Equatorial Guinea Gabon Mali Niger	Tonga (Australian dollar)	Seychelles Vanuatu	Kuwait Malawi Malaysia[8] Malta Mauritius				Indonesia Jamaica Korea Mauritania Mexico[4,9]	Maldives New Zealand Nigeria[4] Philippines Sierra Leone
Iraq	Trinidad and Tobago Uganda Venezuela[4] Viet Nam[4] Yemen Arab Rep. Yemen People's Democratic Rep.	Senegal Togo			Nepal Norway Papua New Guinea Poland				Morocco Pakistan Peru[10] Spain	South Africa[4] United Kingdom
					Romania Singapore Solomon Islands Sudan[4]				Sri Lanka Tunisia	United States Uruguay Zaire Zambia
					Sweden[12] Tanzania Thailand Zimbabwe				Turkey[11] Western Samoa Yugoslavia	

[1]No current information is available relating to Democratic Kampuchea.

[2]In all cases listed in this column, the U.S. dollar was the currency against which exchange rates showed limited flexibility.

[3]This category consists of countries participating in the exchange rate mechanism of the European Monetary System. In each case, the exchange rate is maintained within a margin of 2.25 percent around the bilateral central rates against other participating currencies, with the exception of Italy, in which case the exchange rate is maintained within a margin of 6 percent.

[4]Member maintains dual exchange markets involving multiple exchange arrangements. The arrangement shown is that maintained in the major market.

[5]Exchange rates are determined on the basis of a fixed relationship to the SDR, within margins of up to ± 7.25 percent. However, because of the maintenance of a relatively stable relationship with the U.S. dollar, these margins are not always observed.

[6]The exchange rate is maintained within margins of ± 2.25 percent.

[7]The exchange rate is maintained within margins of ± 7.5 percent.

[8]The exchange rate is maintained within margins of ± 5 percent on either side of a weighted composite of the currencies of the main trading partners.

[9]As of March 31, 1987 the spread between the two exchange rates was less than 1 percent.

[10]Member maintains a system of advance announcement of exchange rates.

[11]The Central Bank establishes its selling rate daily and the buying rate is set at ½ percent below the selling rate. Commercial banks must use the Central Bank's selling rate, but are free to set their own buying rate.

[12]The exchange rate is maintained within margins of ± 1.5 percent.

The historical correlation between currencies is powerful information for the contractor in its project selection and currency of revenue definition. Although it is both not feasible, as well as not desirable to shift currency of revenues in response to short-term exposures, it is strategically important to factor exchange rate correlation information for medium- and long-term project and business development decisions, in order to minimize currency risk through operational decisions and reduce the costs of financial hedging.

For example, if the third currency is positively correlated with a currency in which the contractor already has an exposure, the third currency will contribute to the contractor's exposure in the same direction. Such currencies are, for example, the pound sterling and the Cypriot pound. A contractor with a long position in pound sterlings may increase its exposure when it enters a new contract with revenue in Cypriot pounds, as the currencies tend to move in the same direction.

Tables 4.4a and 4.4b, and figures 4.4a and 4.4b illustrate the strong positive correlation between pound sterling and Cypriot pound and contrast it to the correlation between the pound sterling and the Uruguay peso. The correlation between the sterling and Cypriot pound is so strong that the Cypriot pound is considered a proxy currency to the sterling. The strong correlation is partly due to the common British Commonwealth history and bond between the two countries.

The currency correlations are important not only in medium- and long-term project and business development strategies, but can also help with financial hedging instruments, such as forward, futures and options contracts. For example, a contractor exposed in a developing country's currency that may not have such financial hedge

TABLE 4.4A

EXCHANGE RATE CORRELATIONS

	US$ per Sterling Pound	US$ per Cyprus Pound	Change in Ex. Rate Sterling Pound	Change in Ex. Rate Cyprus Pound	
	X	Y	a=dX	b=dY	
23-Sep-87	1.6365	2.0657			
21-Oct-87	1.6536	2.0777	0.0104	0.0058	
18-Nov-87	1.7605	2.1584	0.0646	0.0388	
16-Dec-87	1.8242	2.2287	0.0362	0.0326	
13-Jan-88	1.8320	2.2346	0.0043	0.0026	
10-Feb-88	1.7582	2.1706	-0.0403	-0.0286	
09-Mar-88	1.8350	2.2046	0.0437	0.0157	
Sample Mean	1.7571	2.1629	0.0198	0.0111	
	a-MEAN(a)	b-MEAN(b)	[a-MEAN(a)]2	[b-MEAN(b)]2	[a-MEAN(a)]* [b-MEAN(b)]
	-0.0094	-0.0053	0.00008791	0.00002851	0.00005006
	0.0448	0.0277	0.00200897	0.00076687	0.00124122
	0.0164	0.0214	0.00026757	0.00045890	0.00035041
	-0.0155	-0.0085	0.00024179	0.00007227	0.00013219
	-0.0601	-0.0398	0.00361311	0.00158317	0.00239168
	0.0239	0.0045	0.00056910	0.00002039	0.00010772
			0.0067884441	0.0029301048	0.004273283
			0.0000		
			0.0045		
Sample Correlation			0.958		

Regression Output:		
Constant		0.7399122858
Std Err of Y Est		0.012741684
R Squared		0.9710045295
No. of Observations		7
Degrees of Freedom		5
X Coefficient(s)	0.8098304	
Std Err of Coef.	0.0625840	

Source : International Monetary Fund, International Financial Statistics, various issues.

TABLE 4.4B

EXCHANGE RATE CORRELATIONS

	US$ per Sterling Pound	US$ per Uruguay Peso	Change in Ex. Rate Sterling Pound	Change in Ex. Rate Uruguay Peso
	X	Y	a=dX	b=dY
23-Sep-87	1.6365	0.0041		
21-Oct-87	1.6536	0.0039	0.0104	-0.0419
18-Nov-87	1.7605	0.0038	0.0646	-0.0155
16-Dec-87	1.8242	0.0037	0.0362	-0.0456
13-Jan-88	1.8320	0.0035	0.0043	-0.0379
10-Feb-88	1.7582	0.0034	-0.0403	-0.0405
09-Mar-88	1.8350	0.0033	0.0437	-0.0358
Sample Mean	1.7571	0.0037	0.0198	-0.0362

a-MEAN(a)	b-MEAN(b)	[a-MEAN(a)]2	[b-MEAN(b)]2	[a-MEAN(a)]* [b-MEAN(b)]
-0.0094	-0.0057	0.00008791	0.00003217	0.00005318
0.0448	0.0207	0.00200897	0.00042718	0.00092638
0.0164	-0.0094	0.00026757	0.00008771	-0.00015319
-0.0155	-0.0017	0.00024179	0.00000274	0.00002573
-0.0601	-0.0043	0.00361311	0.00001886	0.00026106
0.0239	0.0004	0.00056910	0.00000013	0.00000875
		0.0067884441	0.0005687937	0.0011219146
		0.0000		
		0.0020		
Sample Correlation		0.571		

Regression Output:

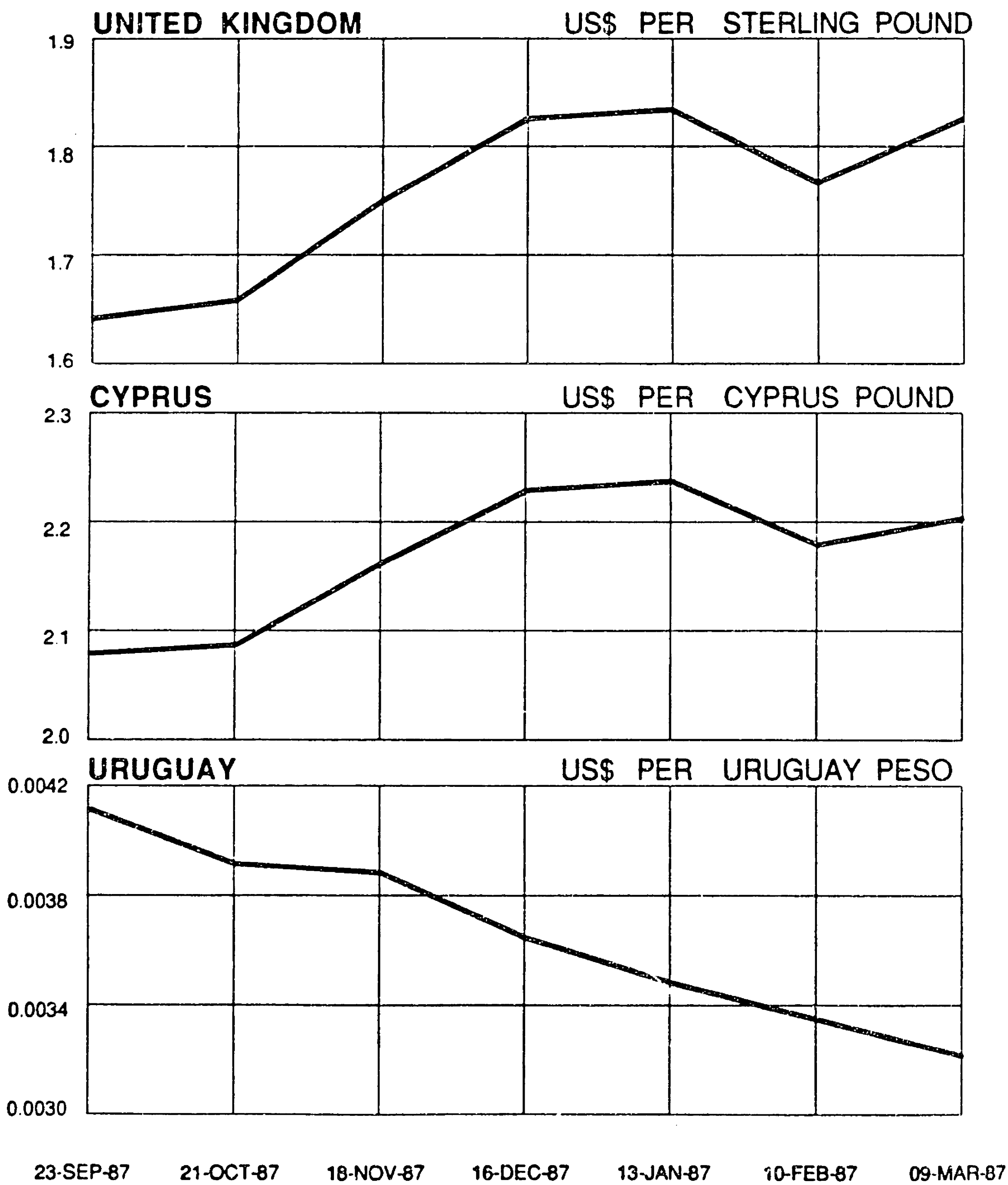
Constant	0.0085194451
Std Err of Y Est	0.0001965418
R Squared	0.6215366821
No. of Observations	7
Degrees of Freedom	5

X Coefficient(s)	-0.002766
Std Err of Coef.	0.0009653

Source : International Monetary Fund, International Financial Statistics, various issues.

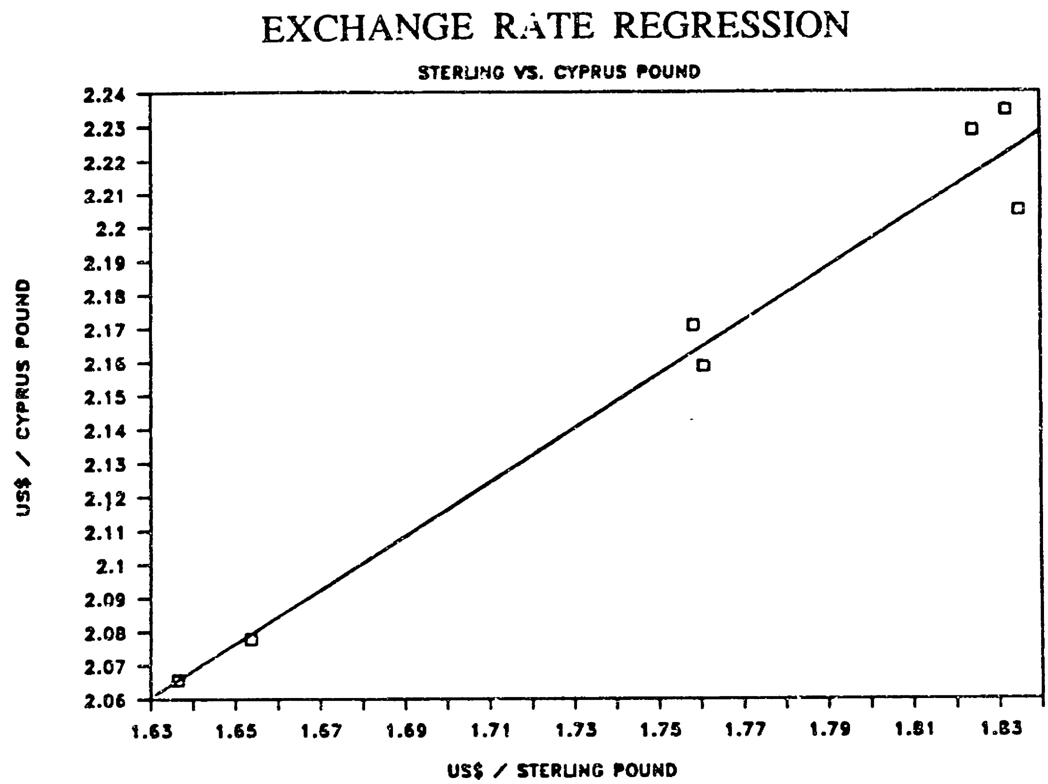
FIGURE 4.4A

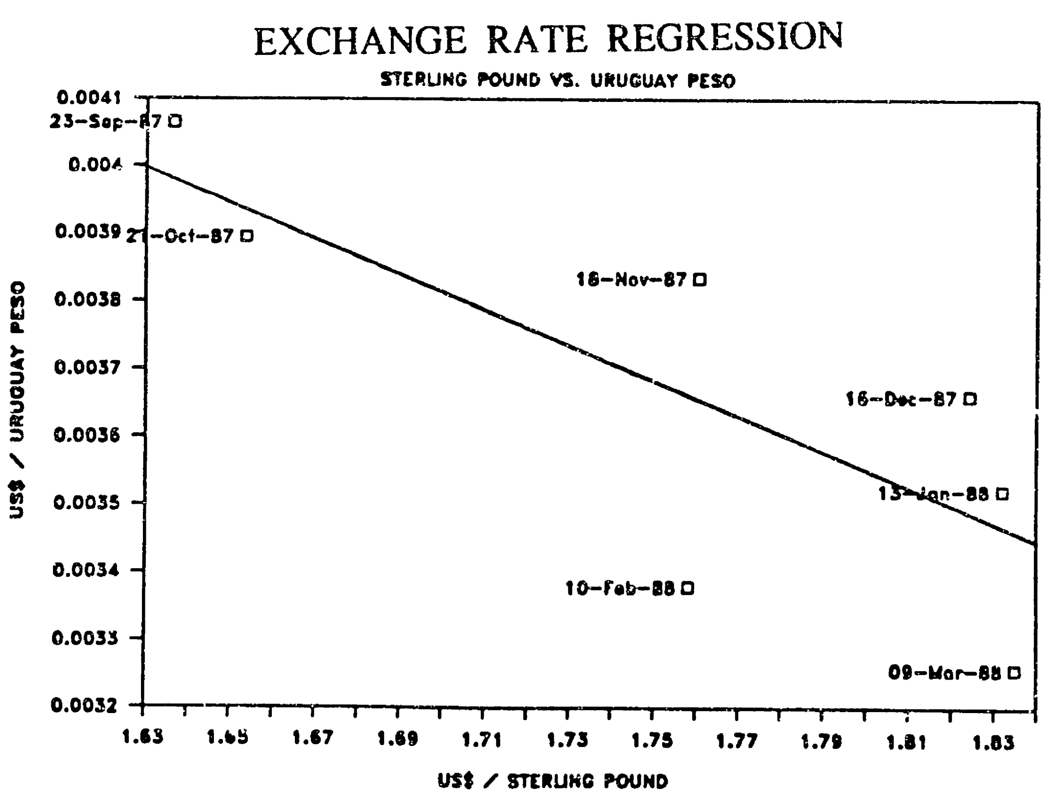
EXCHANGE RATE CORRELATIONS



Source : International Monetary Fund, International Financial Statistics, various issues.

FIGURE 4.4B


EXCHANGE RATE REGRESSION
STERLING VS. CYPRUS POUND
US$ / CYPRUS POUND
2.24
2.23
2.22
2.21
2.2
2.19
2.18
2.17
2.16
2.15
2.14
2.13
2.12
2.11
2.1
2.09
2.08
2.07
2.06
1.63
1.65
1.67
1.69
1.71
1.73
1.75
1.77
1.79
1.81
1.83
US$ / STERLING POUND


EXCHANGE RATE REGRESSION
STERLING POUND VS. URUGUAY PESO
US$ / URUGUAY PESO
0.0041
0.004
0.0039
0.0038
0.0037
0.0036
0.0035
0.0034
0.0033
0.0032
23-Sep-87
21-Oct-87
16-Nov-87
16-Dec-87
13-Jan-88
10-Feb-88
09-Mar-88
1.63
1.65
1.67
1.69
1.71
1.73
1.75
1.77
1.79
1.81
1.83
US$ / STERLING POUND

instruments, may be able to utilize instruments of highly positively correlated and widely traded currencies.

For example, such can be the case of revenue exposure in the Cypriot pound, for which there are not standard hedge instruments in the international financial markets. However, given its proxy relationship to the pound sterling, a contractor can insure itself using hedging instruments of the pound sterling. Similar approaches can be used with a wide variety of African country currencies pegged to the French franc, as the International Monetary Fund's information of table 4.3 implies.

4.4 International Construction Project Valuation Models

The current thesis makes a strong argument for understanding and measuring a contrac or's operational and noncontractual aspects of its projects and business, in order to make better project selection and foreign exchange exposure management decisions. Such decisions are formally supported by project value measures. Therefore, whether faced with a decision to bid or not bid a project, evaluating the worth of on-going projects, or assessing the value of foreign exchange hedging alternatives, the international contractor needs project value measures that explicitly account for exchange rate factors.

The present section discusses the applicability of project valuation models for supporting project selection and foreign exchange risk management decisions in projects with multiple currencies. Specifically, it shows how the expected value and risk of operational and financial hedging alternatives can be transparently factored in project valuation models. The discussion evolves around the :

(a) applicability of traditional discounted cash flow (DCF) techniques, including risk-adjustment discounted cash flow methodologies, for valuing construction projects;

(b) risk-adjustment of construction project discount rates and cash flows in home and foreign currencies; and

(c) separation of contractual from noncontractual cash flows using the Valuation by Components (VC) framework for international construction projects.

4.4.1 Project Valuation Methodologies

Among the various project evaluation methods , present value based discounted cash flow methodologies provide the most accurate measures of project value in international construction. The discounted cash flow methodologies adopted here are appropriate extensions of the Net Present Value (NPV) technique. The theoretical correctness and overall superiority of the Net Present Value approach vis a vis other techniques of project evaluation (such as the Internal Rate of Return, Profitability Index and Payback Period) have been sufficiently established in the finance literature (Brealey and Myers, 1988). The NPV of a project is:

$$NPV = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t},$$

where CF_t is the expected after tax cash flows of the project at time t and r a discount rate reflecting the associated risks.

The NPV rule assumes that the project selection and contractor's financing decisions do not interact and treats projects as if they were all-equity financed. What matters are the after-tax cash flows of the project, their timing and the required rate of return (discount rate). The NPV rule is consistent with the value additivity principle, which, applied to construction, states that the value of the firm is equal to the sum of the value of the firm's projects and other assets (Brealey and Myers, 1988).

Cash flows are estimated and valued on an incremental basis: only future cash flows are relevant. As already discussed in previous sections (see 4.1), in international construction, the accurate projection of future cash flows depends on the maintenance of reliable multicurrency earned project value information, regarding the cost and schedule performance of the contractor. The value and risk of future project cash flows is the only relevant measure of a project's contribution to the return-risk profile of existing project portfolio, whose analysis is critical in the selection of new projects. By contrast, sunken costs, including foreign exchange losses from past exposures, are irrecoverable and, therefore, irrelevant to the NPV computation.

System effects, such as corporate tax benefits, and the impact from project related working capital requirements and the borrowing method used are taken into account. Similarly, opportunity costs and allocated corporate overhead costs in home currency are included in the NPV computation. Equipment and plant depreciation is not a cash flow, but it has to be considered for the nominal tax shields that it generates, due to the substantial investment in it, especially in heavy construction projects.

The correct use of the NPV rule requires that cash flows be treated consistently for inflation: nominal cash flows should be discounted at nominal discount rates, while real cash flows should be discounted using real discount rates. Inflation rates can be extrapolated from construction cost index trends by project type. Engineering News Record and the Construction Review provide extensive historical U.S. construction cost data using a variety of industry and project type specific indexes. Similar construction related cost indexes can be available for other countries in annual industry reports published by ministries of national economy.

The Rationale for an Adjusted Present Value (APV) Approach

The lack of interaction between the investment and financing decisions assumed in the NPV rule is consistent with an ideal Modigliani-Miller (MM) world: the decision on how to spend funds should not be affected by the way these funds are raised. In practice, the relatively low profit margins of international construction makes the potential impact of construction financing transactions, including foreign exchange hedging alternatives, important to analyze. The impact of such transactions on project value affects the present value of costs and, therefore, the contractor's ability to compete. It also affects its decision to hedge or not hedge an exposure in an on-going project. Therefore, if we want to be more accurate in project evaluation, we have to consider the contribution of financing and hedging choices to project value.

For example, a U.S. contractor using bank overdraft facilities or issuing stock to raise capital has financing costs that are likely to be different from a foreign contractor financed with subsidized government loans. Similarly, the choice of financial hedge instruments, or the availability of government insurance facilities will affect the project value to the contractor. Such different costs of financing have differential impact on the contractor' present value of future costs, its ability to compete and its real profitability.

In addition, a contractor's commitment to a new project increases the present value of its assets and, assuming for simplicity a fixed target debt/equity ratio policy, it increases the debt capacity of the firm. But the increase in the debt capacity of the firm results in tax shields that have some value, because interest is tax deductible. The value of the tax shields is a function of the corporate and stockholder personal tax rates. In this case, the contractor's bid or other international investment decision affects the financing decision which in turn affects the investment decision in a circular fashion.

Following these observations, a modified version of the NPV methodology is required to account for the contractor's financing decisions. The Adjusted Present Value (APV) approach modifies the NPV by considering two groups of cash flows. One that accounts for the operating, base case project cash flows and another that incorporates the side effects of the financing decision:

APV = NPV(base case project) +

+ NPV(financing decision side effects)

(Brealey and Myers, 1988, ch. 19)

Based on this definition of the APV, its computation starts with the standard present value computation discussed in the NPV section, assuming the project is all equity financed. The second step is to compute the present value of the side effects of the contractor's financing decision. The project cash flows are discounted at rates appropriate for their riskiness. For example, a subsidized loan's cash flows should be discounted at the unsubsidized loan's market interest rate, because that is the true opportunity cost of the funds, while the base case cash flows would be discounted at the return rate of cash flows with equal risk. This results in higher project value for the subsidized contractor.

Discount Rate Adjustment Techniques

The drawback of the APV approach for some managers is that it requires a clear and disciplined identification and evaluation of the financing and hedging decision side effects, which is not easy. For this reason, firms often prefer to only adjust the discount rate and otherwise follow the standard NPV methodology. For the purpose of providing a more thorough overview of alternative to standard NPV discounted cash flow methodologies, we now summarize adjusted discount rate and weighted average cost approaches.

The previously introduced APV methodology can be summarized as follows:

APV = f[r of base case NPV, and r_1, r_2,..of financing side effects],

where

r = return on assets with same risk (opp.cost of capital), and

r_1,r_2,...= appropriate discount rates for financing side effects terms.

The adjusted discount rate formulation can be summarized as follows:

NPV = Base Case NPV(r^*),

where r^* is an adjusted discount rate that incorporates the opportunity cost of capital and the financing side effects. The simplification accomplished is the incorporation of a single discount rate in the base case NPV computation and the abandonment of cash flow terms for the financing side effects.

The adjusted discount rate can be computed as the minimum acceptable internal rate of return corresponding to a perpetual annual income (perpetuity) that results in a base case NPV equal to the present value of the operating cash flows, plus the tax shields of the project. The methodology assumes that all projects generate the same perpetual debt capacity, that they all have perpetual annuity type of cash flows, that the only financing side effect is the tax shields generated and that the tax rate is constant in perpetuity.

An adjusted discount rate often used is the Modigliani-Miller (MM) formula):

$r^* = r(1-T^* * L)$

where r is the opportunity cost of capital (all-equity rate), T^* is the effective (net) tax rate (i.e., a tax rate that incorporates the corporate tax rate and the bondholders'/stockholders' tax rates). -d L is the project's marginal debt contribution ratio. A generalized version of the formula can be used for different project types:

$$r^*_i = r_i(1-T^* * L_i),$$

where i relates to a specific project. r_i reflects the project's risk and Li the marginal contribution of the project to the firm's debt capacity.

To be considered "similar", a project has to be a perpetuity, in the same risk class, have the same debt capacity and face same tax rules. At first look, these assumptions seem too restrictive for construction. In particular, the perpetuity assumption is not consistent with the nature of construction projects with their relatively short duration. The MM formula can be relatively reliable in simple, normal projects, especially after considering other uncertainties in the present value computation, like the accuracy of cash flow estimates. However, the error can be large for complex and/or international projects with complicated and/or subsidized financing.

The weakest element of the adjusted discount rate formulae is the assumption that the only financing side effects are those of tax shields generated from the financing decision. In practice, the financing decision may have other side effects, such as the costs of stock issue, or changes in dividend policies resulting from the contractor receiving subsidized financing.

A simplified and more widely used approach proposes a weighted average cost of capital (WACC) formula. Under this methodology, a project is acceptable if it can pay the after-tax debt used to finance it and generate a better return on the equity invested. The formula is:

$$r^* = r_D\ (1-T_C)\ \frac{D}{V} + r_E * \frac{E}{V}$$

where

r_D	:	firm's current borrowing rate,
r_E	:	expected return on firm's levered equity
D	:	market value of firm's debt
E	:	market value of firm's equity
V	:	the total value of the firm = D+E
T_C	:	corporate (not the effective T*) tax rate

The advantage of this formula is its ease of computation with data from the stock market and its use of the base case project operating cash flows of the NPV evaluation. One major drawback is the assumption that the project's risks are the same as the firm's average risks. This extrapolation is theoretically inaccurate and leads to incorrect evaluations. If a construction firm enters a contract with different than its existing project profile, this is not reflected in the computation. In addition, this computation will always bias against less than average risky projects.

As with adjusted discount rates, the WACC avoids estimating the impact of financing decisions on the project's cash flow profile. It is based on the same with MM assumptions about the perpetuity of cash flows, the risk class, the debt capacity and tax rules. Conceptually, it is more inappropriate than the adjusted discount rate approaches, as it is based on historical information which may be irrelevant to new project types in new countries and currencies. Finally, it bases the cost of capital on sources of funds, rather than the risks in the use of funds.

4.4.2 Discounting Foreign Currency Construction Cash Flows

In a single-currency environment a project's single-period riskless cash flows are evaluated with present value discounted cash flow formulae:

$$PV(CF_t) = CF_t/(1+r)^t$$

where CF_t is the after tax cash flows of the project and r a discount rate reflecting the opportunity cost of capital, derived from tradeoffs between current and future consumption, and thus representing the equilibrium between savings and investment. In international projects we need to consider how the multiple currencies of denomination, country, political and exchange risks, and different tax regimes affect the cash flows and discount rates applied.

In previous sections of this dissertation, the necessity for translating foreign currency cash flows focused primarily around the issue of foreign exposure analysis and measurement, and secondarily on the contractor's reporting requirements. In this section we discuss the translation process as it affects project valuation and investment analysis. In Lessard, Flood and Paddock's (1986) definitions, cash flows are:

(a) Expressed in a currency, when they are translated to that currency using current exchange rates . Such translation is typical during the pre-bid estimating phase.

(b) Denominated in a currency, when they are contractually specified in the currency. In construction, revenue or costs in fixed-price contracts can be said to be denominated in the stated currency.

(c) Settled in a currency, when a relevant transaction, such as the actual owner's payment or payment to a subcontractor, actually takes place in the currency.

(d) Determined in a currency, when market forces linked to the country of the currency affect the cash flows. This definition refers to such items as noncontractual costs that fluctuate with market trends.

To value a project in base currency, cash flows in multiple currencies, one needs to have (a) cash flow forecasts in these currencies, (b) exchange rate forecasts for the translation, and (c) appropriate discount rates. In most cases of construction firms, cash flows of international projects should be translated in base currency and then discounted to determine present value measures. Alternatively, for wholly owned foreign subsidiaries of construction firms, they can be discounted in foreign currency and then translated to base currency.

Cash Flow and Discount Rate Risk Adjustment

When risky cash flows are considered, the most widely accepted model for risk-adjusting discount rates and valuing them in domestic currency is the Capital Asset Pricing Model (CAPM). Using capital asset pricing theory, in a home currency, single-period cash flow model we have:

$$PV(CF_1) = E(CF_{HC1})/(1+r_{HC}),$$

with $E(CF_{HC1}) = E(e_1 * CF_{FC1})$, with CF_{FC1} the expected cash flow in base currency, and $r_{HC} = r_{fHC} + \beta_{HC} * (r_{mHC} - r_{fHC})$. Subscripts HC and FC imply home and foreign currency respectively, r_f is the nominal risk-free interest rate, r_m is the expected nominal return on market portfolio, and $\beta = \sigma_{CF,m} / \sigma^2_m$ ($\sigma_{CF,m}$ is the covariance between the cash flow and market returns and σ^2_m is the variance of market returns).

The model is applied for cash flows occurring at period t after discounting iteratively using the CAPM for t times. In practice, we can discount using a constant risk-adjusted discount rate:

$$PV(CF_t) = E(CF_t)/(1+r)^t$$

The application of the CAPM in construction project evaluation implies that diversifiable risks should not be reflected in the discount rate, but rather in the value of expected cash flows. For example, diversifiable risks in construction include industry specific risks, such as construction materials and equipment availability, or company specific risks, such as experience in project type and supervision. The beta (β) used to define the discount rate should only reflect market related factors that can not be diversified, such as energy costs.

Therefore, industry and company related risks should be accounted for in the cash flow estimates, discounted at rates consistent with the CAPM. In the case of foreign exchange exposure analysis, operational and financial hedging reduce the covariance of construction cash flows with market trends, i.e., their beta, and, therefore, reduce the discount rate used in the present value computation. As such, they contribute positively to the value of the project, from the contractor's perspective. In addition, they affect the expected cash flow in foreign and home country currency, due to different construction costs, exchange rates and hedge instrument costs.

A reference for estimating the CAPM based discount rate, for a construction project valued in home currency, are the observed betas for a number of public construction firms published by Merrill Lynch ("Security Risk Evaluation"). These betas should be used in the context of the listed firms' volume of work and specialization in project types. In other words, a beta of a building contractor may not be appropriate for the contractor in question or other contractor, when evaluating a heavy construction project.

The international contractor can evaluate the project in foreign currency, using interest parity relationships (IRP). IRP states that interest differentials are on par with differentials between forward and spot exchange rates. To provide the equivalent cash flow valuation, let us refer to foreign currency with FC, home currency with HC, interest rates with I and forward exchange rate with F_0. Then, one unit of FC (i.e., $1 * e_0$ in HC) invested in domestic contractual instruments will return $1 * e_0 * (1+I_{HC})$ in HC. At the same time, one unit of FC invested in foreign contractual instruments will return $1 * (1+I_{FC})$ in FC (i.e., $1 * (1+I_{FC}) * F_0$ in home currency) where F_0 the forward rate. IRP implies that:

$$1 * e_0 * (1+I_{HC}) = 1 * (1+I_{FC}) * F_0 \Rightarrow \frac{F_0}{e_0} = \frac{(1+I_{HC})}{(1+I_{FC})} \Rightarrow$$

$$(1+I_{HC}) = \frac{F_0}{e_0} * (1+I_{FC})$$

The above expression that uses forward rates provides a discounting factor for nominal contractual cash flows. To derive a nominal discounting factor for noncontractual cash flows, the expected spot rate substitutes for the forward rate, and risk-adjusted discount rates for the interest rates:

$$(1+r_{HC}) = \frac{E(e_1)}{e_0} * (1+r_{FC})$$

and the present value is:

$$PV(CF_1) = \frac{E(e_1*CF_{FC1})}{1+r_{HC}} = \frac{e_0 * E(CF_{FC1})}{1+r_{FC}}$$

Discounting Cash Flows in Real Terms when PPP holds

The relevance of real purchasing power of foreign earnings has been sufficiently demonstrated in preceding sections (see section 4.4). The rationalization for evaluating project cash flows in real rather than nominal terms is based on the premise that construction firm shareholders are interested in the purchasing power of future returns and the resulting consumption made possible by them.

The real return of their investment is the change in the real value of their investment, defined as the nominal value adjusted with the use of an appropriate consumption price index. The index should reflect cost of living conditions, and not construction related prices, which are relevant primarily for determining the competitive costs of the construction firm.

For example, if p_0, p_1 are security prices, P_0, P_1 are price indexes, and f is the inflation rate, the real return on an investment is determined by the relationship:

$$r_{real} = [(p_1/P_1)/(p_0/P_0)] - 1 \Rightarrow$$
$$1+r_{real} = [(p_1/P_1)/(p_0/P_0)] = (p_1*P_0)/(p_0*P_1)$$

With $P_1 = (1+f)*P_0$, and $p_1=p_0*(1+r_{nominal})$, we have

$$1+r_{real} = \frac{p_1}{p_0*(1+f)} = 1+\frac{(r_{nominal}-f)}{(1+f)}$$

It can be shown that, when PPP holds, the real return will be the same in base and foreign currencies. Finally, to account for risky cash flows, Black (1972) provided an adaptation of the CAPM that replaces the risk-free rate of return implied in the domestic CAPM with the more realistic zero-beta portfolio in a world where such risk-free rate is not available:

$$r_{CFreal} = r_{zero} + \beta_{CF} * (r_{real,m} - r_{zero}),$$

where

r_{zero} : expected real return on zero-beta portfolio

$r_{real,m}$: expected real return on market portfolio

β_{CF} = covariance(r_{CFreal},$r_{real,m}$)/variance($r_{real,m}$)

Discounting Cash Flows When PPP Does Not Hold

Discounting in real terms can be taken one step further by accounting for departures from PPP. PPP will often not hold across two or more countries for a number of reasons. One factor is the non-tradeability of a variety of products and services. In addition, the price indexes used across countries will be different, as they reflect different consumption patterns (e.g., the weights of consumption bundle items varies). Such differences will affect the required real return, and, therefore, have an impact on the profit requirement and competitiveness of the construction firm.

Construction firms from different countries will have different cost of living indexes to consider and therefore different exposure to deviations from PPP. Even in the same country, different construction firm investors may have different consumption patterns to satisfy. For simplicity, we can assume that the real return on a project or portfolio of projects will only be a function of the construction firm's home country. Project selection decisions to hedge PPP risk will be country specific.

Construction firms can hold a "safety" portfolio of assets which is uncorrelated to real consumption (the equivalent of "risk-free" portfolio of the CAPM), or a "diversified" portfolio of projects that maximizes return for a given level of risk (although it should be stressed that ideally its shareholders could do it themselves). Alternatively, to protect against PPP risk, they may hold a "hedge" portfolio of projects whose profit will offset unexpected changes in the cost of living.

In this context, the required return is derived from the consumption CAPM (Breeden,1979 and Stulz, 1981):

$$r_{CFreal} = r_{zero} + \beta_{CF,c} * (r_p - r_{zero}),$$

where

r_{CFreal} :expected real return on market portfolio

r_{zero} :expected real return on portfolio uncorrelated with real consumption

r_p :real return on reference portfolio with known combination of assets

$b_{CF,c}$= covariance($r_{CFreal,c}$)/ variance ($r_{p,c}$)

where c denotes future consumption.

As in the traditional CAPM formula, the relevant risk is the nondiversifiable or systematic, reflected by the covariance of a project's real return with real consumption.

4.4.3 The Valuation by Components (VC) Model

The review of project valuation methodologies reveals two major conceptual differences between present value and discount rate adjustment approaches. First, the adjusted present value (APV) methodology proposes that the project cash flows be estimated systematically and discounted at appropriate rates for each cash flow. By contrast, the adjusted discount rate and weighted average cost of capital methods propose the aggregation of operational and financing cash flows, and their discounting at a single rate. Secondly, the APV approach proposes the separation of the investment from the financing decision and the inclusion of all financing side effects in the project value. The other methods either oversimplify the computation or limit the financing effects included to the tax shields generated from the project's debt capacity.

Which approach is more appropriate for international construction project valuations and exposure analysis depends on the complexity of the project and on the construction firm's role in the project cycle, including its financing and operation. The more complex the exposure and investment environment, the higher the need for transparency in analyzing the contribution of risk factors to a project's present value. For example, in recent years, international construction firms have been increasingly involved in project financing. Large engineering and construction organizations, such as Bechtel, have developed, acquired or strategically allied with private project finance organizations. A contractor may, for instance, commit to recovering its investment from operating a constructed facility or other market linked activity with revenues and costs in foreign currencies.

Furthermore, when analyzing foreign exchange exposure and hedging opportunities, we need explicit present value measures of the expected shifts in future value of cash flows (factoring results from first order conditions of the preceding economic analysis). If hedging opportunities are evaluated, the costs associated with them and the benefits on the variability of exposed cash flows need to be valued.

In such environments, the APV approach is more appropriate. The method, modified and extended to the valuation by components (VC) model covers those aspects of economic exposure and contractor's financing that characterize international projects. VC goes beyond the separation of investment and financing decisions. It makes a further distinction between noncontractual and contractual cash flows with explicit recognition of inflation and exchange rate changes. A version of the VC model that can be applied to international construction is the following:

Adjusted Present Value (APV) =

NONCONTRACTUAL OPERATING FLOWS

$$\sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{I_{ti}}{(1+r_1)^t}$$

(a) Capital Outlay,

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{CF_{ti}(1-TX)}{(1+r_2)^t}$$

(b) Remittable After-Tax Operating Flows, such as Noncontractual Constr. Costs and potentially Revenues

CONTRACTUAL FLOWS

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{CONT_{ti}(1-TX)}{(1+r_3)^t}$$

(c1) Contractual Revenue Flows

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{CONT_{ti}(1-TX)}{(1+r_3)^t}$$

(c2) Contractual Cost Flows

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{DEP_{ti}(TX)}{(1+r_4)^t}$$

(d) Equipment, Plant and other Depreciation Tax Shields

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{INT_{ti}(TX)}{(1+r_5)^t}$$

(e) Tax Shields due to Construction Finance and other Normal Borrowing

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{\Delta(INT)_{ti}}{(1+r_6)^t}$$

(f) Financial Subsidies or Penalties

OPERATING FLOWS DEPENDENT ON FIRM'S OVERALL TAX AND CASH FLOW POSITION (SYSTEM EFFECTS)

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{TR_{ti}}{(1+r_7)^t}$$

(g) Tax Reduction or Deferral via Interaffiliate Transfers

$$+ \sum_{i=1}^{N} e_{0i} \sum_{t=0}^{T} \frac{REM_{ti}}{(1+r_8)^t} \qquad \text{(h) Additional Remittances via Interaffiliate Transfers}$$

(Lessard, 1985).

The notation is as follows:

i	:	currency
e_{0i}	:	current spot rate
t	:	time
r_j	:	appropriate discount rate

The VC model components and application are discussed in detail by Lessard and Paddock (1986). The model is applicable to, and innovative for, international construction : it deals with the possible diversity of their cash flows, differentiates contractual from noncontractual cash flows, accounts for the impact of their possible involvement in international project financing and, most important for our research, recognizes the contribution of exchange risk factors to project value.

The first two components (a and b) of the model incorporate the noncontractual exposure often due to unmatched cost/ revenue structures in multiple currencies. The exposure analysis implies that, in traditional construction contracts, term (b) reflects primarily noncontractual cost exposures. However, both terms (a) and (b) may account for cost and revenue related exposures in projects where construction firms decide or are required to take long-term, equity positions in the project's operations. The cash flows accounted for are only those that the contractor can directly or indirectly remit to the parent company.

In recent years, the popular engineering press has often reported cases where construction firms are involved in build and operate projects, countertrade and other contractual schemes exposing them to local and international market trends beyond the narrow engineering/ construction scope of business. Such involvements have become increasingly common and constitute major areas of noncontractual operating exposure.

The second group of terms (c, d, e and f) covers the contractual cash flows, but also treats separately the possible side effects of the contractor's multicurrency financing decision. The separation of terms is more critical in projects with operating exposure and post-construction involvement : the project financing decision affects the value of the project in which the construction firm has an economic interest. Finally, a contractor's foreign exchange or other hedge decision may generate interest tax shields due to the higher than corporate average proportion of debt often used in such hedges.

The last group of terms (g and h) covers the system effects of the project. Whether a construction firm is noncontractually exposed or not, any of its international projects may interact to varying degrees with other projects with system wide effects whose value is part of the project's value. The VC model allows for the explicit treatment of such effects.

The discount rates used reflect the risk premium associated with the systematic (nondiversifiable) risk of the project. Noncontractual cash flows should be discounted at a premium that reflects the systematic risk of the firm and industry in the foreign country. Since the project may be unique for the foreign country, and similar firms or construction activity may not be present, measures of systematic risk (i.e., of beta β) are not likely to be available. Therefore, it may be necessary to analyze the activities in smaller components that may allow for an approximate assessment of the systematic risk.

Contractual cash flows may be discounted at rates close to the riskless debt rate. The risk premium of contractual cash flows should reflect the possibility of default associated with them and can vary across contractual cash flows. For example, a host country may be unable to meet hard currency contractual obligations if its revenue from hard currency exports slows down. This has been reported for some oil producing countries following the decline of their dollar revenue in recent years. Similarly, depreciation tax shields discount rates should reflect the possibility of losing them, or the impact of having to transfer or carry forward or backward.

In conclusion, VC's key advantage is the separate analysis and valuation of cash flows with different exposure and risk profiles. As such, it lends itself to incorporating the results from foreign exchange elasticity measures of preceding chapters, makes transparent the contribution of individual exposures to the project's value and facilitates sensitivity analysis. VC also provides the structure for evaluating the direct and indirect benefits and costs from hedging. The reduced exposure associated with hedging decisions reduces the project's cash flow (due to the costs of hedging) but also reduced variability of exposed cash flows. The reduction in cash flow's systematic variability results in reduced discount rates (lower systematic risk) applied to the exposed cash flows, and therefore, an increase in the project's value. The VC allows for the necessary separation of cash flows by type and for discounting with appropriate discount rates. Finally, the VC provides for the inclusion of interest tax shields and other financial impact of foreign exchange hedging.

Chapter 5 : Case Studies

A number of senior officers of top international construction firms with foreign exchange risk management responsibility were interviewed as part of the research performed for this dissertation. They included the corporate treasurer and controller of a heavy construction firm, the chief financial officer and the treasurer of an energy project construction firm, and the treasurer of a plant construction firm. The case studies summarized in this subsection were provided by the treasurer and controller of the heavy construction contractor.

5.1 Company Description

The company that provided the case studies is the international subsidiary of a large US construction firm that specializes in heavy construction projects. In recent years, the company has experienced substantial gains and losses from exposed positions in foreign currencies. More recently it has enhanced its sophistication in using financial instruments. Although there is no explicit differentiation between operational and financial hedging, some of the company's currency management practices are operational in character.

The foreign exchange management decisions are made by the corporate chief financial officer, the corporate treasurer, and the controller of the international subsidiary. The role of financial managers covers the bid and proposal process, the definition of project risks, exposure management decisions and, finally, project monitoring and control. Foreign exchange risk is one of the multiple risks addressed. Other include political, contractual, operating, taxation, legal and accounting risks. As already stressed, all foreign project risks can impact foreign cash flows directly or indirectly, and, therefore, have an implicit foreign exchange risk component.

Projects undertaken by the contractor include, but are not limited to, US government owned and sponsored military or civilian overseas facilities, as well as US foreign aid financed projects for foreign government owners. As such, these projects often come with input sourcing, currency and operational constraints that characterize government financed and owned projects. Revenues and costs can be in US dollars or mix of US dollars and local currency. The projects are sometimes long in duration, i.e., over three years. The financial managers of the company research the risks of their projects by visiting the foreign country, meeting with sponsoring and local entities, and consulting with bankers.

The importance of currency factors is most clearly communicated in the mission statement of the international subsidiary, which, among other, states that the firm's objective is to:

> "...achieve maximum return on assets by providing quality construction services to government agencies on a worldwide basis, on a bid or negotiated basis with maximum payments in hard currency..."

A "hard" currency is implied to contribute positively to the maximization of the firm's return on assets. The explicit assumption of the statement is that currency factors are critical to the success of the international contractor. It is also presumed that the contractor wants to maximize its cash inflow in hard currency, while cash outflows could be in soft currency.

The statement establishes a major constraint for new business development opportunities, bid proposals and contractual agreement negotiations, by instituting that revenue should be pursued in hard currency. Actually, the statement effectively encourages taking long, exposed positions in hard currency, with the implicit assumption that the value of cash flow in that currency is likely to increase. In an economic sense, such positions can be considered speculative, because even hard currencies can lose value vis a vis other currencies. For example, the US dollar has lost a lot of its value after 1986. This observation reminds of the sometimes ambiguous definition of "strong" and "weak" currencies. In contrast with what may sometimes be conventional wisdom, long positions in "strong" currencies can be risky too, if these currencies are out of purchasing power and interest rate equilibrium. Such currencies may be likely to depreciate, in order for exchange rates to return to equilibrium.

Overall, as this dissertation proposes, the non-speculative contractor should consider matching cash inflows with outflows, rather than take long positions in any currency. However, it is intuitively obvious that long positions in currencies which are likely to retain and increase their value vis a vis home currency are preferable to similar positions in currencies likely to lose value.

5.2 Case Study Discussion

The following cases are discussed with an emphasis towards highlighting the relevance of decisions made with the framework proposed in this dissertation. The cases are summarized in chronological order. As such, they reflect a growth in the company's experiences and policy development regarding the subject. Finally, each case stresses a slightly different approach to dealing with foreign exchange exposure.

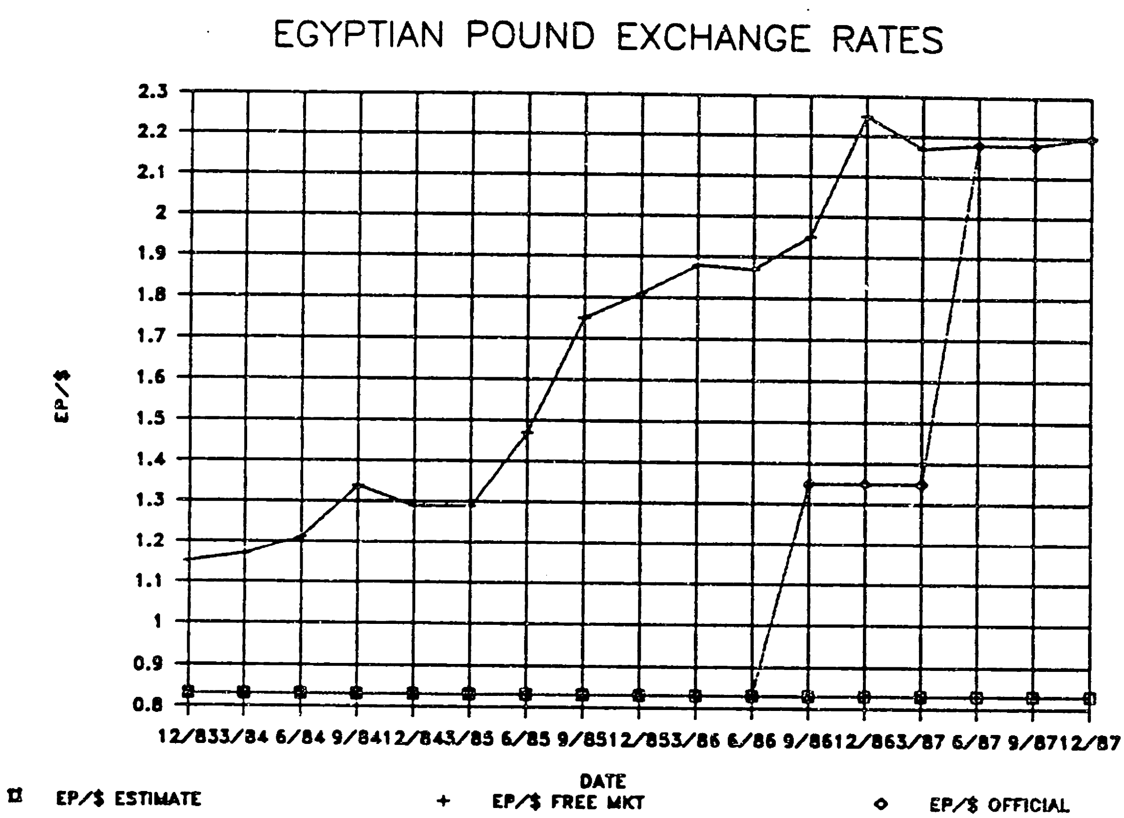
Case 1 : Infrastructure Facilities in Egypt

In October 1983, the company was awarded a contract to build infrastructure facilities for a new community development in Egypt. The contract amount was about $19.5 million denominated in US dollars, with an obligation to source costs from the Egyptian market (i.e., in Egyptian pounds) for the equivalent of $8.0 million. The resulting exposure in US dollars was then as follows:

Revenues		
	US dollars	$19.4
Costs		
	US dollars, about	$10.0
	Egyptian Pounds	$ 8.0

For the most part of the project's duration, there was an official exchange rate that stayed artificially stable (out of market equilibrium) at 0.83 E£/$, until the end of 1986, when it was forced up to 1.35 E£/$. In May 1987, it was allowed to fluctuate in response to market trends up to about 2.20 E£/$. A free ("grey") market rate during the same period was substantially higher than the official rate, and only available for check exchanges (i.e., no cash exchange). The company priced its bid using the official at the time of estimate rate of 0.83 E£/$. However, during construction, it was able to use effectively the free market and thus exchange its dollar denominated revenue for more E£. As a result it recognized substantial exchange rate gains. In addition, the company borrowed about 7.5 million E£ when the official rate was 0.83 E£/$ and was able to repay the debt at the 2.20 E£/$ rate. Figure 5.1 displays the trend in the free and official exchange rates.

FIGURE 5.1



Sources : (1) Wall Street Journal, Various Issues

(2) International Construction Firm Project Records

Table 5.1 describes a possible profile of quarterly cash flow estimates with the corresponding gains from cash flow translation associated with the construction operations and with the loan. The company's actual exchange rate gains were over $10.0 million, compared to the originally projected $1.5 million. The data show that almost 60 percent of the foreign exchange economic gain came from the loan that the contractor arranged at the artificially low official exchange rate of 0.83 E£/$ and then repaid at the equilibrium official rate 2.20 E£/$.

The loan in Egyptian pounds was consistent with the traditional financial hedging strategy of increasing liabilities and/or decreasing assets in currencies likely to depreciate. Based on the International Fisher Effect (Appendix A), if the costs of borrowing reflected the likelihood and extent of the local currency's expected depreciation, the contractor would have protected itself from exchange rate fluctuations, but not have realized the reported gains. However, in this case, the difference between the official and the free market's exchange rates supported expectations substantially different from those reflected by the official interest rates. The net profit made from the loan transactions was equal to the profit generated from financing with it construction activities minus the interest paid for the loan, adjusting for the increased value of the dollar revenues that were used to buy local inputs, and to make the interest and principal payments.

The technique employed by the contractor is part of what Folks (1972) described as "funds adjustment strategy". Other techniques that can be used, given the expected depreciation of the local currency (as the case was for the Egyptian pound in our example) include the reduction of cash levels in local currency; reduction and expedition of local currency receivables; delay of payables in local currency; expedition of translation of local receivables to domestic currency and remittance to the parent

TABLE 5.1

CASE STUDY 1 : INFRASTRUCTURE FACILITIES IN EGYPT

1 PROJECT CASH FLOW

	Year	Mo	Estimate Rate ele	Official Rate elo	Free Market Rate elf	Revenue	Costs US$ estim. =actual	Costs EP estim.	Costs Total estim.	Costs EP' actual	Costs Total actual
1	83	12	0.83	0.83	1.15	1.14	0.50	0.40	0.90	0.29	0.79
2	84	3	0.83	0.83	1.17	1.14	0.50	0.40	0.90	0.28	0.78
3	84	6	0.83	0.83	1.21	1.14	0.50	0.40	0.90	0.27	0.77
4	84	9	0.83	0.83	1.34	1.14	0.50	0.40	0.90	0.25	0.75
5	84	12	0.83	0.83	1.29	1.14	0.50	0.40	0.90	0.26	0.76
6	85	3	0.83	0.83	1.29	1.14	0.50	0.40	0.90	0.26	0.76
7	85	6	0.83	0.83	1.47	1.14	0.67	0.53	1.20	0.30	0.97
8	85	9	0.83	0.83	1.75	1.14	0.67	0.53	1.20	0.25	0.92
9	85	12	0.83	0.83	1.81	1.14	0.67	0.53	1.20	0.24	0.91
10	86	3	0.83	0.83	1.88	1.14	0.67	0.53	1.20	0.24	0.90
11	86	6	0.83	0.83	1.87	1.14	0.67	0.53	1.20	0.24	0.90
12	86	9	0.83	0.83	1.95	1.14	0.67	0.53	1.20	0.23	0.89
13	86	12	0.83	0.83	2.25	1.14	0.67	0.53	1.20	0.20	0.86
14	87	3	0.83	0.83	2.17	1.14	0.67	0.53	1.20	0.20	0.87
15	87	6	0.83	0.83	2.18	1.14	0.67	0.53	1.20	0.20	0.87
16	87	9	0.83	0.83	2.18	1.14	0.50	0.40	0.90	0.15	0.65
17	87	12	0.83	0.83	2.20	1.14	0.50	0.40	0.90	0.15	0.65
Totals						19.40	10.00	8.00	18.00	4.01	14.01

Gains from project cash flow : $3.99

2 DEBT

		Borrow		Repay
Rate	EP/$	0.83	EP/$	2.20
EP Loan	in EP	7.50	in EP	7.50
EP Loan	in $	9.04	in $	3.41

Gains from loan : $5.63

Total Gains : $9.61

company; and selling local currency forward. In all these types of transactions, the contractor has to consider the explicit or implicit costs associated with them. For example, forward contracts have transaction fees and local borrowing has higher interest rates. Similarly, the delay of payables in local currency may harm the contractor's reputation and credit, or simply not be feasible due to contractual obligations towards subcontractors.

The case also highlights the importance of understanding the key foreign exchange economic relationships, predicting government foreign exchange policies and forecasting exchange rate trends, in order to assess the impact on foreign currency cash flows. Such exogenous to the construction firm events can be directly targeted towards the industry, or the result of general macroeconomic policy. In our case, the Egyptian government was aware of the exchange rate disequilibrium and of the artificially high value of the Egyptian pound, but used the "lean against the wind" policy of delaying, rather than resisting, fundamental exchange rate adjustments (Shapiro, 1986). Eventually exchange rates adjusted, and those contractors who understood the trend, structured their costs and revenues properly, and utilized creative funds adjustment techniques not only covered themselves from foreign exchange risk, but also made substantial foreign exchange gains.

Finally, based on the implications from the economic models of chapters 3 and 4, the contractor could have realized even higher gains if it had its local costs fixed in local currency, at the prices prevailing in the beginning of the project. The analysis showed that foreign prices tend to rise when the contractor's domestic currency appreciates vis a vis the foreign currency. The actual free market prices of local construction materials in Egypt rose at an annual rate of about 15 percent, between 1985 and 1986, while the free market exchange rate $e_{\$/E£}$ fell at 24 percent annually. The Egyptian price trends for that period imply an average exchange rate elasticity of prices ($E_{E£} = (dP_{E£}/P_{E£})/(de_{\$/E£}/e_{\$/E£})$) equal to about -0.48, which reflects closely the results of the economic analysis ($-1 \leq E_{E£} \leq 0$, when $(de_{\$/E£}/e_{\$/E£}) \leq 0$).

Case 2 : Military Facilities for the US Navy in Morocco (A)

Early in 1986, the company bid a US Navy sponsored project in Morocco for $25 million. Revenues were to be denominated 100 percent in US dollars, while costs were 60 percent in US dollars and 40 percent in Moroccan dirhams. The company was the second lowest bidder, losing to a competitor whose bid was $19 million. The contract was awarded to the competitor in April 1986. In June 1986, the company was informed that the lowest bidder withdrew and was asked by the US Navy whether it was interested to take the job. The company rushed to accept the project with marginal reevaluation of the bid and of the new expectations about exchange rate movements. True to its mission statement of pursuing revenue in hard currency, and following the extraordinary gains of the Egyptian project, the contractor assumed the long position in US dollars, and the short position in Moroccan dirhams.

Unlike Egypt in the previous case's time frame, there was no parallel free market or possibilities for discounted foreign exchange transactions with other US multinational corporations. In addition, between the beginning of 1986 and July 1986, when the contract was signed, the US dollar had started a slow but steady depreciation against the Moroccan dirham. The loss in the US dollar's value accelerated in the fall of 1986, following multilateral agreements among major industrial country ministers of finance in August 1986, at the initiative of the then US Secretary of Treasury James Baker. The depreciation of the dollar was expected among many market observers, and the US position on the issue was well publicized in the summer of 1986.

Between April 1986 and December 1987, the US dollar depreciated by about 13 percent (table 5.2). The company had the option to financially hedge its exposure with French francs. The Moroccan dirham is loosely linked to the french franc (FF). Figure 5.2 suggests the relationship between the two currencies. The French franc is considered a "proxy" currency of the Moroccan dirham, and as such, its financial hedging instruments can be used to cover Moroccan dirham exposures. For example, the contractor could have bought French francs forward to cover its projected Moroccan dirham payables.. Instead of doing that, it maintained its short position in Moroccan dirhams. There was an optimism implied by statements such as "...now the dollar will turn around...". The dollar did not turn around, and the company lost about $2.5 million from foreign exchange rate changes, thus reducing its before-tax profit from $3.0 million to $0.5 million.

The loss represents a classic failure to manage noncontractual exposure on the cost side of a contract with fixed-price, contractual revenue arrangement. The contractor preferred to effectively speculate by not matching its dirham outflows with dirham inflows, using operational or financial means. For example, it could have entered advance agreements with local subcontractors to make fixed in dollar value payments in dirham at whatever the future dollar/dirham would have been. Or, as indicated above, it could have borrowed forward Moroccan dirhams, or entered French franc forward buy contracts.

The persistence in not dealing with the noncontractual exposure appears to have reflected the mission statement's goal of maximizing revenue in "hard" currency, and the

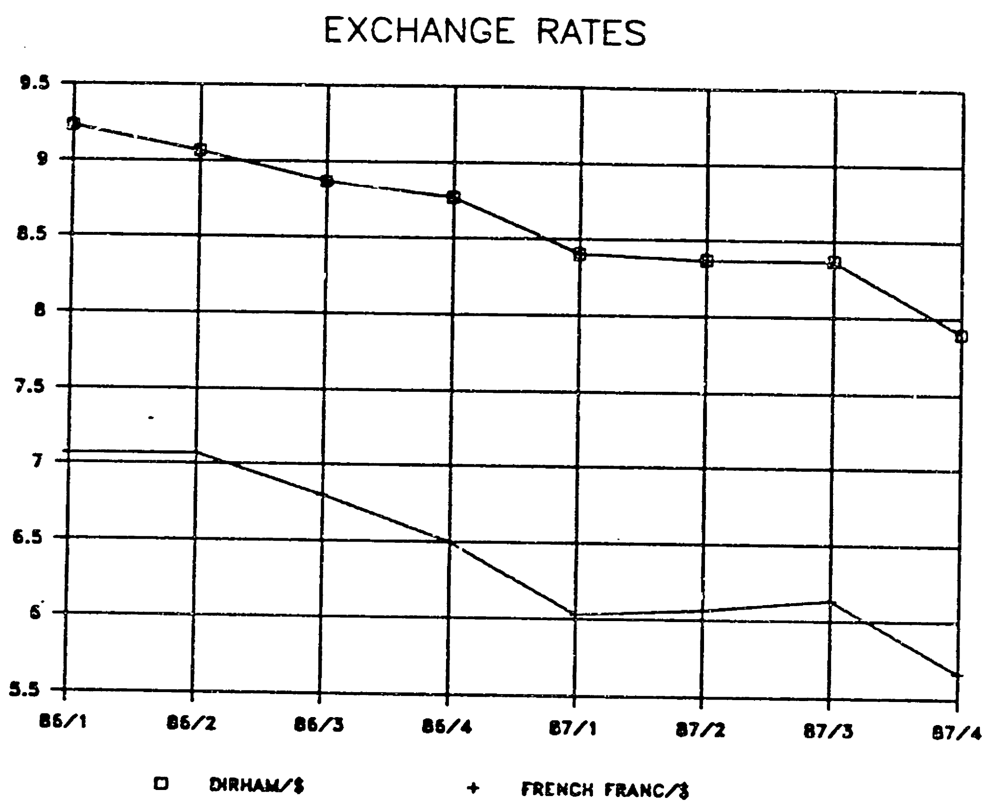
TABLE 5.2

CASE STUDY 2 :EXCHANGE RATES : MOROCCAN DIRHAM/$, FRENCH FRANC/$

Date	Exchange Rate Dirham /$	Exchange Rate French Franc /$	Cumulative Change Dirham /$	Cumulative Change French Franc /$
01/86	9.5	7.3		
02/86	9.1	6.9	-4.2%	-5.5%
03/86	9.1	7.0	-4.2%	-4.1%
04/86	9.0	7.0	-5.3%	-4.1%
05/86	9.1	7.1	-4.2%	-2.7%
06/86	9.1	7.1	-4.2%	-2.7%
07/86	9.0	7.0	-5.3%	-4.1%
08/86	8.8	6.7	-7.4%	-8.2%
09/86	8.8	6.7	-7.4%	-8.2%
10/86	8.8	6.6	-7.4%	-9.6%
11/86	8.8	6.5	-7.4%	-11.0%
12/86	8.7	6.4	-8.4%	-12.3%
01/87	8.4	5.9	-11.6%	-19.2%
02/87	8.4	6.1	-11.6%	-16.4%
03/87	8.4	6.1	-11.6%	-16.4%
04/87	8.4	6.0	-11.6%	-17.8%
05/87	8.3	6.1	-12.6%	-16.4%
06/87	8.4	6.1	-11.6%	-16.4%
07/87	8.4	6.2	-11.6%	-15.1%
08/87	8.4	6.1	-11.6%	-16.4%
09/87	8.3	6.1	-12.6%	-16.4%
10/87	8.0	5.8	-15.8%	-20.5%
11/87	7.9	5.7	-16.8%	-21.9%
12/87	7.8	5.5	-17.9%	-24.7%

Source : Wall Street Journal, various issues

FIGURE 5.2



Source : Wall Street Journal, Various Issues traditional financial hedging strategy of increasing assets in hard currencies. The US dollar has always been considered a hard currency, especially vis a vis less developed country currencies. However, in the context of the project's time frame, the US dollar was artificially strong in real terms, and as such it was likely to depreciate, at least against other freely traded currencies. It did not depreciate substantially, or at all in some cases, against most currencies of weak and protected economies. However, it did depreciate against less developed country currencies which were pegged to strong currencies, or linked to currency baskets with strong currencies, as the Moroccan dirham was.

The case also raises the importance of monitoring and understanding the impact of macroeconomic developments, such as trends in bilateral and multilateral trade, on expectations about, and the determination of, exchange rates. It also suggests the importance of quality forecasting methods in measuring and managing foreign exchange economic exposure. These systems are most critical in fixed or managed float exchange rate systems, where market-based indicators, such as inflation, interest rates and currency forward rates can not incorporate government intervention or other political risk factors.

Case 3 : Military Facilities for the US Navy in Morocco (B)

In 1988, the company was awarded a new contract for US military projects in Morocco. The contract value was about $20 million, with about $6 million of costs in Moroccan dirhams, i.e., the cost structure was about 70 percent in US dollars and 30 percent in Moroccan dirham. At time of the bid the spot rate was 8.4 dirham/$. Therefore, the short position in Moroccan dirham was about 50,400,000.

This time the contractor did not take a speculative position on its exposure. It systematically and almost completely covered its exposure with operational and financial hedging programs. First, it used its leverage to persuade a major earthmoving subcontractor to fix the subcontract amount in dollar terms at bid time. The subcontractor accepted to invoice the company in US dollars although, due to foreign exchange controls, it would be paid in Moroccan dirhams at the prevailing spot rate. The contractor effectively reduced its exposure by the amount of the subcontract.

In addition, the contractor implemented a comprehensive financial hedging program. Given the absence of forward contracts in Moroccan dirham, the contractor exploited the local currency's proxy relationship to the French franc, and purchased forward contracts in French francs, i.e., it cross-hedged its exposure. Table 5.3 lists the contracts. The total amount of costs covered are about 41 million Moroccan dirham, or over 80 percent of the total exposure, with a locked exchange rate of 8.26 dirham/$ that will prevent any substantial losses from a possible depreciation of the US dollar. The profile of cumulative amount of forward contracts resembles the familiar S-curve shape of cumulative construction costs (figure 5.3).

The relevant questions when hedging a contractor's exposure are how much of an exposed position to hedge, and when to hedge it. The completeness of the hedging program in the present case is close to the so-called "naive approach" to covering foreign exchange exposure with financial instruments. In the naive approach, the contractor builds a forward contracts position, such that its dollar value matches the dollar value of the exposed position. A useful measure is the "hedge ratio" h, defined as the ratio between the forward contract value and exposed position:

$$h = \frac{V_{fc}}{V_{ep}}$$

TABLE 5.3

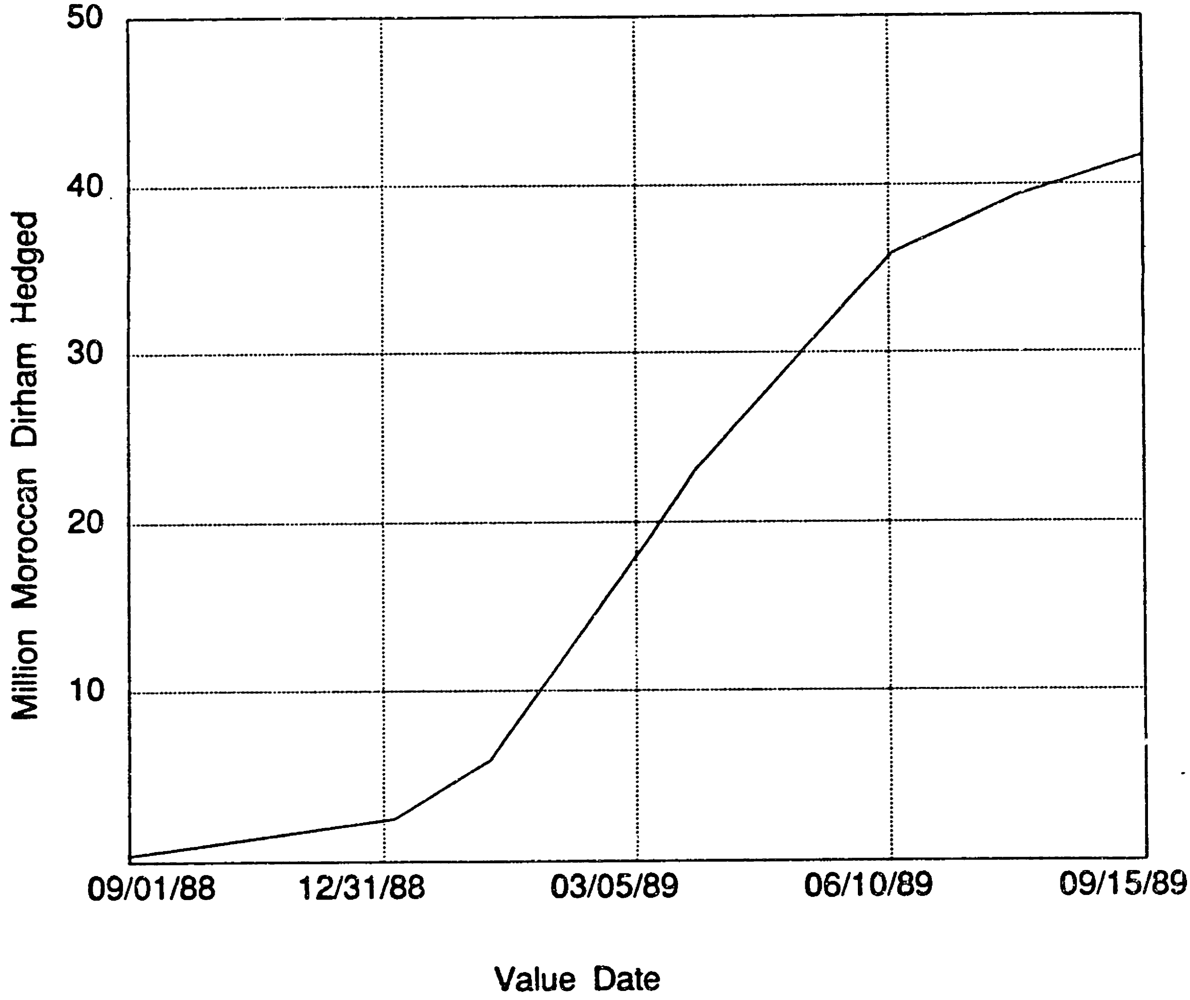
CASE STUDY 3 : FORWARD CONTRACTS IN "PROXY" CURRENCY

Purchase Date	Value Date	US Dollar Amount	French Franc (FF) Amount	Contract FF/$ Rate	Moroccan Dirham (DH) Amount	Implied DH/$ Rate
06-Sep-88	04-Jan-89	300,000	1,880,850	6.2695	2,501,531	8.3384
06-Sep-88	06-Mar-89	700,000	4,388,020	6.2686	5,836,067	8.3372
06-Sep-88	05-Apr-89	800,000	5,012,480	6.2656	6,666,598	8.3332
06-Sep-88	07-Mar-89	700,000	4,384,100	6.2630	5,830,853	8.3298
31-Oct-88	31-Jan-89	500,000	3,030,350	6.0607	4,030,366	8.0607
31-Oct-88	31-Mar-89	500,000	3,028,650	6.0573	4,028,105	8.0562
31-Oct-88	28-Apr-89	500,000	3,027,900	6.0558	4,027,107	8.0542
18-Jan-89	15-Jun-89	300,000	1,888,890	6.2963	2,512,224	8.3741
18-Jan-89	15-Aug-89	400,000	2,514,600	6.2865	3,344,418	8.3610
18-Jan-89	15-Sep-89	300,000	1,884,510	6.2817	2,506,398	8.3547
		5,000,000	31,040,350		41,283,667	8.2567

Source : International Construction Firm Project Records

FIGURE 5.3

CASE STUDY 3 : CUMULATIVE FORWARD HEDGING CONTRACTS



Source : International Construction Firm Project Records where V_{fc} is the home currency value of forward contracts, and V_{ep} is the home currency value of exposed costs. The hedge ratio in naive approach is close to 1. In the discussed project, given the approximate value of total exposed costs of about $6 million, and the fact that some of this exposure was covered with operational means, such as the fixed in dollar terms subcontracting of earthwork, the $5 million dollar value of forward contracts corresponds to a hedge ratio of over 0.83 (h = $5.0/$6.0).

Because of risks associated with cross hedging (covering Moroccan dirham exposures with forward contracts in French francs) and with differences between forward contract rates and future spot rates ("basis risk"), even the most comprehensive program can not provide perfect hedge in this and similar projects. An alternative to hedging the dollar value of costs would be to search for the hedge ratio that minimizes its variance, using "minimum variance" approaches described by Solnik (1988). Solnik concludes with simple calculus that, in the case of asset portfolio hedging, the optimal hedge ratio is equal to the covariance of asset (in our case cash flow) return with the return on the forward contracts, divided by the variance of return on the forward contracts. The contractor's risk-minimization objective requires that the minimum variance strategy be applied to changes of exposed costs in foreign currency. In other words, an appropriate for the international contractor hedge ratio would be:

$$h = \frac{\sigma_{cf}}{\sigma_f^2}$$

where σ_{cf} is the covariance between the contractor's exposed costs and forward contracts value, and σ_f^2 the variance of forward contracts value.

The optimal timing of financial hedge decisions has been analyzed with decision analysis models proposed by a number of authors (see Folks, 1972; Shapiro et al., 1974;

Wheelwright, 1975), although such models have not been discussed in the construction management literature. The fundamental decision is whether to hedge at the time of analysis, or wait until the next time period to reevaluate one's exposure. In international construction, this decision can be made with the combination of updated exposure profiles, which are dynamically linked to the construction schedule, with foreign exchange rate forecasts.

In the present case, the contractor's treasurer decided to enter substantial amounts of forward contracts before the 1988 US presidential election, relying on forecasts that the US dollar would depreciate after the election. Instead, the US dollar appreciated, resulting in reduced amounts in Moroccan dirhams for these contracts (table 5.3). Some managers voiced the opinion that the treasurer should not have entered the October 31 contracts, when the dollar value was at its lowest. The treasurer reminded them of the substantial currency losses in the project of case (2) and the consensus was not to take chances this time. The capital market theory implies that what matters is the risk aversion of the market and not the personal utility of the treasurer. However, at least in this case, the treasurer's risk aversion reflected the overall consensus of the firm regarding risk, and not just the idiosyncrasies of the treasurer.

Case 4 : US Department of State Facilities in Cyprus

The final case illustrates the foreign exchange problems that can arise from long time intervals between bid and award dates. In October 1987, following local visits and extensive research, the contractor submitted a bid for a building construction project of the US Department of State in Cyprus. The bid was $21 million for a two-year project, with 100 percent revenue in US dollars and $8.1 million local inputs priced in Cypriot pounds (C£). Following negotiations, a "best and final offer" was to be made on 12/15/87. The project was scheduled for award on 2/15/88.

In addition to researching the behavior of the Cypriot pound, the contractor also considered the exchange rate trends between the Sterling pound and the US dollar. The Cypriot £ has traditionally had a high positive correlation with the Sterling £, as figure 4.4 of the preceding chapter suggests. Therefore, the Sterling £ is a good currency for cross hedging Cypriot £ exposure. Of course, past positive correlations between currencies are by no means guarantee of similar correlation in the future, and there is an associated cross hedging risk. At the time of the bid, on 10/20/87, the exchange rates were 2.07 $/C£ and 1.67 $$/S£. On 12/8/87 the exchange rates had changed to 2.20 $/C£ and 1.80 $/S£. It was clear that the costs were increasing in US dollar terms. The company had the alternatives to bid using spot rates, covering its exposure between bid and award date with financial hedges, or price the bid at higher $/C£.

As with any construction bid, the construction firm claimed a sum in a currency, US dollars in this case, to be paid progressively with the completion of the project, and assumed an exposure associated with the input sourcing commitment. The claim was contingent on acceptance of the proposal by the owner of the project, who in this case was the Department of State. The uncertainty would be resolved on 2/15/88, date of the contract award. Exposures from contingent claims, when foreign jobs are bid and prices and revenues are fixed in multiple currencies, are best managed with contingent currency instruments, such as currency options (Agmon et al., 1983). The usefulness of currency options, when uncertain cash flows are involved, was also proposed by Giddy (1983), in a discussion of the merits of major hedging instruments. Forward contracts are considered more appropriate in fixed cash flow situations.

Following consultation with its bankers, the contractor evaluated the merits of currency option hedging, to cover itself from further deterioration of the dollar value. The following chronology provides the context of the decision for covering about 4,500,000 Sterling £ with option contracts expiring on 2/20/88.

```
Tuesday, 12/8/87
     Spot Rate  1.8050
     Option Strike Prices          Cost
                1.80              $200,000
                1.81              $165,000
                1.82              $135,000
                1.83              $100,000
     Company postpones decision

Thursday, 12/10/87
     Event : Unfavorable for US economy and dollar trade
             figures released.

Friday, 12/11/87
     Spot Rate  1.8350
     Option Strike Prices          Cost
                1.83              $200,000
                1.84              $165,000
                1.85              $135,000
                1.86              $100,000
```

The comparison of the data shows an effective doubling of the option contract price in two days, after a depreciation of the US dollar, and following the release of trade figures. The company decided not to enter the contract, but rather price its bid using an exchange rate of 1.94 $/Sterling £. The bid was adjusted from $21 to $22.5 million. Unfortunately for it, the job was lost to another bidder, perhaps partly due to the higher price proposed.

In brief, when bidding a foreign job, international contractors are faced with two currency problems. First, they have to estimate costs in multiple currencies and assume an exposure when pricing in a given currency. Second, they have to handle the exchange risk between bid and award date. Solving the second problem can help with the first, as the contractor will tend to price higher when he has exposed currency positions. The case demonstrates the suitability of currency options in dealing with the second problem, and the impact of time on exchange rates on financial instrument costs, and, therefore, on the hedge decision. It also highlights once more the effectiveness of cross-hedging exposures in currencies for which hedge instruments are not available.

5.3 Conclusions from the Case Studies

The case studies highlight the volatility of international construction project cash flows and profits, due to unmatched exposures in multiple currencies. The exposures often reflect contractual obligations towards the sponsors and owners. All reviewed projects had local sourcing requirements between 30 and 50 percent of the total construction costs. Given that, the contractor's ability to understand the rules of, and network itself in, the local construction and financial markets, were critical in managing its exposure.

The cases outline a variety of currency exposure management methods, primarily with financial hedging instruments. However, some of the techniques used reflect an implicit objective to operationally cover its exposure. For example, the use of the company's leverage to negotiate fixed in home or local currency prices from foreign subcontractors, is consistent with the emphasis of this thesis on reducing currency exposure operationally, before resorting to financial hedges. Following the exhaustion of operational techniques, systematic financial hedging can reduce, perhaps substantially, the potential of foreign exchange losses. At the same time, however, the contractor gives up any potential gains that could result from exchange rate movements in the opposite than feared direction.

The contractor's foreign exchange management decisions in recent projects (cases 3 and 4) resulted from a corporate consensus against taking positions in currencies and speculating on the movement of exchange rates. The consensus developed after observing the volatility of profits in both directions, following exchange rate changes in the time frame of projects 1 and 2.. Although the company's shareholders could manage the exposure for themselves, it is clear that the company had more information about the project cash flow and exposure profiles, and the correlation among its project and other investments, in order to make better hedge decisions. Furthermore, only the contractor has the project information to make operationally hedging decisions, before even considering hedging in the financial markets. Therefore, it is appropriate that financial managers be responsible for the impact of foreign exchange rates on the firm's financial performance.

The discussion of the cases reveals an emphasis on the translation impact of exchange rate changes, and not much focus on the response of noncontractual construction costs to them. The limited available data on construction costs for the time frame of case 1 shows how the contractor could have realized even higher gains, had it fixed its local construction costs in local currency terms. This underscores the economic significance of understanding and measuring the sensitivity of noncontractual costs, using the results of foreign exchange elasticity analysis, like those discussed in chapters 3 and 4 of this dissertation.

The cases also demonstrate the need to clarify beyond abstract statements the definitions of hard, or strong, and soft, or weak, currencies, with a focus towards the likelihood of their depreciation or appreciation in the future, and the impact on exposed positions. An artificially strong currency may be likely to depreciate, as exchange rates are allowed to move towards equilibrium purchasing power and interest parity relationships. They also underline the criticality of managing one's exposure, not only during the construction process, but also between the bid and award date. Finally, the cases emphasize the importance of being able to understand the potential impact of macroeconomic developments, such as trends in the balance of trade, on exchange rates, foreign currency costs and, therefore, on the international contractor's exposure and hedge decisions.

Chapter 6 : Conclusions and Recommendations

The objective of this dissertation was to provide a conceptual and analytic framework for understanding and analyzing the economic and competitive aspects of foreign exchange exposure in international construction. The central argument developed is that fluctuating nominal and real exchange rates present the industry with major challenges across the cost, time, quality and coordination elements of international projects, and require contractors to increasingly globalize their operations, in order to manage more effectively their foreign exchange exposure in the short run, and strengthen their competitive position in the long run. The globalization of construction operations provides opportunities for operational hedging in the areas of production, marketing and financial management, as an alternative to financial hedging approach. It is also shown that deviations from purchasing power parity conditions can provide substantial competitive advantage or disadvantage to the construction industry, with the potential for serious positive or negative long term impact on international contractors' market share. The conclusions and recommendations for further research are summarized in this chapter.

6.1 Conclusions

The expression, denomination, settlement and determination of costs and revenues in multiple currencies add a new dimension to the traditionally risky and uncertain nature of materials, labor, capital equipment and financing costs of construction projects. The currency dimension compounds the forecasting needs in construction estimating, results in exposure with potential for gains or losses in home currency, due to unmatched currency positions, and requires more complex cost planning and monitoring systems.

The accounting aspects of foreign exchange translation required for financial reporting purposes are straightforward, although sometimes complex in application. The thesis emphasizes that translation measures of gains or losses do not accurately reflect a contractor's economic exposure and competitive position, as a function of exchange rates. As we saw, the absolute (in terms of dollar value), as well as relative (in terms of financial performance ratios) impact of currency translation on a contractor's financial statements can vary, depending on the accounting assumptions made. Financial statements focus on reporting historical information about the contractor's performance and provide little information about the present value of future cash flows. The economic exposure, due to foreign exchange factors, of an international contractor can be more or less serious than financial statements may actually imply.

Foreign exchange economic exposure can be defined as the home currency based present value of long or short positions in foreign currencies. In other words, it is the result of unmatched cash flow positions in foreign currencies. The exposure is often induced by an owner's and/or sponsor's cost and revenue structure requirements in currencies of the owner's and/or sponsor's preference. Such requirements typically reflect the desire to utilize local resources, as far as the project owner is concerned, or a commitment to procure from a contractor's home country, when the home country finances the project. Finally, it can also be induced by the contractor's ability and desire to choose the currency of denomination for its costs and revenues.

In most projects, the international contractor makes fixed price contractual commitments to project owners. By contrast, at the time of making such commitments, it rarely has its costs contractually fixed. Unlike other manufacturing industries, actual costs follow the pricing of the product. In international construction, this translates to large economic exposures that we also characterized as noncontractual, implying that the nominal value of future foreign currency cash flows will be fluctuate with risky and uncertain market conditions. Traditional foreign exchange analysis approaches place most of the emphasis on exchange rate changes and their impact on translating projected cash flows, without an explicit distinction between, and separate treatment of, contractual and noncontractual cash flows. The current thesis places equal emphasis on the volatility of noncontractual, foreign currency cash flows and analyzes the origin, magnitude and implications of such noncontractual exposure as they relate to the competitive industry structures facing the international contractor.

International contractors often use traditional financial hedging techniques, in order to cover their accounting exposure and reduce the variability of home currency cash flows from exchange rate changes. The objective is to increase assets and decrease liabilities in currencies likely to appreciate, while decreasing assets and increasing liabilities in currencies likely to depreciate. Financial hedging instruments can be utilized selectively and using decision analysis criteria, including optimal hedge criteria. They provide relatively short-term benefits and primarily with widely traded currencies and in countries where the financial hedging instruments are cost-effectively available. Construction's unique features, including the longer term fixed contractual obligations, lumpiness and nondivisibility of projects, and focus of operations in LDCs rather than industrial countries, demand additional, other than just financial hedging approaches.

The key proposition of the current dissertation is that the effective management of foreign exchange exposure in international construction requires the proactive integration of currency considerations in all aspects of the contractor's international operations, including production, marketing and financial management. This approach, referred to as operational hedging, does not eliminate the use of traditional, short-term focused financial hedging instruments. Instead, it limits their use to managing residual exposure after operational hedging options are exhausted.

Production strategies that provide exposure management opportunities involve input sourcing and mixing from appropriate countries and in appropriate currencies, based on the contractor's expectations about exchange rate, price, and, therefore, home currency cash flow movements. In other words, the international contractor who is interested to reduce its overall cash flow exposure at the project and firm levels, could shift its sourcing to markets such that the translated in domestic currency international revenues (cash inflows) and costs (cash outflows) move in the same direction when exchange rates change. The contractor can be expected to make such production management responses in the context of maximizing its profits and reducing its exposure to acceptable, for the associated risk, levels.

Shifts in input sourcing can be guided by changes in international and domestic prices of construction inputs, as they are influenced by macroeconomic variables, including foreign exchange rates. Overall, when a currency depreciates, prices of construction inputs sold in the depreciating currency's country will rise, in terms of the depreciating currency. As a result, an international contractor should be fixing its costs, in nominal terms, in currencies likely to depreciate, where the unit prices will tend to rise.

The extent of price changes reflects the competitive structure of the industry, the proportion of domestic and international producers and consumers, and the elasticities of supply and demand. For example, due to higher relative foreign exchange elasticities of prices, the extent of price changes will be larger for monopolistically, rather than competitively priced construction inputs. This conclusion is consistent with the intuitive expectation that exposure in inputs sourced from monopolies is more risky than exposure in inputs sourced from competitive markets. As a result, the international contractor should be fixing its nominal costs more often for inputs sourced from monopolistic rather than from more competitive markets.

In international projects, some of the contractor's suppliers may be able to exercise price discrimination across separated markets and different currencies. Such practices are reflected by deviations from the exchange rate equilibrium relationship of purchasing power parity. The price discrimination analysis shows that costs will move in the same direction with the case when PPP holds. However, it is shown that the exchange rate elasticity of foreign and domestic prices is lower for the price discriminator than for the monopolistic competitor. In other words, the variability of costs facing the international contractor will tend to be lower from price discriminating sources.

Therefore, the international contractor that sources inputs from price discriminating environments will have higher exposure, due to the higher prices it has to pay, compared to competitive environments, but will also have reduced variability of its cash flows due to foreign exchange rate changes. In other words, part of the contractor's foreign exchange risk (i.e., part of the variability of its cash flows) is traded off with the higher price it pays to the price discriminating producer. Of course, the higher costs associated with price discriminating industries can contribute positively or negatively to exposure in a given currency, depending on the overall short or long, respectively, position that the contractor may have in it.

Regarding input mixing decisions of the international contractor, the cost minimization analysis shows how the contractor can optimize the combination of resources, subject to production constraints, based on expectations about exchange rate movements. The extent of substitution of inputs and tradeoff between alternative construction technologies and inputs sourced from international markets will be a function of exchange rates, as well as of the exchange rate elasticities of construction input prices analyzed in the thesis. The derived measures of marginal rate of technical substitution imply that the international contractor will tend to favor input mixes that source marginally more in depreciating currencies.

To the extent that foreign exchange rates result in contraction or expansion of production, such production changes can affect the availability of construction inputs, and, therefore, have impact on the schedule and timely completion of a project. There is likely to be increased costs associated with alternative sources and/or penalties due to the construction delays. For example, it can be shown that shortages of construction inputs associated with reduced production are possible for competitively priced goods sourced from all-exporting countries whose currency is likely to depreciate.

Marketing strategies, as an approach to operational hedging a contractor's foreign exchange exposure, include market or currency selection, pricing strategy and project type focus. Market selection implies the contractor's flexibility (subject to existing demand) to target new business development markets, on the basis of criteria that incorporate foreign exchange considerations. The ability of the contractor to profitably stay in a foreign market is closely linked to the volatility of local revenue in real purchasing power terms. Contractors can choose to stay away from certain markets with soft or inconvertible currency revenue, or pursue opportunities in countries with hard currencies. As such, the market selection may have an explicit currency selection component.

Currency selection suggests that the international contractor may have room to negotiate with the owner at least partial payment in currency of its preference. Of course, the lumpiness of construction projects does not provide for ad hoc changes of the currency of billings, following shifts in expectations about exchange rates, as sometimes practiced in other exporting industries. It is also doubtful whether the owner will be sympathetic to the decrease in nominal and real value of its payments. However, the risk of contractor's financial failure due to foreign exchange exposure may affect the project value to the owner. More specifically, an exposed contractor may be forced to adopt defensive pricing strategies, such as incorporating excessive contingencies and suboptimizing the use of technologies. It can also opt for sourcing its inputs based on currency of costs rather than quality criteria, which can be against the owner's goals. Finally, negotiating the revenue currency can be in the mutual interest of both parties, if their respective exposures are in opposite directions.

Profit maximization analysis can guide the contractor into making currency of revenue shifts. The decision is equivalent to choosing its business volume in a given country, if work for that country's owners is billed in the country's currency. Of course, the currency and geographic shift in business development is easier to be suggested than implemented, given the local networking and other investment required for establishing a contractor's presence in a market. However, it not likely to be as difficult as the relocation of manufacturing businesses that typically have substantial fixed investment in plant and equipment.

The international contractor's pricing decision and bidding strategy is similarly affected from exchange rate fluctuations in a competitive environment. In construction industry segments with many competing firms and no tangible product differentiation (such as the building and highway construction), contractors with depreciating home currency will tend to have increased fixed overhead costs, and therefore higher bid prices, or lower profit margins. The more competitive the environment, the more its markup will be defined by the competition. By contrast, in less competitive environments, a contractor can have more control over pricing.

When operational hedging options are exhausted, the contractor may be left with undesired residual exposure. At this point it can decide to bear the risk, or cover it with futures, forward and options contracts, or other financial transactions, including contracts in proxy currencies, when these contracts are not available. In general, due to the often short-term nature of such instruments, relative to a construction project's duration, the contractor may have to reevaluate and extend such coverage on a periodic basis.

The thesis also demonstrates that the often observed aversion towards international work on the basis of, among other reasons, foreign exchange risks, may not be justified. Given appropriate market and foreign exchange correlations, international diversification can reduce the contractor's variability of cash flows, even when the contractor diversifies its operations in highly risky markets. The risks to be evaluated are two. First, there are the local market risks that affect the value of foreign cash flows. Second, there are the exchange risks associated with local currency volatility.

International diversification reduces the contractor's systematic risk below the levels of domestic operations. In addition, foreign currency correlations can provide useful indications about the exposure offsetting potential from existing positions in different currencies. The exposure will tend to increase when long positions are taken in highly positively correlated currencies, as the currencies will tend to move in the same direction. Many less developed countries, that constitute the largest source of international contracts, have their currencies pegged or otherwise linked to major currencies. This can be useful information for managing exposure in them, as they may allow the use of financial hedging instruments in proxy currencies, but can also be deceiving, as their governments often complement currency arrangements with unpredictable devaluations.

The current thesis also discusses the impact of deviations in purchasing power parity (PPP) on the competitiveness of international contractors. Deviations from PPP at the construction industry level affect the contractor's competitiveness in its labor, materials and equipment costs. They also affect its markup decisions, if PPP does not hold at the national economy level. Real exchange rates for the construction industry can provide the basis for monitoring the advantage or disadvantage resulting from deviations from PPP.

The over time increase in real construction costs can permanently handicap contractors in their international competition, as the negative impact of the relatively "strong" dollar of the early 1980s on US contractor competitiveness suggests. The persistence of such competitive disadvantage can eventually affect the market share of international contractors, which is most difficult to regain when real exchange rates return to equilibrium. On the positive side, strong in real terms currencies can buy more project value, when financial aid is provided to a less developed country. Overall, the importance of deviations from purchasing power parity on the contractors' international competitiveness should be a major concern for industry leaders and policy makers.

Finally, the thesis reviews a framework for valuing international projects with cash flows in multiple currencies. The valuation by components (VC) methodology provides a transparent approach to incorporating and evaluating noncontractual cash flows, and for discounting them based on their individual riskiness. The impact of financial hedging instruments is reflected by reduced cash flows, but also by reduced discount rates. The estimates of project cash flows are affected by the results of the economic analyses discussed in the preceding sections.

6.2 Recommendations for Further Research

The work of this thesis is only the first step towards a more analytic definition, understanding, measurement and management of foreign exchange exposure in international construction. A number of extensions to the present research can be made in order to analyze other aspects of foreign exchange exposure, or support foreign exchange management decisions.

One extension can be the use of dynamic methodologies of economic analysis, in order to study the response of construction costs to continuous time changes of exchange rates. This type of analysis would complement the static, discrete time analysis of this thesis, where changes in exchange rates were assumed to take place once-and-for-all, at least between two points in time. The dynamic analysis would effectively date the economic variables and, therefore, provide for the explicit consideration of time in the economic study of foreign exchange exposure.

A subject that has been discussed in this thesis, which lends iself for more analytic treatment, is the economic evaluation and selection of financial hedging instruments, and the development of optimal currency hedging policies, using mathematical programming models under uncertainty. Two specific questions that can be modeled are first, the timing of the contractor's decision to protect itself, and, second, the extent of such protection. Such models could be used as early as the bid date, and continue being used while a project is in progress, and as cash flow and exposure projections are updated and revised based on actual construction completion and other data.

The use of mathematical programming models under uncertainty in making hedging decisions, as well as the more general need to make crucial contractual decisions at the top management level, requires the maintenance and modeling of relevant project and economic data. Such data can include, for example, real and nominal foreign exchange and interest rate forecasts and correlations . The definition of data structures and the design of effective executive information systems for supporting contracting, hedging and other significant economic decisions, constitute an area of potential future research.

The thesis indicated the usefulness of the valuation by components methodology, as a means of transparently and more accurately evaluating multiple currency contractual and noncontractual cash flows. The appraisal and adaptation of this or other appropriate adjusted present value methodologies for international construction projects can be the subject of further research. Such research could address many of the side and nontraditional issues of contemporary projects, including construction and project financing. Overall, it would have the potential of providing the analytic framework and accurately incorporating appropriate information for making economically important international construction business decisions.

Finally, an interesting extension for further research can be the quantitative analysis and study of foreign exchange risk allocation between owners and contractors. Such research can focus on the design of contractual agreements that take advantage of the possible different ability to bear foreign exchange risk among owners and contractors, provide management incentives for cost savings, and address the presumably mutual desire to avoid contracting risks.

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APPENDIX A

Overiview of Foreign Exchange Rate Determination and Relationships

A.1 Foreign Exchange Markets

Currencies are traded in foreign exchange markets. The greater part of these markets is demand deposits traded between major international banks. The foreign exchange markets have three basic functions:

(a) They provide clearing services, by helping people and firms who trade currencies to end up holding the currencies they prefer.

(b) They help people who do not want to gamble on the movements of exchange rates to "hedge" against a foreign currency's fluctuations, ie. make sure that they don't have a net asset or net liability in that currency. This is the function most relevant to construction firms' operations.

(c) They allow others to "speculate", ie. take a net asset or net liability position in a foreign currency. The typical construction firm does not intentionally engage in currency speculation. However, unintentional foreign currency positioning, which has been observed in construction projects, often produces the equivalent to speculation.

A.2 Foreign Exchange Rates

For the purpose of the present thesis, we define as foreign exchange rate the price of a unit of foreign currency in domestic currency units. For example, if the US dollar is the domestic currency, e_1 is the exchange rate between the US dollar and the British pound, and e_2 is the exchange rate between the US dollar and the Mexican peso respectively:

	e_1 US dollars	buy	1 British pound
and	e_2 US dollars	buy	1 Mexican peso, respectively.

Based on the above definition we will say that the US dollar appreciates (or depreciates respectively) vis a vis a foreign currency between $t=t_1$ and $t=t_2$, if $e_{t2} < e_{t1}$ (or $e_{t2} > e_{t1}$ respectively). Furthermore, we distinguish between spot and forward exchange rates. Spot rate is the current price of a foreign currency to be delivered within two days. Forward rates are those negotiated now for later delivery (30-, 90- and 180-day forward rates).

A.3 Key Foreign Exchange Relationships

Four economic relationships are most relevant to the thesis. They are discussed in detail by Shapiro (1982) and they are:

(a) purchasing power parity (PPP)

(b) Fisher effect (FE)

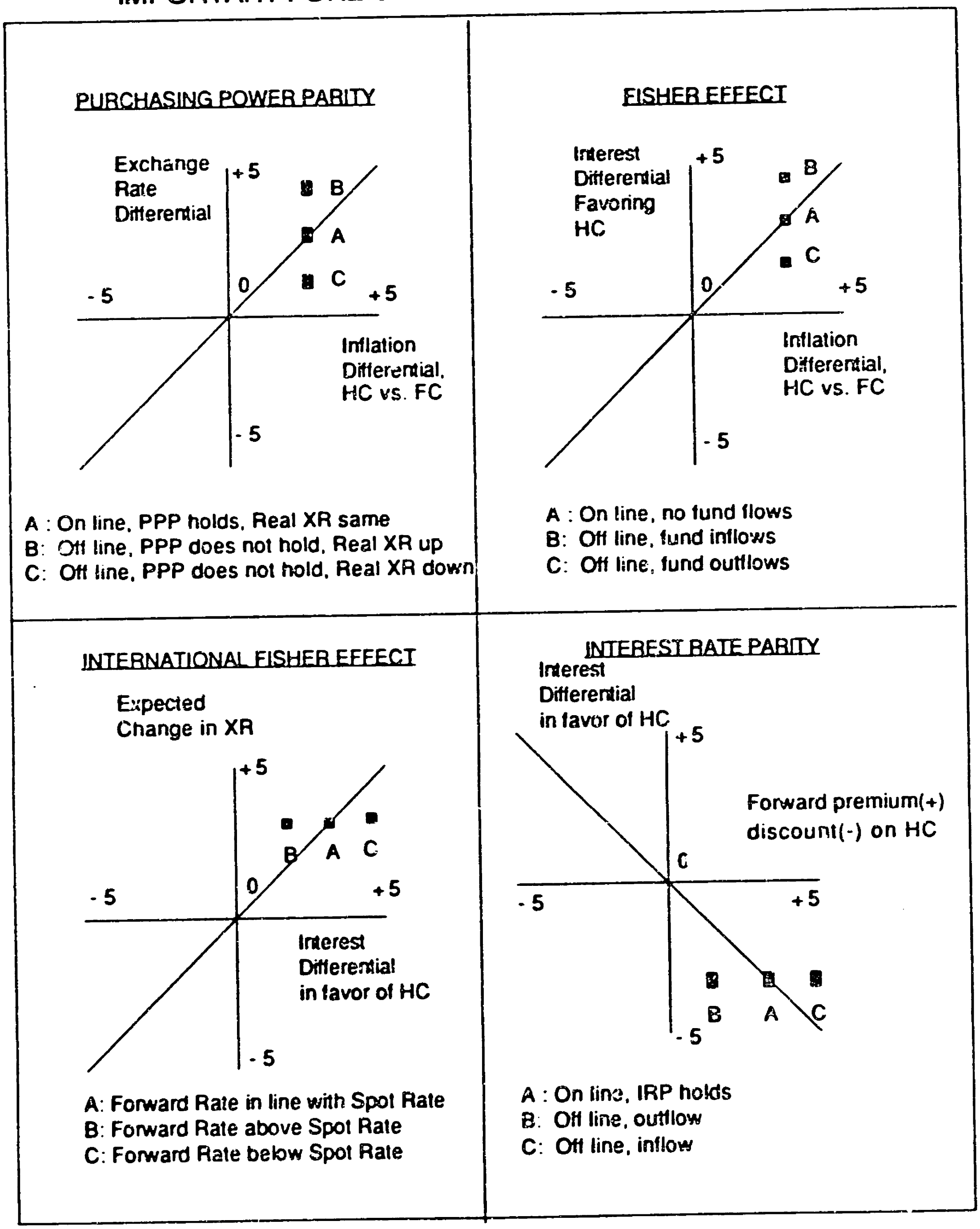
(c) international Fisher effect (IFE)

(d) interest rate parity (IRP)

A brief presentation of the major issues follows. Figure A.1 summarizes graphically the above key foreign exchange relationships.

FIGURE A.1

IMPORTANT FOREIGN EXCHANGE RELATIONSHIPS



Notation : HC - Home Currency, FC - Foreign Currency, XR - Exchange Rate

Source : Adapted from Shapiro, A., Multinational Financial Management, Allyn and Bacon, Boston, 1986

Purchasing Power Parity

The major relationship used in the determination of foreign exchange rates (and critical for the present research) is that of purchasing power parity (PPP). PPP states that the exchange rate between two currencies moves so as to offset relative changes in price levels of the two countries. For example, in the construction environment, PPP states that construction materials prices move in the opposite direction to exchange rates, so the prices of such materials are effectively the same across countries. The analytic expression of PPP is :

$$e = \frac{P_d}{P_f} \qquad \text{("absolute" version)}$$

where :

e is the exchange rate (domestic currency price of foreign exchange),

P_d is the domestic price level, and

P_f is the foreign price level.

A "relative" version of PPP is :

$\Delta e = \Delta P_d - \Delta P_f$

where "Δ" indicates rates of change. The relative version of PPP states that differentials in inflation rates are reflected on exchange rates. Therefore, if inflation in the United States is 5 percent while in the United Kingdom it is 9 percent, under PPP the US dollar will appreciate by (9-5) = 4 percent relative to the British pound.

The PPP theory is based on the law of one price under which "free trade will equalize the price of any good in all countries - otherwise arbitrage opportunities will exist" (Shapiro, 1982). If PPP holds, changes in nominal exchange rates do not result in purchasing power gains or losses. So, in a two country world where PPP holds, a US and a British construction firm, would face the same real costs, both before and after a change in currency relationship between the US dollar and the British pound.

However, PPP does not account for transportation costs, tariffs, quotas and product differentiations. Under such conditions, deviations from PPP are observed and the nominal exchange rates do not any longer accurately reflect relative changes in price levels. The concept of Real Exchange Rate is introduced as a measure of changes in the real purchasing power parity of a currency. PPP is then rewritten to reflect nominal exchange rate deviations from parity with prices as follows :

$$e = RX \frac{P_d}{P_f} \qquad \text{(absolute version), or}$$

$$\Delta e = \Delta RX + \Delta Pd - \Delta Pf \qquad \text{(relative version)}$$

Now we can implicitly define the real exchange rate (RX) as :

$$RX = e \frac{P_f}{P_d}, \text{ or}$$

$$\Delta RX = \Delta e - (\Delta P_d - \Delta P_f)$$

The above equations show that the real exchange rate is a function of two factors, the nominal exchange rate and the relative level of prices. When price level changes are not reflected in nominal exchange rates, ie. when Δe is not equal to $(\Delta Pd - \Delta Pf)$, the real exchange rate displays a trend.

Using the same example as above, if the nominal exchange rate changed by 3 percent, while inflation differentials were still 4 percent, there would be a real exchange rate change equal to -1 percent (= 3 - 4), and the US dollar would buy less of the same goods in the United Kingdom than in the United States.

Fisher Effect

The Fisher Effect relationship states that the nominal interest rate is equal to the real interest rate adjusted for the expected rate of inflation:

$$1+r_{nh} = (1+r_{rh})(1+f_h)$$

where: r_{nh} = nominal interest rate, home country

r_{rh} = real interest rate (required return), home country

f_h = rate of inflation, home country

Real returns are equalized across countries. Therefore, it should be:

$$\frac{1+r_{nh}}{1+r_{nf}} = \frac{1+f_h}{1+f_f}$$

where: subscript f indicates foreign country. The approximate relationship is then:

$$r_h - r_f = f_h - f_f$$

International Fisher Effect

The purchasing power parity relationship coupled with the Fisher Effect implies that the interest differential between countries is an unbiased predictor of the future spot exchange rate. In terms of a mathematical relationship,

$$\frac{1+r_{nh}(t)}{1+r_{nf}(t)} = \frac{1+f_h(t)}{1+f_f(t)} = \frac{e(t)}{e(o)} \Rightarrow r_{nh}(t) - r_{nf}(t) = \frac{e(t)-e(o)}{e(o)}$$

Interest Rate Parity Theory

Similarly, the interest rate differential between two countries determines the forward rate premiums and discounts associated with currency rates. In other words, higher home country interest rates translate into higher expected future value of the home currency, and, therefore, higher forward rate of the home currency (lower e).

A.4 Floating and Fixed Rate Systems

In the course of the past fifteen years, economic activities have been unified globally and changes in national economic policies (national income, interest rates, money supply) are quickly reflected in fluctuations of currency values. Foreign exchange uncertainties have become an area of major concern in international business especially after the prevailing of floating exchange rates in the world's financial systems in 1971. This does not mean that they were nonexistent with the fixed rate system, but rather that some exchange risk aspects became more visible in day to day operations with the floating rates.

In a very broad context, a country's Balance Of Payments (BOP) status influences its currency's value. Exports create a demand for domestic currency and supply of foreign currencies. Conversely, imports create a demand for foreign currencies and supply of domestic currency. Typically, a BOP deficit translates into demand for foreign exchange which is greater than the existing supply. As a result, the foreign currencies appreciate while the domestic currency depreciates. With analogous reasoning, a BOP surplus typically contributes to the appreciation of the local currency.

Floating Rates

The floating rate system assumes that currency rates are adjusted in foreign exchange markets through the price mechanism, without internvention by governments or central banks. In other words, currency prices are determined by the supply and demand for each currency, which in turn are influenced by domestic and foreign price levels of goods and services, awareness of trading opportunities and so on.

In theory, under a floating rate system the currency of a country running BOP deficits depreciates, imports are reduced, exports are stimulated and the deficit is corrected automatically. This self-correcting adjustment process is usually far from painless though, as it stimulates inflation and the decline of purchasing power and real currency value.

Floating rates have helped absorb big shocks (like the quadrupling of OPEC oil prices in 1973) which would have resulted in major international financial (BOP) crises under fixed rates systems. However, floating rates have not removed the BOP deficit problems, probably because the BOP correction process takes relatively longer compared to the currency value adjustment time (the consumption of imports does not change automatically with a home country currency devaluation, and, at least short-term, the trade deficit worsens) or because countries often intervene in foreign exchange markets to manage exchange rates ("dirty" float). It is the slow response of such macroeconomic variables that create some of the foreign currency uncertainties and risks in construction projects whose duration may not be long enough to benefit from restoration of equilibrium relationships (such as the PPP) in a floating exchange rate environment.

For most multinational corporations, including those involved in international construction projects, floating rates have resulted in continuous visibility of their gains and losses from currency fluctuations. International construction and engineering firms are obliged by law to report their gains/losses after 1981. However, these gains/losses are typically balance sheet related (i.e. mainly historical) in nature. As such, they do not necessarily provide information about the economic success of individual projects, or about the future risks and opportunities of the overall business. Nevertheless, floating rates have introduced an on-going crisis management atmosphere in many companies with projects having unmatched revenue cost structures in multiple currencies.

Fixed Rates

With the fixed rate system, government and central bank officials intervene to keep the exchange rate fixed even if the rate tends to be away from the equilibrium rate. Currencies forced to the fixed rate standard are allowed to fluctuate within a "band" of rates and are either overvalued or undervalued compared to the equilibrium rate.

Currencies were traded at fixed rates after 1944 under the supervision of the International Monetary Fund (IMF) (Bretton Woods agreements). The system worked tolerably until increasing international Balance of Payments (BOP) crises led to its end in 1971.

With fixed rates in effect, countries running BOP deficits are absorbing (buying from international markets) the excess supply of their own money with their foreign exchange reserves. These reserves are not infinite, however, and this tactic has always carried with it the threat of sudden devaluations and international crises. Countries with BOP deficits and fixed rates are viewed with suspicion regarding the maintenance of their currency's value.

The conclusion is that even under fixed rate systems, currency devaluations are as real a possibility as they are under floating rate systems. Construction firms have to deal with the possibility of sudden devaluations/ revaluations that may wipe away the thin margins of international projects. There is always an exchange risk resulting from country risk related phenomena. And, as discussed in later sections, whether fixed or floating rates prevail, the real and not the nominal value of currencies held by investors is of importance to them: artificially maintained rates do not provide comfort if PPP does not hold.

APPENDIX B

Pricing and Output Responses to Exchange Rate Changes

The internationally competing firm makes pricing and output decisions in relation to the competitive structure of its industry. The competitive structure of the industry is a function of the number of firms participating in it (one, few, many) and of the type of product (homogeneous, differentiated). This appendix summarizes methodologies by Flood (1983, 1985) and Chiang (1984) for analyzing pricing and output decisions under perfect and monopolistic competition, including price discrimination.

B.1 Perfect Competition

Perfect competition assumes the existence of many firms selling a homogeneous product. The analysis assumes a two-country setting, with a fixed number of domestic and foreign firms, sourcing their inputs in domestic markets and selling to both countries. The following notation is used:

P_d Domestic Price
P_f Foreign Price
S_d Domestic Supply
S_f Foreign Supply
D_d Domestic Demand
D_f Foreign Demand
N_{dd} Number of Domestic Customers
N_{df} Number of Foreign Customers
N_{sd} Number of Domestic Firms
N_{sf} Number of Foreign Firms
e Exchange Rate, i.e. the price of the foreign currency unit in US dollars.
$P_d = e * P_f$, i.e., Purchasing Power Parity (PPP) holds.

Pricing Response

Prices in perfect competition are determined by the equilibrium of market supply and demand (partial equilibrium):
Supply = Demand, where
Supply = Domestic Supply + Foreign Supply = $N_{sd}*S_d+N_{sf}*S_f$
Demand = Domestic Demand + Foreign Demand = $N_{dd}*D_d+N_{df}*D_f$

$S_d=S_d(P_d)=S_d(e*P_f)$, $S_f=S_f(P_f)$, $D_d=D_d(P_d)=D_d(e*P_f)$, $D_f=D_f(P_f)$

$$\Rightarrow \quad \underbrace{N_{sd}*S_d(e*P_f)+N_{sf}*S_f(P_f)}_{(A}=\underbrace{N_{dd}*D_d(e*P_f)+N_{df}*D_f(P_f)}_{=B\ )}$$

$$\frac{dA}{de} = N_{sd}*\frac{dS_d}{d(e*P_f)}*[e*dP_f + P_f*de] + N_{sf}*\frac{dS_f}{dP_f}*dP_f$$

$$\frac{dB}{de} = N_{dd} * \frac{dD_d}{d(e*P_f)} * [e*dP_f + P_f*de] + N_{df} * \frac{dD_f}{dP_f} *dP_f$$

After multiplying the numerator by e and the denominator by P_f,

$$\frac{dA}{de} = \frac{dB}{de} \Rightarrow$$

$$\frac{e}{P_f} * \frac{dP_f}{de} \left[-e*N_{sd}*\frac{dS_d}{d(e*P_f)} - N_{sf}*\frac{dS_f}{dP_f} + e*N_{dd}\frac{dD_d}{d(e*P_f)} + N_{df}*\frac{dD_f}{dP_f} \right] =$$

$$e*N_s*\frac{dS_d}{d(e*P_f)} - e*Nd*\frac{dD_d}{d(e*P_f)} \Rightarrow$$

K1 A1

$$\frac{dP_f}{de} * \frac{e}{P_f} = \frac{e*N_s*\frac{dS_d}{d(e*P_f)} - e*N_d*\frac{dD_d}{d(e*P_f)}}{\left[e*N_d*\frac{dD_f}{dP_f} - N_s*\frac{dS_f}{dP_f}\right] - \left[e*N_s*\frac{dS_d}{d(e*P_f)} - e*N_d*\frac{dD_d}{d(e*P_f)}\right]}$$

B1 A1

$$\text{or,} \quad K1 = \frac{A1}{B1 - A1}$$

where K1 = Exchange Rate Elasticity of Foreign Price
A1 = Net Domestic Supply Response
B1 = Net Foreign Supply Response

Assuming

$$\frac{dD_d}{dP_d} \left(= \frac{dD_d}{d(e*P_f)} \right), \frac{dD_f}{dP_f} < 0 \quad \text{and} \quad \frac{dS_d}{dP_d} \left(= \frac{dS_d}{d(e*P_f)} \right), \frac{dS_f}{dP_f} > 0,$$

$K1 < 0$.

In addition, we observe that:

$[A1>0, B1<0] \Leftrightarrow [A1>0, -B1>0] \Leftrightarrow A1-B1>A1 \Leftrightarrow$

$$\frac{A1}{A1-B1} < 1 \text{ and } K1 = \frac{A1}{B1-A1} > -1 \text{ or, finally, } -1 < K1 < 0$$

Therefore, when the domestic currency depreciates, i.e., when e increases ($de/e > 0$), foreign prices fall ($K1<0 \Leftrightarrow dP_f/P_f < 0$).

Output Response

The output can be expressed as the total demand or, equivalently, total supply:

(1) $Q = Q_d = N_{dd} * D_d(e * P_f) + N_{df} * D_f(P_f)$

(2) $Q = Q_s = N_{sd} * S_d(e * P_f) + N_{sf} * S_f(P_f)$

We totally differentiate (1) and (2) with respect to e:

$$(1)\quad \frac{dQ}{de} = N_{dd} * \frac{dD_d}{d(e*P_f)} \; \frac{d(e*P_f)}{de} + N_{df} * \frac{dD_f}{dP_f} \; \frac{dP_f}{de} =$$

$$= N_{dd} * \frac{dD_d}{d(e*P_f)} * \left[P_f + e * \frac{dP_f}{de}\right] + N_{df} * \frac{dD_f}{dP_f} * \frac{dP_f}{de} \Rightarrow$$

$$(1')\quad \frac{dQ}{de} = N_{dd} * \frac{dD_d}{d(e*P_f)} * Pf + \underbrace{\left[N_{dd} * \frac{dD_d}{d(e*P_f)} * e + N_{df} * \frac{dD_f}{dP_f}\right]}_{A1} * \frac{dP_f}{de}$$

$$(2)\quad \frac{dQ}{de} = N_{sd} * \frac{dS_d}{d(e*P_f)} * \frac{d(e*P_f)}{de} + N_{sf} * \frac{dS_f}{dP_f} * \frac{dP_f}{de} =$$

$$= N_{sd} * \frac{dS_d}{d(e*P_f)} * \left[P_f + e * \frac{dP_f}{de}\right] + N_{sf} * \frac{dS_f}{dP_f} * \frac{dP_f}{de} \Rightarrow$$

$$(2')\quad \frac{dQ}{de} = N_{sd} * \frac{dS_d}{d(e*P_f)} * P_f + \underbrace{\left[N_{sd} * \frac{dS_d}{d(e*P_f)} * e + N_{sf} * \frac{dS_f}{dP_f}\right]}_{A2} * \frac{dP_f}{de}$$

We now solve the system of equations (1') and (2').

To do so, we eliminate $\frac{dP_f}{de}$ and solve for $\frac{dQ}{de}$:

$$(1'') : \quad \frac{dQ}{de} * A2 = Ndd * \frac{dDd}{d(e*Pf)} * Pf * A2 + A1 * A2 * \frac{dPf}{de}$$

$$(2'') : \quad \frac{dQ}{de} * A1 = Nsd * \frac{dSd}{d(e*Pf)} * Pf * A1 - A1 * A2 * \frac{dPf}{de}$$

Adding (1") and (2") we have:

$$\frac{dQ}{de}*[A2-A1] = Ndd*\frac{dDd}{d(e*Pf)}*Pf*A2 - Nsd*\frac{dSd}{d(e*Pf)}*Pf*A1 \Rightarrow$$

$$\frac{dQ}{de} = \frac{Ndd*\frac{dDd}{d(e*Pf)}*Pf*A2 - Nsd*\frac{dSd}{d(e*Pf)}*Pf*A1}{A2 - A1}$$

Assuming:

$$\frac{dD_d}{dP_d} = \left(\frac{dD_d}{d(e*P_f)}\right), \frac{dD_f}{dP_f} < 0 \text{ and } \frac{dS_d}{dP_d} = \left(\frac{dS_d}{d(e*P_f)}\right), \frac{dS_f}{dP_f} > 0$$

we have $A2 > 0$, $A1 < 0 \Rightarrow A2-A1 > 0$, and, therefore,

$$\frac{dQ}{de} = \frac{\{\text{ negative component }\} + \{\text{ positive component }\}}{\{\text{ positive component }\}}$$

Under these circumstances dQ/de can be either positive or negative depending on the slope of the supply and demand curves, i.e., total output may increase or decrease, depending on the slope of the supply and demand curves.

B.2 Monopolistic Competition

Monopolistic competition is characterized by many firms producing a differentiated product. This section analyzes the impact of exchange rate changes on the prices and output and of international firms. The analysis is based on the firm being a profit maximizer. Other assumptions and the notation of the subsection on perfect competition are maintained in this section too.

Pricing Response

First, we get an expression for the firm's profit:

Profit = Revenues - Costs

Revenue (dom.currency) = Dom.Revenue + For.Revenue =

$= P_d*D_d + e*(P_f*D_f) = e*P_f*D_d + e*P_f*D_f = e*P_f*(D_d+D_f) =$

$= e*P_f*D = e*P_f(e,D)*D$

(PPP holds, i.e., $P_d=e*P_f$, and P_f is a function of exchange rate and total demand D)

Costs = $C(D) = C(D_d+D_f)$

Therefore,

Profit = Pr= $e*P_f(e,D)*D - C(D) = e*P_f*D_d + e*P_f*D_f - C(D_d+D_f)$

The firm is a profit maximizer. Therefore, $\frac{dPr}{dP_f} = 0$

or, [1] [2] [3] [4] [5] [6]

$$\frac{dPr}{dP_f} = \underbrace{e^2 P_f * \frac{dD_d}{d(e*P_f)}}_{[1]} + \underbrace{e*D_d}_{[2]} + \underbrace{e*P_f*\frac{dD_f}{dP_f}}_{[3]} + \underbrace{e*D_f}_{[4]} - \underbrace{e*\frac{dC}{dD_d}*\frac{dD_d}{d(e*P_f)}}_{[5]} - \underbrace{\frac{dC}{dD_f}*\frac{dD_f}{dP_f}}_{[6]} = 0 \qquad (3)$$

To get an expression for dP_f/de we differentiate (1) with respect to e :

$$\frac{d[1]}{de} = \frac{d(e^2*P_f)}{de} * \frac{dD_d}{d(e*P_f)} + \frac{d(dD_d/d(e*P_f))}{de} * e^2*P_f =$$

(assuming Dd straight line, i.e., second term = 0))

$$= \left[\frac{de^2}{de} * P_f + e^2 * \frac{dP_f}{de}\right] * \frac{dD_d}{d(e*P_f)} =$$

$$= 2*e*P_f*\frac{dD_d}{d(e*P_f)} + e^2*\frac{dP_f}{de} * \frac{dD_d}{d(e*P_f)} \qquad (4)$$

$$\frac{d[2]}{de} = D + e*\frac{dD_d}{d(e*P_f)} * \frac{d(e*P_f)}{de} =$$

$$= D + e*\frac{dD_d}{d(e*P_f)}*\left[P_f + e*\frac{dP_f}{de}\right] =$$

$$= D + e*P_f*\frac{dD_d}{d(e*P_f)} + e^2*\frac{dP_f}{de}*\frac{dD}{d(e*P_f)} \qquad (5)$$

$$\frac{d[3]}{de} = \frac{d(e*P_f)}{de} * \frac{dD_f}{dP_f} + e*P_f*\frac{d(dD_f/dP_f)}{de} =$$

$$= P_f*\frac{dD_f}{dP_f} + e*\frac{dP_f}{de}*\frac{dD_f}{dP_f} \qquad (6)$$

$$\frac{d[4]}{de} = \frac{d(e*D_f)}{de} = \frac{e*D_f + D_f*de}{de} = D_f + e*\frac{dD_f}{dP_f}*\frac{dP_f}{de} \qquad (7)$$

$$\frac{d[5]}{de} = \frac{dC}{dD}*\frac{dD_d}{d(e*P_f)} + e*\frac{dD}{d(e*P_f)}*\frac{d^2C}{dDde} + e*\frac{dC}{dD}*\frac{d^2D}{d(e*P_f)de} =$$

(assuming slope of marginal cost and demand curves = 0)

$$= \frac{dC}{dD}*\frac{dD_d}{d(e*P_f)} \tag{8}$$

$$\frac{d[6]}{de} = \frac{d^2C}{d(e*P_f)}*\frac{dD_f}{dP_f} + \frac{dC}{dD_f}*\frac{d^2D_f}{dP_f de} = 0 \tag{9}$$

Therefore,

$$\frac{d^2P}{dP_f de} = 0 \iff (4)+(5)+(6)+(7)+(8)+(9) = 0 \iff$$

$$\iff 2*e*P_f*\frac{dD_d}{d(e*P_f)} + e^2*\frac{dP_f}{de}*\frac{dD_d}{d(e*P_f)} +$$

$$+ D_d + e*P_f*\frac{dD_d}{d(e*P_f)} + e^2*\frac{dP_f}{de}*\frac{dD}{d(e*P_f)} + Pf*\frac{dD_f}{dP_f} + e*\frac{dP_f}{de}*\frac{dD_f}{dP_f} +$$

$$+ D_f + e*\frac{dD_f}{dP_f}*\frac{dP_f}{de} - \frac{dC}{dD}*\frac{dD_d}{d(e*P_f)} = 0 \tag{10}$$

Equation (3) gives an expression for D_d+D_f which we will use in (10):

$$D_d+D_f = -\ e*P_f*\frac{dD_d}{d(e*P_f)} - P_f*\frac{dD_f}{dP_f} + \frac{dC}{dD_d}*\frac{dD_d}{d(e*P_f)} + \frac{1}{e}*\frac{dC}{dD_f}*\frac{dD_d}{dP_f}$$

Therefore, (10) can be modified to :

$$2*e*P_f*\frac{dD_d}{d(e*P_f)} + e^2*\frac{dP_f}{de}*\frac{dD_d}{d(e*P_f)} +$$

$$+ e*P_f*\frac{dD_d}{d(e*P_f)} + e^2*\frac{dP_f}{de}*\frac{dD}{d(e*P_f)} + Pf*\frac{dD_f}{dP_f} + e*\frac{dP_f}{de}*\frac{dD_f}{dP_f} +$$

$$+ e*\frac{dD_f}{dP_f}*\frac{dP_f}{de} - \frac{dC}{dD}*\frac{dD_d}{d(e*P_f)} -$$

$$- e*P_f*\frac{dD_d}{d(e*P_f)} - P_f*\frac{dD_f}{dP_f} + \frac{dC}{dD_d}*\frac{dD_d}{d(e*P_f)} + \frac{1}{e}*\frac{dC}{dD_f}*\frac{dD_f}{dP_f} = 0 \iff$$

$$2*e*P_f*\frac{dD_d}{d(e*P_f)} + 2*e^2*\frac{dP_f}{de}*\frac{dD_d}{d(e*P_f)} + 2*e*\frac{dP_f}{de}*\frac{dD_f}{dP_f} + \frac{1}{e}*\frac{dC}{dD_f}*\frac{dD_f}{dP_f} = 0 \iff$$

$$\frac{dP_f}{de}*\frac{e}{P_f} = \frac{-2*e^2*P_f*\frac{dD_d}{d(e*P_f)} - \frac{dC}{dD_f}*\frac{dD_f}{dP_f}}{2*e^2*P_f*\frac{dD_d}{d(e*P_f)} + 2*e*P_f*\frac{dD_f}{dP_f}} = K$$

$$= \frac{-\{\text{component } -\} - \{\text{component } +\}*\{\text{component } -\}}{\{\text{component } -\} + \{\text{component } -\}} =$$

$$= \frac{\{+\}}{\{-\}} = \{-\}$$

I.e., K is ≥ 0. We also note that K is ≤ 1. Now, we define (for simplicity):

$$l = e^2*P_f*\frac{dD_d}{d(e*P_f)} < 0$$

$$m = \frac{dC}{dD_f}*\frac{dD_f}{dP_f} < 0$$

$$n = e*P_f*\frac{dD_f}{dP_f} < 0$$

Therefore, $K = \frac{-l - m}{+l + n}$

$$|K| \leq 1 \iff \left|\frac{-l - m}{+l + n}\right| \leq 1 \iff \frac{+l + m}{-l - n} \leq 1 \iff \frac{2l + m + n}{-l - n} \leq 0$$

which holds, since $2l+m+n<0$, and $-l-n>0$.

Therefore, $-1 \leq K = \frac{dPf}{de}*\frac{e}{Pf} \leq 0$.

Finally, we examine the impact on domestic prices:

$$P_d = e^*P_f$$

$$\frac{dP_d}{de} = e^*\frac{dP_f}{de} + P_f \Rightarrow$$

$$\frac{dP_d}{de}*\frac{e}{P_d} = e^*\frac{dP_f}{de}*\frac{e}{P_d} + P_f*\frac{e}{P_d}$$

$$= e^*\frac{dP_f}{de}*\frac{e}{e^*P_f} + 1$$

$$= \frac{dP_f}{de}*\frac{e}{P_f} + 1 = K + 1$$

Therefore, $0 \le K + 1 = \frac{dPd}{de}*\frac{e}{Pd} \le 1$

We conclude that the exchange rate elasticity of foreign price is negative. Therefore, when the exchange rate decreases, i.e., when the domestic currency appreciates, foreign prices increase. In contrast, the exchange rate elasticity of domestic prices is positive, therefore, when the exchange rate decreases, i.e., the domestic currency appreciates, domestic prices decrease.

<u>Output Response</u>

Again, profit is expressed as:

$$Pr = e^*P_f{}^*D_d + e^*P_f{}^*D_f - C(D_d+D_f) =$$
$$= e^*P_f{}^*(D_d+D_f) - C(D_d+D_f) =$$
$$= e^*P_f{}^*D - C(D)$$

$$\frac{dPr}{dD} = e^*P_f + e^*D^*\frac{dP_f}{dD} - \frac{dC}{dD} = 0$$

[6] [7] [8]

Now, we totally differentiate with respect to e:

d(d/dD)/de =0. In detail, we have:

$$[6] = f(e,P_f) \Rightarrow$$

$$\frac{d[6]}{de} = \frac{-[6]}{-e}*\frac{de}{de} + \frac{-[6]}{-P_f}*\frac{dP_f}{de} = P_f*1 + e^*\frac{dP_f}{de} =$$

$$= P_f + e*\frac{dP_f}{de}$$

[7] = $f(e,D)$ =>

$$\frac{d[7]}{de} = \frac{-[7]}{-e}*\frac{de}{de} + \frac{-[7]}{-D}*\frac{dD}{de} =$$

$$= D*\frac{dP_f}{dD} + e*\frac{dP_f}{dD}*\frac{dD}{de} + e*D*\frac{d^2P_f}{dDde} + e*\frac{dP_f}{dD}*\frac{dD}{de} + e*D*\frac{d^2P_f}{dD^2}*\frac{dD}{de}$$

[8] = $f(e,D)$ =>

$$\frac{d[8]}{de} = \frac{-[8]}{-e}*\frac{de}{de} + \frac{-[8]}{-D}*\frac{dD}{de} =$$

$$= \frac{-C'}{-e}*1 + C''*\frac{dD}{de} = C''*\frac{dD}{de}$$ (costs sourced in domestic market/currency)

Therefore,

$$\frac{d^2Pr}{dDde} = 0 = P_f + e*\frac{dP_f}{de} +$$

$$+ D*\frac{dP_f}{dD} + e*\frac{dP_f}{dD}*\frac{dD}{de} + e*D*\frac{d^2P_f}{dDde} + e*\frac{dP_f}{dD}*\frac{dD}{de} + e*D*\frac{d^2P_f}{dD^2}*\frac{dD}{de}$$

$$- C''*\frac{dD}{de} \Rightarrow$$

$$\frac{dD}{de} = \frac{-\left[e*\frac{dP_f}{de} + P_f + e*D*\frac{d^2P_f}{dDde} + D*\frac{dP_f}{dD}\right]}{\left[2*e*\frac{dP_f}{dD} + e*D*\frac{d^2P_f}{dD^2} - \frac{d^2C}{dD^2}\right]}$$

We note the following :

1) The general conditions for profit maximization are:

$$\frac{dPr}{dD_d} = 0, \quad \frac{dPr}{dD_f} = 0, \quad \frac{d^2Pr}{dD_d^2} < 0, \quad \frac{d^2Pr}{dD_f^2} < 0, \text{ and}$$

$$\left(\frac{d^2Pr}{dD_d^2}\right)*\left(\frac{d^2Pr}{dD_f^2}\right) - \left(\frac{d^2Pr}{dD_d\,dD_f}\right)^2 > 0$$

or,

$$\frac{dPr}{dD_d} = Pd*\frac{dD_d}{dD_d} + Dd*\frac{dP_d}{dD_d} + e*Pf*\frac{dD_f}{dD_d} + Df*\frac{d(e*P_f)}{dD_d} - \frac{dC}{dD}*\frac{dD}{dD_d} =$$

$$= P_d + D_d*\frac{dP_d}{dD_d} - \frac{dC}{dD} = 0 \qquad (11)$$

[A] [B] [C]

$$\frac{d^2Pr}{dD_d^2} = \frac{dP_d}{dD_d} + Dd*\frac{d^2P_d}{dD_d^2} + \frac{dD_d}{dD_d}*\frac{dP_d}{dD_d} - \frac{d^2C}{dD^2}*\frac{dD}{dD_d}$$

$$= 2*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2} < 0$$

Similarly,

$$\frac{dPr}{dD_f} = P_d*\frac{dD_d}{dD_f} + D_d*\frac{dP_d}{dD_f} + e*P_f*\frac{dD_f}{dD_f} + D_f*\frac{d(e*P_f)}{dD_f} - \frac{dC}{dD}*\frac{dD}{dD_f} =$$

$$= e*P_f + e*D_f*\frac{dP_f}{dD_f} - \frac{dC}{dD} = 0 \qquad (12)$$

[D] [E] [F]

$$\frac{d^2Pr}{dD_f^2} = e*\frac{dP_f}{dD_f} + e*Df*\frac{d^2P_f}{dD_f^2} + e*\frac{dD_f}{dD_f}*\frac{dP_f}{dD_f} - \frac{d^2C}{dD^2}*\frac{dD}{dD_f}$$

$$= 2*e*\frac{dP_f}{dD_f} + e*D_f*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2} < 0$$

and

$$\left(2*\frac{dP_d}{dD_d} + Dd*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}\right)*\left(2*e*\frac{dP_d}{dD_d} + e*Df*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}\right) - \frac{d^2C}{dD^2} > 0$$

The above second order condition $\frac{d^2Pr}{dD_f^2} < 0$ makes the denominator of the expression above negative.

2) The numerator is negative, as the parenthesis is positive, since it represents the partial derivative of domestic currency marginal revenue with respect to exchange rate.

Therefore, $\frac{dD}{de} > 0$.

Finally, we observe that $dD_d/de = (dD_d/dP_d)*(dP_d/de) < 0$, and that $dD_f/de = (dD_f/dP_f)*(dP_f/de) > 0$.

The analysis shows that, when the domestic currency appreciates, i.e., when e decreases, total output decreases, domestic output increases and foreign output decreases. When the domestic currency depreciates, i.e., when e increases, total output increases, domestic output decreases and foreign output increases.

B.3 Price Discrimination

In the previous sections it was assumed that purchasing power parity (PPP) holds, i.e., that exchange rate changes offset changes in prices. The mathematical expression that has explicitly been used in the analysis is Pd = e*Pf (Pd=domestic price level, Pf=foreign price level, e=exchange rate). In this subsection we relax this assumption, i.e., Pd is not equal to e*Pf. The firm is again assumed to be a profit maximizer. Other notations are the same.

Profit is given now by the following expression:

$$Pr = P_d*D_d + e*P_f*D_f - C(D), \text{ where } D=D_d+D_f$$

The conditions for profit maximization in domestic and foreign markets are:

$$\frac{dPr}{dD_d} = 0, \quad \frac{dPr}{dD_f} = 0, \quad \frac{d^2Pr}{dD_d^2} < 0, \quad \frac{d^2Pr}{dD_f^2} < 0, \text{ and}$$

$$\left(\frac{d^2Pr}{dD_d^2}\right)*\left(\frac{d^2Pr}{dD_f^2}\right) - \left(\frac{d^2Pr}{dD_d\, dD_f}\right)2 > 0$$

$$\frac{dPr}{dD_d} = P_d*\frac{dD_d}{dD_d} + Dd*\frac{dP_d}{dD_d} + e*Pf*\frac{dD_f}{dD_d} + D_f*\frac{d(e*P_f)}{dD_d} - \frac{dC}{dD}*\frac{dD}{dD_d} =$$

$$= P_d + D_d*\frac{dP_d}{dD_d} - \frac{dC}{dD} = 0 \qquad (13)$$

[A] [B] [C]

$$\frac{d^2Pr}{dD_d^2} = \frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2} + \frac{dD_d}{dD_d}*\frac{dP_d}{dD_d} - \frac{d^2C}{dD^2}*\frac{dD}{dD_d}$$

$$= 2*\frac{dP_d}{dD_d} + Dd*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2} < 0$$

Similarly,

$$\frac{dPr}{dD_f} = P_d*\frac{dD_d}{dD_f} + D_d*\frac{dP_d}{dD_f} + e*P_f*\frac{dD_f}{dD_f} + D_f*\frac{d(e*P_f)}{dD_f} - \frac{dC}{dD}*\frac{dD}{dD_f} =$$

$$= e*P_f + e*D_f*\frac{dP_f}{dD_f} - \frac{dC}{dD} = 0 \qquad (14)$$

[D] [E] [F]

$$\frac{d^2Pr}{dD_f^2} = e*\frac{dP_f}{dD_f} + e*D_f*\frac{d^2P_f}{dD_f^2} + e*\frac{dD_f}{dD_f}*\frac{dP_f}{dD_f} - \frac{d^2C}{dD^2}*\frac{dD}{dD_f}$$

$$= 2*e*\frac{dP_f}{dD_f} + e*D_f*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2} < 0$$

and

$$\left(2*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}\right)*\left(2*e*\frac{dP_d}{dD_d} + e*D_f*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}\right) - \frac{d^2C}{dD^2} > 0$$

To generate expressions for price and output changes, first we differentiate equations (13) and (14) with respect to e, and then solve for $\frac{dD_d}{de}$ and $\frac{dD_f}{de}$. Subsequently, $\frac{dP_d}{de}$ and $\frac{dP_f}{de}$ are computed.

$$\frac{d(1)}{de} = \frac{d^2Pr}{dDd\ de} = \frac{d[A]}{de} + \frac{d[B]}{de} - \frac{d[C]}{de} = 0$$

$$\frac{d[A]}{de} = \frac{dP_d}{dD_d}*\frac{dD_d}{de}$$

$$\frac{d[B]}{de} = \frac{dD_d}{de}*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2}*\frac{dD_d}{de}$$

$$\frac{d[C]}{de} = \frac{d^2C}{dD^2}*\frac{dD}{de} = \frac{d^2C}{d(D_d+D_f)^2}*\frac{d(D_d+D_f)}{de} = \frac{d^2C}{dD^2}*\left[\frac{dD_d}{de} + \frac{dD_f}{de}\right]$$

Therefore,

$$\frac{d^2Pr}{dDdde} = 2*\frac{dP_d}{dDd}*\frac{dD_d}{de} + D_d*\frac{d^2Pd}{dDd^2}*\frac{dD_d}{de} - \frac{d^2C}{dD^2}*\frac{dD_d}{de} - \frac{d^2C}{dD^2}*\frac{dD_f}{de} = 0 \qquad (15)$$

Similarly,

$$\frac{d(2)}{de} = \frac{d2Pr}{dD_f de} = \frac{d[D]}{de} + \frac{d[E]}{de} - \frac{d[F]}{de} = 0$$

$$\frac{d[D]}{de} = P_f + e*\frac{dP_f}{dD_f}*\frac{dD_f}{de}$$

$$\frac{d[E]}{de} = e*\frac{dD_f}{de}*\frac{dP_f}{dD_f} + Df*\frac{dP_f}{dD_f} + e*D_f*\frac{d^2P_f}{dD_f^2}*\frac{dD_f}{de}$$

$$\frac{d[F]}{de} = \frac{d^2C}{dD^2}*\frac{dD}{de} = \frac{d^2C}{d(D_d+D_f)^2}*\frac{d(D_d+D_f)}{de} = \frac{d^2C}{dD^2}*\left[\frac{dD_d}{de} + \frac{dD_f}{de}\right]$$

Therefore,

$$\frac{d^2Pr}{dD_f de} = Pf + 2e*\frac{dP_f}{dD_f}*\frac{dD_f}{de} + e*Df*\frac{d^2P_f}{dD_f^2}*\frac{dD_f}{de} + D_f*\frac{dP_f}{dD_f} -$$

$$- \frac{d^2C}{dD^2}*\frac{dD_d}{de} - \frac{d^2C}{dD^2}*\frac{dD_f}{de} = 0 \qquad (16)$$

(15) and (16) can be rewritten:

$$\left[2*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}\right]*\frac{dD_d}{de} - \frac{d^2C}{dD^2}*\frac{dD_f}{de} = 0 \qquad (15')$$

$$- \frac{d^2C}{dD^2}*\frac{dD_d}{de} + \left[2e*\frac{dP_f}{dD_f} + e*D_f*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}\right]*\frac{dD_f}{de} = -P_f - D_f*\frac{dP_f}{dD_f} \qquad (16')$$

If we call:

$$1 = \left[2*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}\right]$$

$$m = -\frac{d^2C}{dD^2}$$

$$n = 0$$

$$u = -\frac{d^2C}{dD^2}$$

$$v = [2e*\frac{dP_f}{dD_f} + e*D_f*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}]$$

$$w = P_f + D_f*\frac{dP_f}{dD_f}$$

Therefore,

$$l * \frac{dD_d}{de} + m * \frac{dD_f}{de} = n \qquad (17)$$

$$u * \frac{dD_d}{de} + v * \frac{dD_f}{de} = -w \qquad (18)$$

After solving the above system of equations, we have:

$$\frac{dD_d}{de} = \frac{[P_f + D_f*\frac{dP_f}{dD_f}] * \frac{d^2C}{dD^2}}{[2*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d} - \frac{d^2C}{dD^2}]*[2e*\frac{dP_f}{dD_f} + e*Df*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}]-[\frac{d^2C}{dD^2}]^2}$$

or

$$\frac{dDd}{de} = \frac{- C'' * w}{l * v - C''}$$

and $dP_d/de = (dP_d/dD_d)*(dD_d/de)$. Similarly,

$$\frac{dD_f}{de} = \frac{- [P_f + D_f*\frac{dP_f}{dD_f}] * [2*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}]}{[2*\frac{dP_d}{dD_d} + D_d*\frac{d^2P_d}{dD_d^2} - \frac{d^2C}{dD^2}]*[2e*\frac{dP_f}{dD_f} + e*D_f*\frac{d^2P_f}{dD_f^2} - \frac{d^2C}{dD^2}]-[\frac{d^2C}{dD^2}]^2}$$

$$\frac{dD_f}{de} = \frac{- w * l}{l * v - C''}$$

and $dP_f/de = (dP_f/dD_f)*(dD_f/de)$.

We observe the following:
1) w = marginal revenue from foreign sales in foreign currency => $w > 0$.
2) $l, v < 0$ from maximization conditions.
Therefore,

$$-[C'']^2 = \left[\frac{d^2C}{dD_d * dD_f}\right]^2 > 0 \quad \Rightarrow l * v - C''^2 > 0$$

Also, $- w * l > 0$
$\qquad - C''^2 * l < 0$

$$\Rightarrow \frac{dD_d}{de} < 0 \,, \quad \frac{dP_d}{de} > 0 \quad \text{and} \quad \frac{dD_f}{de} > 0 \,, \quad \frac{dP_f}{de} < 0$$

The analysis gives similar results to the case of monopolistic competition. Foreign prices increase (decrease) and foreign demand decreases (increases), when the exchange rate appreciates (depreciates). In contrast, domestic prices increase (decrease) and domestic demand decreases (increases), when the exchange rate depreciate (appreciate).