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International production diversification of multinational corporations and exchange rate uncertainty

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INTERNATIONAL PRODUCTION DIVERSIFICATION OF MULTINATIONAL CORPORATIONS AND EXCHANGE RATE UNCERTAINTY

by

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Abstract

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by

MUHITTIN CENGIZ ONUK

Advisor: Professor Yaman Asikoglu

Multinational Corporation producing and selling abroad is analyzed in this dissertation. Three basic versions of the model are examined and compared under different exchange rate processes. Behavior and level of exchange rate pass through effects were observed to be significantly different from the literature. Also, I found that the diversification of production in different countries contributes to the value of the firm even if international financial diversification is possible without friction. Finally, it has been shown that diversified multinational corporation stabilizes profits and magnifies the effect of exchange rate on local production and increases international transmission of business cycles.

ACKNOWLEDGMENTS

I am greatly indebted to Professor Michael Grossman of the Graduate School of the City University of New York, who has patiently followed and actively contributed to my study's progress, as a chairperson of the department.

I must acknowledge my greatest debt to Professor Yaman Asikoglu, my thesis advisor. No formal obligation as an advisor can account for Professor Asikoglu's constant interest, assistance and encouragement with this project.

Fortitude is also the adjective that best describes my wife Regina's contribution to this dissertation.

All thanks, of course, must be coupled with my own acceptance of full responsibility for the final product, and especially so for the errors either of technique or of concept, that remain.

CENGIZ M. ONUK

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CHAPTER ONE

INTRODUCTION

I.1. PURPOSE OF THE DISSERTATION

The basic purpose of this dissertation is to understand the behavior of Multinational Corporations producing and selling in more than one country. Diversification of production refers to the extent to which a firm locates its horizontal activity in different location rather than the diversification of product which refers to the variety of different kind of outputs.

Most of the literature on international trade assumes perfect competition which is not very realistic in today's world where majority of the trade takes place in less than perfectly competitive markets and between a parent company and its subsidiaries. Recently, some attempts have been made to integrate imperfect competition into the analysis but most extensions are borrowed from industrial organization literature and applied into multinational issues. Although nothing is wrong with the application of tools developed in industrial organization to Multinational Corporations, few issues are noteworthy. First, there is no integrated theory of Multinational Corporations. Second, most important dimension of Multinational Corporations is often overlooked which is the correlation between values of the currencies of the countries where production and sale takes place. In the case of two countries, correlation between currencies is negative and creates room for many strategic maneuvers in a portfolio diversification framework which is not available in domestic economies. This dissertation attempts to contemplate these two issues.

The motivation behind the dissertation is the thrust that with the increasing globalization of the production, Organization of International Markets or International Industrial Organization is worth looking into and is a new and fertile research area.

I.2. SURVEY OF THE LITERATURE ON MULTINATIONAL CORPORATIONS

Most models of direct foreign investment and Multinational Corporations have stressed the motivational behavior arising out of market imperfections. Some models set the problem in terms of imperfect mobility of factors such as capital and labor between countries. Others in terms of the market imperfections such as increasing return, product differentiation, taxes, tariffs and etc. Most of these models attempted to capture the motivation to become multinational. On the other hand, Kogut in his 1982 article sees the advantage of the multinational firm, as differentiated from natural corporation in its flexibility to transfer resources across borders through a globally maximizing network. Prominent feature of his approach is to see Multinational Corporations not as an arbitrageur but as a flexible system which is the view taken in this study. Kogut [1982] notes "The ability to shift exports from a country whose currency is appreciating to use where other plants are located is a valuable option assuming that pricing is denominated in the currency of the importing country and factor payments are derived out of overseas revenues."[1]

Literature on Multinational Corporations goes back to Stephen Hymer's Ph.D. dissertation and his later work on this issue. His later critics of Multinational companies extend the discussion to the law of uneven development and he sees multinational companies as a producer of power and poverty [Hymer 1971b]. Dunning and Rugman [1985] discuss the influence of Hymer's dissertation to move the analysis of Multinational Corporations from trade to industrial organization theory.

Lecraw [1985] discusses the importance of Hymer's contribution in this area specifically in terms of public policy in less developed countries. Teece [1985] notes the shortcomings of Hymer's approach and suggests to analyze Multinational Corporations in Coasian sense. Das [1983] shows that Multinational firm under cost uncertainty reduces the scale of operation in the host country increase in the parent country, and expands its exports to the host country. Eden [1978] models vertically integrated multinational corporations and investigates the profit maximization of the firm in response to change in import tariffs and profit taxation. Another study [Host 1971] with similar model

investigates the optimal behavior of the multinational firm under different tariff and tax rates. Shapiro [1977] demonstrates the optimal exposure of Multinational Corporation by using utility function of the firm. Also in his 1979 article, he presents the view that the economic definition of exposure to exchange rates gains and losses has far greater consequences than traditional accounting exposure. Horstman and Markusen [1987] focuses on strategic investment decisions of Multinational Corporation in terms of entry and competition with local or other multinational producers. Aliber [1986] demonstrates that variations in the domestic price of tradeables as a result of changes in exchange rate, is substantially higher under the floating rate system.

Itagaki [1991] develops a two step decision model of the multinational enterprise under foreign demand uncertainty. First step is investment and second is utilization of investment. He argues that former is affected with the risk structure of the firm and latter is not.

In line with Industrial Organization, few works are noteworthy. Krugman in his 1986 article develops

Differentiated Products and Vertical Integration, Gaspari [1986] Foreign Market Operations and Domestic Market Power, Shapiro [1986] Entry and Exit in Multinational Corporation framework. Welfare implications are discussed in Johnson [1970].

Hymer [1970] is the first author to suggest the nameinternational industrial organization. He notes that "Our aim is to point out some likely consequences and contradictions of the laws of international industrial reorganization,..."

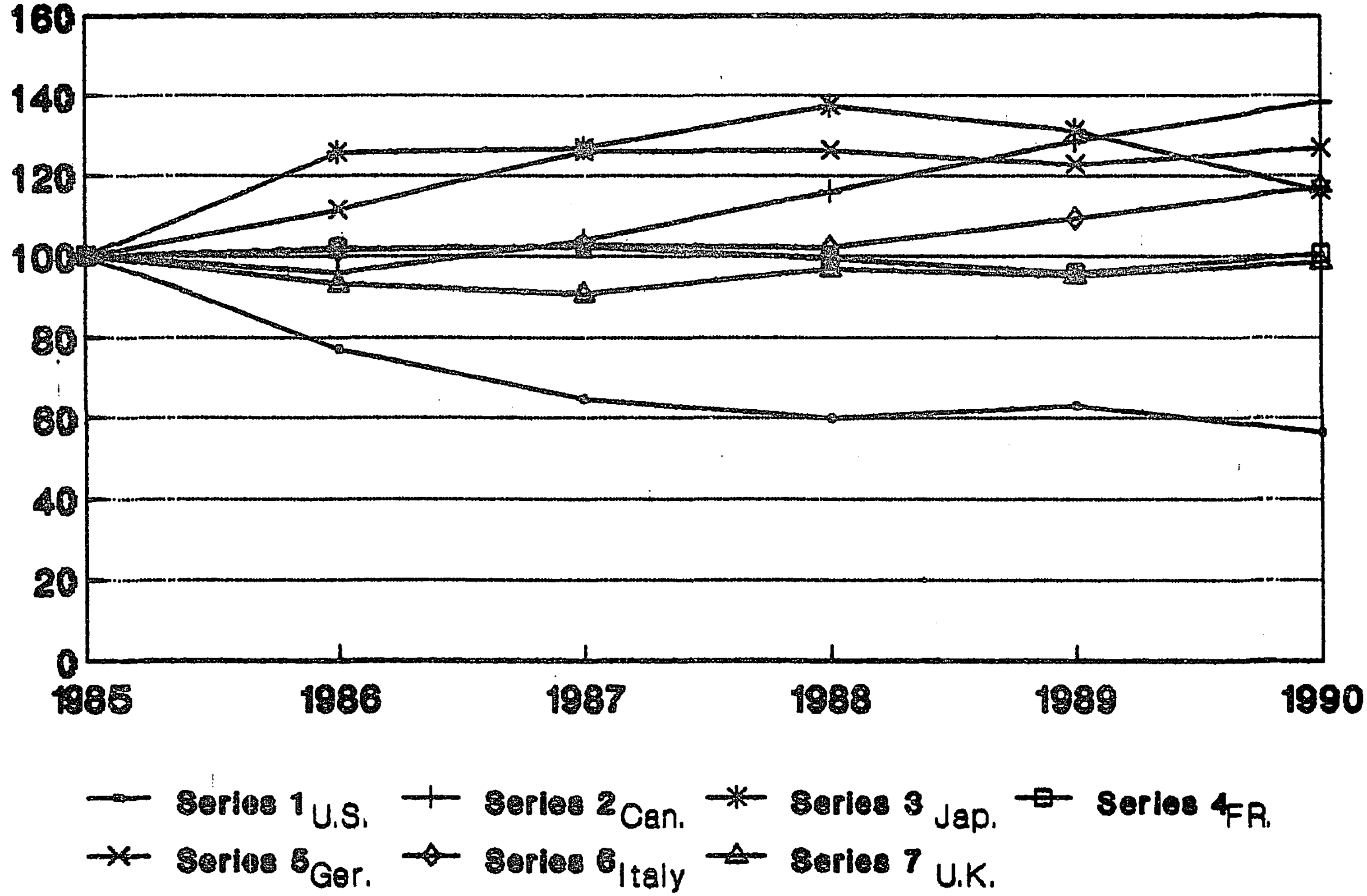
I.3. NEW INTERNATIONAL ECONOMIC ENVIRONMENT

Experience with floating exchange rates since early 1970s has revealed the violent and persistent nature of nominal and real exchange rate fluctuations. Fluctuations of real exchange rates for seven industrialized countries from 1985 to 1990 is shown in figure 1.[2] The fluctuations of nominal exchange rate of the U.S. dollar for the Japanese Yen on yearly, quarterly and monthly basis is shown in figure 2, 3 and 4 respectively.[3]

Volatility of exchange rates, observed in recent years, has had a negative impact on the competitiveness of firms in both local and global markets, if firm is located in the country whose currency has appreciated. Those firms, heavily invested in such countries, experience downward pressure in demand and upward pressure in cost - in relative terms -

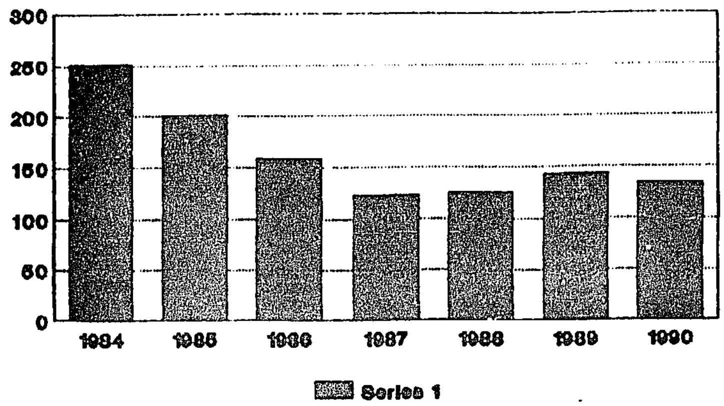
Real Effective Exchange Rates (1985=100)

Based on Relative Export Unit Values



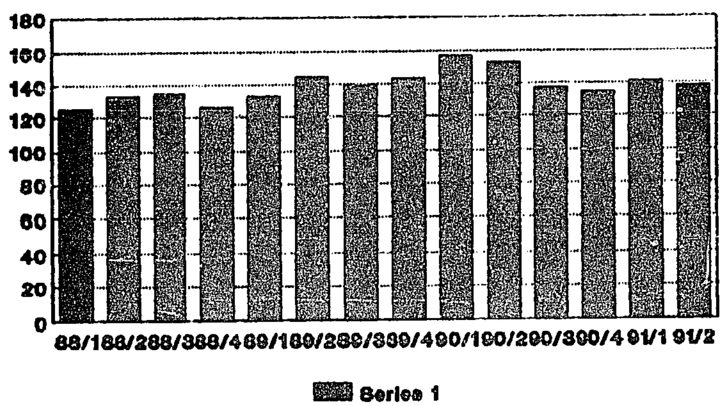
Source: International Financial Statistics, Oct 1991.

Japanese Yen Per U.S.$ Nominal
YEARLY, End of Period.



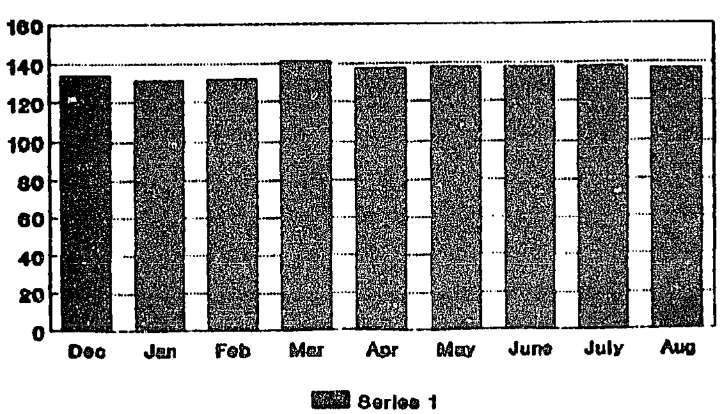
Source: Int. Fin. Statistics. Oct. 1991

Japanese Yen Per U.S.$Nominal
Quarterly, End of Period



Source: Int. Fin. Statistics.

Japanese Yen Per U.S.$Nominal
Montly, End of Period 1990-1991



Source: Int Fin Statistics.

after the appreciation of the local currency. Donald V. Fites, Executive Vice President of Caterpillar tractor puts the problem in the following statement "Let's face it. If you've got 75% of your assets in the U.S. and 50% of your sales outside it, and the dollar's strong, you've got problems."[4] Some Japanese companies such as Nissan had first time losses in 1986 since World War II following appreciation of Yen.[5]

Another observed phenomenon in recent years is the increasing nature of the international production, reflecting partially diversification efforts in response to increased fluctuations of exchange rates, and partially takeover opportunities created by over valued and undervalued currencies in other countries. Following the appreciation of Yen in 1986, Japanese started to buy many U.S. companies.To name a few, Firestone U.S. Tire Operation and one California Bank; second largest foreign takeover in the U.S..[6]

I.4. EXCHANGE RATE AND HEDGING

As internationalization of production increases, more and more companies become dependent on foreign sales in many different currencies "Last year, according to the Commerce Department, 19 percent of American corporate profits came from abroad up from 11.7 percent in 1986. In the first quarter of this year that percentage rose to 23.8 percent."[7] As a result of this, demand for insurance against adversity have increased.

Although it is possible to use certain financial instruments such as currency options for the purposes of hedging against unexpected changes in the value of currencies, they are either too costly or limited to short term insurance against adversity. They are limited to reduce transaction exposure of exchange rate risk.

Alternative hedging instrument is economic hedging. This involves diversification of plant locations, labor and supplies and offer longer term and/or lower cost of insurance. Economic hedging specifically regarding plant location is the focus of this dissertation. This kind of diversification targets long-term operating exposure.

I.5. NEW STRATEGIES IN INTERNATIONAL MARKETS

In Fortune Magazine going back to 1980, changes in strategy of Japanese companies reported as follows: "They got where they are by manufacturing at home and selling abroad. Now reluctantly, they're saying sayonara to all that."[8] Reasons vary for multinational companies to invest and produce abroad. High tariffs, national import quotas, transportation costs, securing raw materials, production in the market they serve to know the changing consumers' preferences, etc. Many of the most promising markets require not only local manufacturing but often local exporting too. In our study, we assume all of these motivations away and focus on exchange rate related risks and diversification of economic activity to reduce this risk.

There are many alternative strategies open to Multinational Corporations such as joint production, licensing, buying or building new plant in the host country, duplicating same production process in more than one country (horizontal diversification), moving production of some stages to another country (Vertical diversification) rather than the whole operation and financing issues such as raising funds in home or host country, reinvesting funds abroad, timing of repatriation of the profits so on and so forth.

In this study, I focus on three basic cases

(See figure 5)

1. **CASE A**

   (Superior to financial portfolio diversification)

   Production in both countries with cross shipments (See figure 6).

2. **CASE B**

   (Substitute for financial portfolio diversification)

   Production in both countries: No cross shipment is

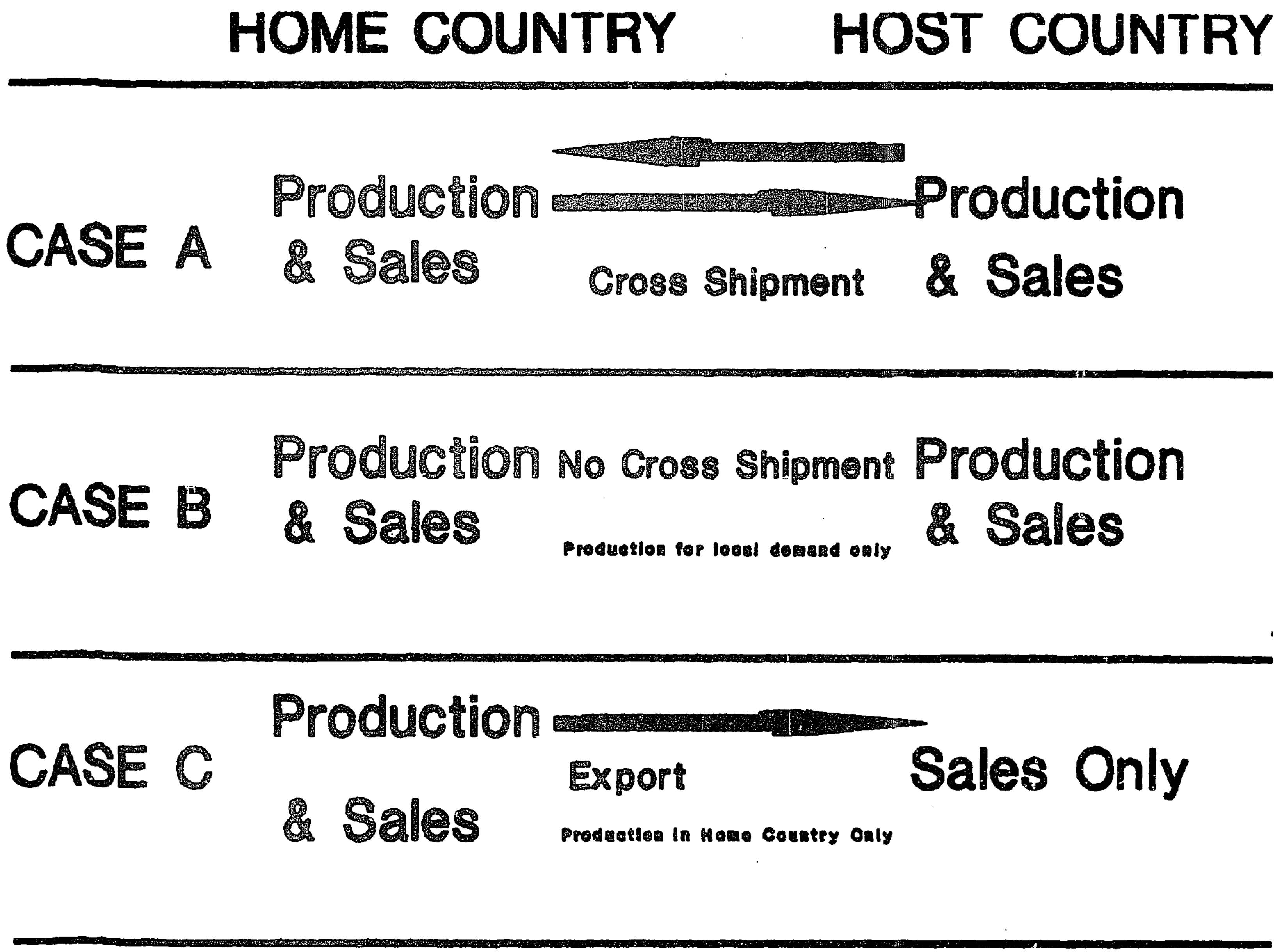
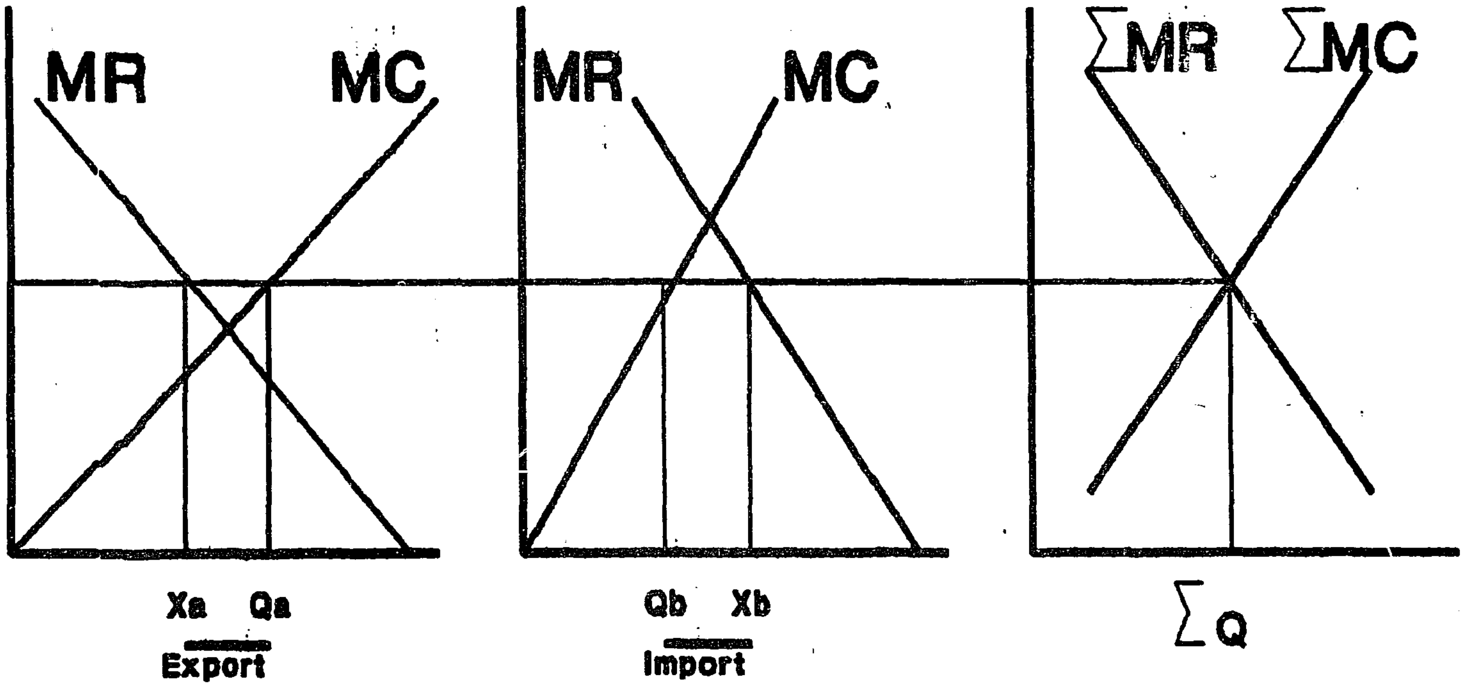


Figure 1: Graphical Description of Cases A, B and C

CASE A

Cross Shipments



Home Country Plant Host Country Plant

allowed between countries: This case is actually subset of Case A since in Case A, firm always has the option of not shipping overseas. Nevertheless, comparing these two Cases is important to measure the economic value of this option.

3. CASE C

(Case of no production diversification)

Export from home country to host country: It is assumed that there are two plants producing in home country to keep all of the above Cases comparable.

I.6. METHODOLOGICAL ISSUES

Basic structure of the problem is very simple. It is a maximization with more than one control variable. One parameter (exchange rate) of the model is subject to random shocks. Different restrictions are imposed on the model and results are compared.

Control variables are sales and production (X_is and q_is). Constraints are $\Sigma X_i = \Sigma q_i$ for Cases A and C, $X_i = q_i$ for every i for Case B. The constraints for Case c are same as Case A. In Case C, part of the model which is subject to reverse of the same stochastic process which is e and 1/e is redefined.

This dissertation is not a straightforward extension of a well defined discussion in the literature. Rather it is experimental and tries to redefine a new problem with many potential extensions in different areas of economics. A study of this kind needs to define basic premises of the model very carefully. That is the main objective of Chapter Two. Chapter Three extends this model to simulation analysis to discover regularities for possible future theoretical propositions.

A prominent feature of the study is employment of micro simulation techniques with profit maximizing agents.

I.7. OUTLINE OF THE THESIS

Absence of an integrated theory of Multinational Corporations and diversification opportunities created by negatively correlated exchange rate is explained in I.1. Survey of literature highlights few different routes that has been taken in the literature. Most studies try to explain motivational factors for Multinational Companies rather than the consequences of the phenomenon. Multinational Companies have been regarded as arbitrageur rather than a firm paying an option price for flexibility and diversity at a real cost. Following flexible exchange rate regime since 1970's wild fluctuations have been observed in real and nominal exchange rates. Section I.3. shows these fluctuations with real exchange rates for seven industrialized countries and nominal exchange rate between the U.S. dollar and Japanese yen.

Possible strategies followed by Multinational Companies are summarized in Section I.4. This study was in the mill for nearly five years. The first question asked by many people with whom I discussed this topic throughout this period was, why diversify production internationally if exchange rate exposure can be reduced by using financial hedging. This has been explained in Section I.5. We have been trained to see economic issues as a mathematical problem. Section I.6. explains the problem in terms of the objective function, constraints and control variables.

In Chapter Two, as theoretical model of Multinational Corporations is developed which is simple but capable of exploring a variety of related issues. Selection of the cost function and its relation to the underlying production function is carefully defined over the years.

Chapter Three presents a general discussion of Micro Simulations. Following the description of the model simulations and explanation of the generation of exchange rate processes used in simulation, sensitivity of the results to model parameters has been discussed. In Section III.5, computer programs and their usage in simulations are discussed. Section III.6 reports results of simulation in two different topics; Pass-Through Effects and Mean-Variance frontier.

Possible extensions of the model in different topics have been suggested in Chapter Four to give an idea of the possibility of extending this model to variety of subjects. Chapter 5 summarizes the dissertation and provides conclusions.

CHAPTER TWO

THE THEORETICAL MODEL

II.1. THE MODEL

There is a multinational corporation which produces a homogeneous good and acts as a monopoly in both domestic and foreign markets. Versions of the model explained in I.5 under Cases A, B and C.

This model is a partial equilibrium anaylsis; exchange rates are given and microeconomic forces underlying exchange rate is not investigated in another word commodity and currency prices are not tied together in the model.

Cost functions are derived from a Cobb Douglas production function with decreasing returns to scale, $\alpha + \beta < 1$. Production in one country is more profitable with increasing returns to scale and the need for the second plant disappears in Case C. Production will switch from one country to another at some exchange rate if constant returns to scale is present because MC of one of the plants will always be lower than that of the other irrespective of the output level. Plant use is not effected by exchange rates in Case C since both plants are located in the same country and the ratio of MC's are not an argument of the exchange rate.

It is assumed that because of the high cost of opening a new plant or for some other reason, it is not possible to build more plants than the existing ones. All plants are assumed to have the same cost structure and equal cost at some exchange rates. This exchange rate is taken as one in simulations but this has no specific importance and is chosen simply for convenience.

Tariffs, income tax, transportation costs are all assumed away. All the costs are born by plants. There is no firm costs above the plant for organization of the network, R & D etc.

Demand curves are assumed to be linear to allow for the change in price elasticity of demand when firm changes the optimal values of the variables in response to changes in the exchange rate. Importance of this assumption is to observe the change in pricing to the market or Price discrimination. With constant elasticities, magnitude of the discrimination would be fixed. Price discrimination in two market is possible and all the conditions of price discrimination such as monopoly power, high cost of arbitrage is assumed to be maintained.

Transfer price is not important because global profit maximization rather than the maximization of profits for decentralized units is assumed.

Quadratic, strictly concave utility functions are assumed in derivation of linear demand curves.[9]

Multinational company maximizes profits in its own currency. Basic model assumes that pricing and production discussion is made after the exchange rate is known for certainty. Then foreign price is announced by translating domestic price to foreign price at a realized exchange rate.

II.2. DEFINITION OF THE EXCHANGE RATE

Prices are assumed to be fixed, therefore changes in e reflect changes in the real exchange rate. This assumption helps us to isolate lagged adjustment of prices to exchange rates and some other complications from the model in order to focus on diversification issues.

e(t) is the price of host country currency in terms of home country currency at time t.

$$e = \frac{\text{Price in home country currency}}{\text{Price in host country currency}}$$

Translation to home country currency is calculated by using the following formula.

$$\text{Price in host country currency} = \frac{\text{Price in home country currency}}{e}$$

1/e(t) is price of the home country currency in terms of the host country currency.

II.3. THEORETICAL PROOFS

Π = Global Profit

A = Home Country

B = Host Country

X_A = Sales in Country A

X_B = Sales in Country B

Q_A = Production in Country A

Q_B = Production in Country B

TR_A = Total Revenue in Country A

$R_1 = dTR_A / dX_A$ Marginal Revenue in A

where

$R_1 > 0 \qquad R_{11} < 0$

$R_2 = dTR_B / dX_B$ Marginal Revenue in B

where

$R_2 > 0 \qquad R_{22} < 0$

$C_1 = dTC_A / dQ_A$ Marginal Cost in A

where

$C_1 > 0 \qquad C_{11} > 0$ Decreasing Return

e = Exchange Rate as defined previously

The following model is for a multinational corporation producing and selling in both countries. It is defined as case A previously. Proofs in this Chapter are based on this model. This version of the model is also simulated to compare different versions. Solutions and differences are highlighted in the following Chapter.

$$\Pi = TR_A(X_A) - TC(Q_A) + e * TR_B(X_B) - e * TC(Q_B)$$

Subject to,

$$X_A + X_B = Q_A + Q_B$$

$$MAX\ \Pi = TR_A(X_A) - TC(Q_A) + e * TR_B(X_B) - e * TC(Q_B) - \lambda * (Q_A + Q_B - X_A - X_B)$$

First order conditions:

$$\frac{\partial \Pi}{\partial X_A} = R_1 + \lambda = 0 ;$$

$$\frac{\partial \Pi}{\partial X_B} = e * R_2 + \lambda = 0 ;$$

$$\frac{\partial \Pi}{\partial Q_A} = C_1 + \lambda = 0 ;$$

$$\frac{\partial \Pi}{\partial Q_B} = e * C_2 + \lambda = 0 ;$$

$$\frac{\partial \Pi}{\partial \lambda} = Q_A + Q_B - X_A - X_B = 0 ;$$

Differentiating first order conditions yield;

$$R_{11} * dX_A + d\lambda = 0$$

$$de * R_2 + e * R_{22} * dX_B + d\lambda = 0$$

$$C_{11} * dq1 + d\lambda = 0$$

$$de * C_2 + e * C_{22} * dq_2 + d\lambda = 0$$

$$dQ_A + dQ_B - dX_A - dX_B = 0$$

$$\begin{bmatrix} R_{11} & 0 & 0 & 0 & 1 \\ 0 & e * R_{22} & 0 & 0 & 1 \\ 0 & 0 & C_{11} & 0 & 1 \\ 0 & 0 & 0 & e * C_{22} & 1 \\ -1 & -1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} dX_A \\ dX_B \\ dQ_A \\ dQ_B \\ d\lambda \end{bmatrix} = \begin{bmatrix} 0 \\ -R_2 \\ 0 \\ -C_2 \\ 0 \end{bmatrix} * de$$

$$\mathbb{D}_1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ -R_2 & e * R_{22} & 0 & 0 & 1 \\ 0 & 0 & C_{11} & 0 & 1 \\ -C_2 & 0 & 0 & e * C_{22} & 1 \\ 0 & 1 & -1 & -1 & 0 \end{bmatrix}$$

$$\mathbb{D}_1 = -(-R_2) \begin{vmatrix} 0 & C_{11} & 0 \\ 0 & 0 & e * C_{22} \\ 1 & -1 & -1 \end{vmatrix} + e\ R_{22} \begin{vmatrix} 0 & C_{11} & 0 \\ -C_2 & 0 & e * C_{22} \\ 0 & -1 & -1 \end{vmatrix}$$

$$\mathbb{D}_1 = -(-R_2)(-C_{11})(-e\ C_{22}) + e\ R_{22}\ (-C_{11})\ (C_2)$$

$$\mathbb{D}_1 = R_2\ C_{11}\ e\ C_{22} - e\ R_{22}\ C_{11}\ C_2 > 0$$

$$|\ \mathbb{D}_1\ | > 0 \qquad |\ \mathbb{D}_2\ | < 0$$

$$\frac{dX_1}{de} = \frac{|\ \mathbb{D}_1\ |}{|\ \mathbb{D}\ |} < 0$$

RESULT : If home country's currency appreciates (depreciates) sales in this country increases (decreases).

$$\mathbb{D}_2 = \begin{bmatrix} R_{11} & 0 & 0 & 0 & 1 \\ 0 & -R_2 & 0 & 0 & 1 \\ 0 & 0 & C_{11} & 0 & 1 \\ 0 & -C_2 & 0 & e * C_{22} & 1 \\ -1 & 0 & 1 & 1 & 0 \end{bmatrix}$$

$$\mathbb{D}_2 = R_{11} \begin{vmatrix} R_2 & 0 & 0 & 1 \\ 0 & C_{11} & 0 & 1 \\ C_2 & 0 & e * C_{22} & 1 \\ 0 & 1 & 1 & 0 \end{vmatrix} + \begin{vmatrix} 0 & -R_2 & 0 & 0 \\ 0 & 0 & -C_{11} & 0 \\ 0 & -C_2 & 0 & e * C_{22} \\ -1 & 0 & 1 & 1 \end{vmatrix}$$

$$\mathbb{D}_2 = R_{11} (-R_2) \begin{vmatrix} C_{11} & 0 & 1 \\ 0 & e * C_{22} & 1 \\ 1 & 1 & 1 \end{vmatrix} - R_{11} \begin{vmatrix} 0 & C_{11} & 0 \\ -C_2 & 0 & e * C_{22} \\ 0 & 1 & 1 \end{vmatrix}$$

$$- (-R_2) \begin{vmatrix} 0 & C_{11} & 0 \\ 0 & 0 & e * C_{22} \\ -1 & 1 & 1 \end{vmatrix}$$

$$\mathbb{D}_2 = R_{11} (-R_2) C_{11} (-1) + R_{11} (-R_2) (-e C_{22})$$

$$- R_{11} (-C_{11}) (-C_2) - (-R_2) (-C_{11}) e C_{22}$$

$$\mathbb{D}_2 = R_{11} R_2 C_{11} + R_{11} R_2 e C_{22} - R_{11} C_{11} C_2 - R_2 C_{11} e C_{22}$$

Since MR = MC, R = C

$$R_{11} C_{11} (R_2 - C_2) = 0$$

$$\mathbb{D}_2 = R_{11} R_2 e C_{22} - R_2 C_{11} e C_{22} < 0$$

$$| \mathbb{D}_2 | < 0 , \quad | \mathbb{D} | < 0$$

$$\frac{dX_2}{de} = \frac{| \mathbb{D}_2 |}{| \mathbb{D} |} > 0$$

RESULT: If home country's currency appreciates (depreciates) sales in host country decreases (increases).

$$\mathbb{D}_3 = \begin{bmatrix} R_{11} & 0 & 0 & 0 & 1 \\ 0 & e * R_{22} & -R_2 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & -C_2 & e * C_{22} & 1 \\ -1 & -1 & 0 & 1 & 0 \end{bmatrix}$$

$$\mathbb{D}_3 = R_{11} \begin{vmatrix} e * R_{22} & -R_2 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & -C_2 & e * C_{22} & 1 \\ -1 & 0 & 1 & 0 \end{vmatrix} + \begin{vmatrix} 0 & e * R_{22} & -R_2 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & -C_2 & e * C_{22} \\ -1 & -1 & 0 & 1 \end{vmatrix}$$

$$\mathbb{D}_3 = R_{11}\ (e\ R_{22}) \begin{vmatrix} 0 & 0 & 1 \\ -C_2 & e * C_{22} & 1 \\ 0 & 1 & 0 \end{vmatrix} + R_{11} \begin{vmatrix} -R_2 & 0 & 1 \\ 0 & 0 & 1 \\ -C_2 & e * C_{22} & 1 \end{vmatrix} + \begin{vmatrix} e * R_{22} & -R_2 & 0 \\ 0 & 0 & 0 \\ 0 & -C_2 & e * C_{22} \end{vmatrix}$$

$$\mathbb{D}_3 = R_{11}\ e\ R_{22}\ (-C_2) + R_{11}\ (-e\ C_{22})\ (-R_2)$$

$$\mathbb{D}_3 = -R_{11}\ R_{22}\ e\ C_2 + R_{11}\ R_2\ e\ C_{22} < 0$$

$$|\ \mathbb{D}_3\ | < 0\ , \quad |\ \mathbb{D}\ | < 0$$

$$\frac{dq_1}{de} = \frac{|\ \mathbb{D}_3\ |}{|\ \mathbb{D}\ |} > 0$$

RESULT: If home country's currency appreciates (depreciates) production in this country decreases (increases)

$$\mathbb{D}_4 = \begin{bmatrix} R_{11} & 0 & 0 & 0 & 1 \\ 0 & e * R_{22} & 0 & -R_2 & 1 \\ 0 & 0 & C_{11} & 0 & 1 \\ 0 & 0 & 0 & -C_2 & 1 \\ -1 & -1 & 1 & 0 & 0 \end{bmatrix}$$

$$\mathbb{D}_4 = R_{11} \begin{vmatrix} e * R_{22} & 0 & -R_2 & 1 \\ 0 & C_{11} & 0 & 1 \\ 0 & 0 & -C_2 & 1 \\ -1 & 1 & 0 & 0 \end{vmatrix} + \begin{vmatrix} 0 & e * R_{22} & 0 & -R_2 \\ 0 & 0 & C_{11} & 0 \\ 0 & 0 & 0 & -C_2 \\ -1 & -1 & 1 & 0 \end{vmatrix}$$

$$\mathbb{D}_4 = R_{11}\ e\ R_{22} \begin{vmatrix} C_{11} & 0 & 1 \\ 0 & -C_2 & 1 \\ 1 & 0 & 0 \end{vmatrix} - (R_{11})\ (-1) \begin{vmatrix} 0 & -R_2 & 1 \\ C_{11} & 0 & 1 \\ 0 & -C_2 & 1 \end{vmatrix}$$

$$- (-1) \begin{vmatrix} e * R_{22} & 0 & -R_2 \\ 0 & C_{11} & 0 \\ 0 & 0 & -C_2 \end{vmatrix}$$

$$\mathbb{D}_4 = R_{11}\ e\ R_{22}\ C_2 + R_{11}\ (-C_{11})\ [(-R_2) - (-C_2)] +$$

$$e\ R_{22}\ C_{11}\ (-C_2)$$

since $R_2 = C_2$

$$\mathbb{D}_4 = R_{11}\ e\ R_{22}\ C_2 + e\ R_{22}\ C_{11}\ (-C_2) > 0$$

$$\frac{dq_2}{de} = \frac{|\ \mathbb{D}_4\ |}{|\ \mathbb{D}\ |} < 0$$

RESULT: If home country's currency appreciates (depreciates) production in this country increases (decreases).

CHAPTER THREE

SIMULATION ANAYLSIS

III. 1 MICRO SIMULATIONS

Micro simulations are designed to describe the process of the interaction between economic agents within a given scenario. This scenario may include the optimizing agents or simply mimicks some observed behaviors, some other postulated behaviors which have not been proved to be optimal.

In this study, there is only one agent, multinational corporation in three different structures subject to different type of exchange rate shocks which uses different prediction rules with different degrees of rationality. Different learning and expectation schemes from very simple to very complex ones is accommodated in this simulation. Results are investigated in different price setting behaviors. Centralized (at the firm level) optimization is assumed.

Different routes may be taken in either theoretical or empirical form to investigate any one of the above settings. Advantages of simulation are explained below.

1. Some theoretical proofs may not be possible with conventional tools.
2 Existence of certain relationships may be detected from the observation of the simulation results.

3. Ambiguous results may be represented with sensitivity analysis.
4. We can explore nonlinearities and their sources. Investigate sensitivity of nonlinearities to functional forms.
5. Prepare artificial data based on certain assumptions and structural forms to be regressed with the observed variables.
6. Values of the variables outside the range of those experienced may be included in simulation.
7. Simulation helps us to separate the effect which is useful where colinearity between explanatory variables exists.
8. Explanatory variables may take on combinations of values not experienced previously.
9. It is useful to study dynamic analysis.
10. Switches of regime are easily accommodated.

Regression may fail to discover what is behind some visible data produced by the system. Many more interactions as a part of the process under the study may be experimented, made visible or ruled out by simulation analysis.

In simulation, deductive anaysis of the formal models is replaced with inductive analysis of numerical results. However those are the results that may motivate the new directions in formal modeling. One potential problem is easiness of introducing many variables into the scenario. Many of these details may be in secondary importance in reality however, results of the simulation may be considerably affected with these details. Staging the play with a component of the same abstraction level requires researcher's common sense.

Simulations also help to form hypothesis, which could then be tested or proved with more traditional methods. For better exposition of simulations and its application in labor market, see Bergman [1973, 1990].

III.2. DESCRIPTION OF THE MODEL USED IN SIMULATION

P1(t)=a-b*x1(t)+d*(e(t)-1) Demand 1

P2(t)=a*e(t)-b*e(t)*x2(t)-d*(e(t)-1) Demand 2

e(t)-1 shifts the distribution of e(t) to $\mu = 0$, therefore negative and positive shocks can be observed on the same demand curve. Sign of d is assumed to be (+) in demand 1 and (-) in demand 2 to ensure opposite movements in demand curves in both countries. P2 is already converted into home country currency and exchange rate shocks calculated on this demand curve to ensure substitution effects are perfectly symmetric.

$$\frac{\partial P1(t)}{\partial (e(t))} > 0 \quad \text{In country 1}$$

$$\frac{\partial P2(t)}{\partial (e(t))} < 0 \quad \text{In country 2}$$

$tr1(t)=P1(t)*x1(t)$ Total Revenue 1

$tr2(t)=P2(t)*x2(t)$ Total Revenue 2

$tc1(t)=k+cq1^2(t)$ Total Cost 1

$tc2(t)=(k+cq2^2(t))*e(t)$ Total Cost 2

Where k is fixed cost and tc2 is expressed in terms of the home country currency.

$PI(t)=Pi1(t)+Pi2(t)$ Total Profit

$Pi1(t)=tr1(t)-tc1(t)$ Profit from home country operation

$Pi2(t)=tr2(t)-tc2(t)$ Profit from host country operation

All profits again are calculated in terms of home country currency. Transfer prices are assumed zero, consistent with global maximization. Therefore, pi1 and pi2 are not meaningful measure of the individual operations.

$Ex(t)=q1(t)-x1(t)$

Ex(t) is the export from home country plant to host country.

CONSTRAINTS

CASE A

$x1(t)+x2(t)=q1(t)+q2(t)$

CASE B

$x1(t)=q1(t)$ and $x2(t)=q2(t)$

For simplication purposes, $x_i(t)$s are replaced with $q_i(t)$s

CASE C

$x1(t)+x2(t)=q1(t)+q2(t)$

q2 is the output of the second plant located in home country.

a = 200;   b = 1;   c = 2;   k = 20

OPTIMAL SOLUTIONS USED IN SIMULATION

CASE A

$$\Pi = (a-b*X_1+d*(e-1))*X_1-C*q_1^2+(a*e-b*e*X_2-d*(e-1))*X_2-e*C*q_2^2$$
$$-\lambda*(X_1+X_2-q_1-q_2)$$

$$\frac{\partial \Pi}{\partial X_1} = a - 2 * b * X_1 + d * (e-1) - \lambda = 0$$

$$\frac{\partial \Pi}{\partial X_2} = a * e - 2 * b * e * X_2 - d * (e-1) - \lambda = 0$$

$$\frac{\partial \Pi}{\partial q_1} = - 2 * C * q_1 + \lambda = 0$$

$$\frac{\partial \Pi}{\partial q_2} = - 2 * C * e * q_1 + \lambda = 0$$

$$\frac{\partial \Pi}{\partial \lambda} = X_1 + X_2 - q_1 - q_2$$

$$\begin{bmatrix} 2*b & 0 & 0 & 0 & 0 \\ 0 & 2*b*e & 0 & 0 & 0 \\ 0 & 0 & -2*c & 0 & 0 \\ 0 & 0 & 0 & -2*c* & e1 \\ -1 & -1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ q_1 \\ q_2 \\ \lambda \end{bmatrix} = \begin{bmatrix} a+d*(e-1) \\ a-d*(e-1) \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

CASE B

$$\Pi = (a-b*q_1+d(e-1))*q_1-c*q_1^2+(e*a-e*b*q_2-d*(e-1))*q_2-e*c*q_2^2$$

$$\frac{\partial \Pi}{\partial q_1} = a-2*b*q_1+d*(e-1)-2*C*q_1$$

$$\frac{\partial \Pi}{\partial q_2} = e*a-2*e*b*q_2-d*(e-1)-2*C*q_2$$

$$q_1 = \frac{a + d * (e-1)}{2 * b + 2 * C}$$

$$q_2 = \frac{e * a - d * (e-1)}{2 * e * b + 2 * e * c}$$

CASE C

$$\begin{bmatrix} 2*b & 0 & 0 & 0 & 1 \\ 0 & 2*b*e & 0 & 0 & 1 \\ 0 & 0 & -2*c & 0 & 1 \\ 0 & 0 & 0 & -2*c & 1 \\ -1 & -1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ q_1 \\ q_2 \\ \lambda \end{bmatrix} = \begin{bmatrix} a + d*(e-1) \\ a*e-d*(e-1) \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

III.3. GENERATION OF EXCHANGE RATE OF PROCESSES USED IN SIMULATIONS

Random numbers are generated by using Matlab "rand" command. Rand produces numbers for standard normal curve $\mu = 0$, $\sigma = 1$. I used the formula e = rand * .3 + 1 to shift the mean to 1 and lower the standard deviation to .3. All the simulations in this study started with zero seed. To avoid any mistake, simulations are written to display the seed before simulation starts.

Markov process follows e(t) = e(t - 1) + rand * .03. There is no drift and variance is smaller.

Cyclical exchange rates are generated by using the following formula e = sin(t) * .3 + 1 + rand(t) * 0.05. Basically, sinus curve loaded with white noise.

III.4. DO PARAMETERS MATTER: SENSITIVITY ANALYSIS

Reported results in this study obviously depend on the functional forms assumed and may change substantially for other functional forms. On the other hand, results are a good representation of many other simulation using different parameters for the same model. First of all, some functional form free proofs are shown in Chapter Two and repeated in simulation analysis to compare the results of the simulation with different parameters which was not part of the model in Chapter Two. Second, e is multiplied by the parameters of the model (intercept and slope of the MR and MC) and is subject to different shocks within a reasonable interval. This process itself can easily be treated as a senstivity analysis. For this reason, senstivity analysis on a, b, c, k is not conducted. Substitution effect parameter d is not multiplied by e and that is why I run the simulations for different d values (d=0 and d=10).

Generality or lack of generality of the results can be established either by empirical testing or attempting theoretical proofs of the implications noted in this Chapter. Although results are fairly general and intuitive, another reason for the simulation is to detect some regularities which is not obvious to the naked eyes or for quick testing of hypothesis.

III.5. COMPUTER PROGRAMS USED IN SIMULATION

Matlab is used for simulation and R.A.T.S. for regression analysis. Data is produced with Matlab than transferred into R.A.T.S. for regression analysis. Some results are printed directly with Matlab and some with Harvard Graphics.

Matlab simulations are written to be used interactively. Although degree of interaction may very well be made much more complicated, it is still possible to experiment with different time periods, stochastic processes and parameters of the model.

Sections of the model are named as parameters, initializations, generation of the model, optimal solutions, calculations and graphs. Pause statements help the user to review each section. Echo is turned on to follow the loops.

First part of the program sets the structural parameters (a, b, c, k and d) of the model.

Second part initializes the vector to be used. Sizes are set according to the number of iterations which is entered interactively and filled with 0s. Although program is capable of setting matrice's to the desired sizes, filling with zero in each start eliminates the possibility of having any junk left from previous runs. Since dynamic interactions are expected and used during simulation processes, this is a good insurance against unexpected results.

Following part is generation of random numbers and more on this was explained previously. The section on optimal solutions finds the optimal values of Xs and qs for Cases A, B and C. The section on calculations contains the calculations of profits, prices, pass-through etc. More calculations have been done outside this program. I tried to keep those variables inside the program that will be used in further calculations. After running program, these basic variables may be stored and used by side programs to produce more variables.

I followed the same principles on graphs section and, included few basic graphs as part of the simulation program. Most of the graphs in this study are drawn by using small subroutines and saved in meta files and printed separately with publication quality.

III.6.A EXCHANGE RATE PASS THROUGH

Much of the literature on pass through emphasizes the imperfect competition from monopoly to different formulation of oligopoly. (See Feenstra 1989, Fisher 1989). But none of them emphasizes the importance of international network of multinational corporations and their abilities to shift production and the effect of international diversification on pass through. Pricing to markets for a multinational firm is emphasized in Marston [1990] but in this case the firm produces only in one country and sells in two countries. For a general survey of the pass through literature and definitions, see Hooper [1989].

Pass through literature defines the pass through in few different ways. Two of them are from exchange rates to import prices or from import prices to domestic prices. In this study, pass through is defined from exchange rate to domestic price of the tradeable. This method also eliminates the need for choice of an index and the difficulties associated with the choice of index. See Feinberg [1991] on the choice of index in calculation of pass through effects.

In this dissertation, the pass throughs are defined as following :

APas1(t) = Pass through in Case A (cross shipment) for Country 1 (home country) at time t

$$APas1(t) = \frac{[Ap1(t) - Ap1(t-1)] / Ap1(t-1)}{[e(t) - e(t-1)] / e(t-1)}$$

where Ap1(t) is price in Case A for country 1 at time t, Apas2(t) = Pass through in Case A for country 2 (host country) at time t

$$APas2(t) = \frac{[Ap2HC(t) - Ap2HC(t-1)] / Ap2HC(t-1)}{[1/e(t) - 1/e(t-1)] / [1/e(t-1)]}$$

where

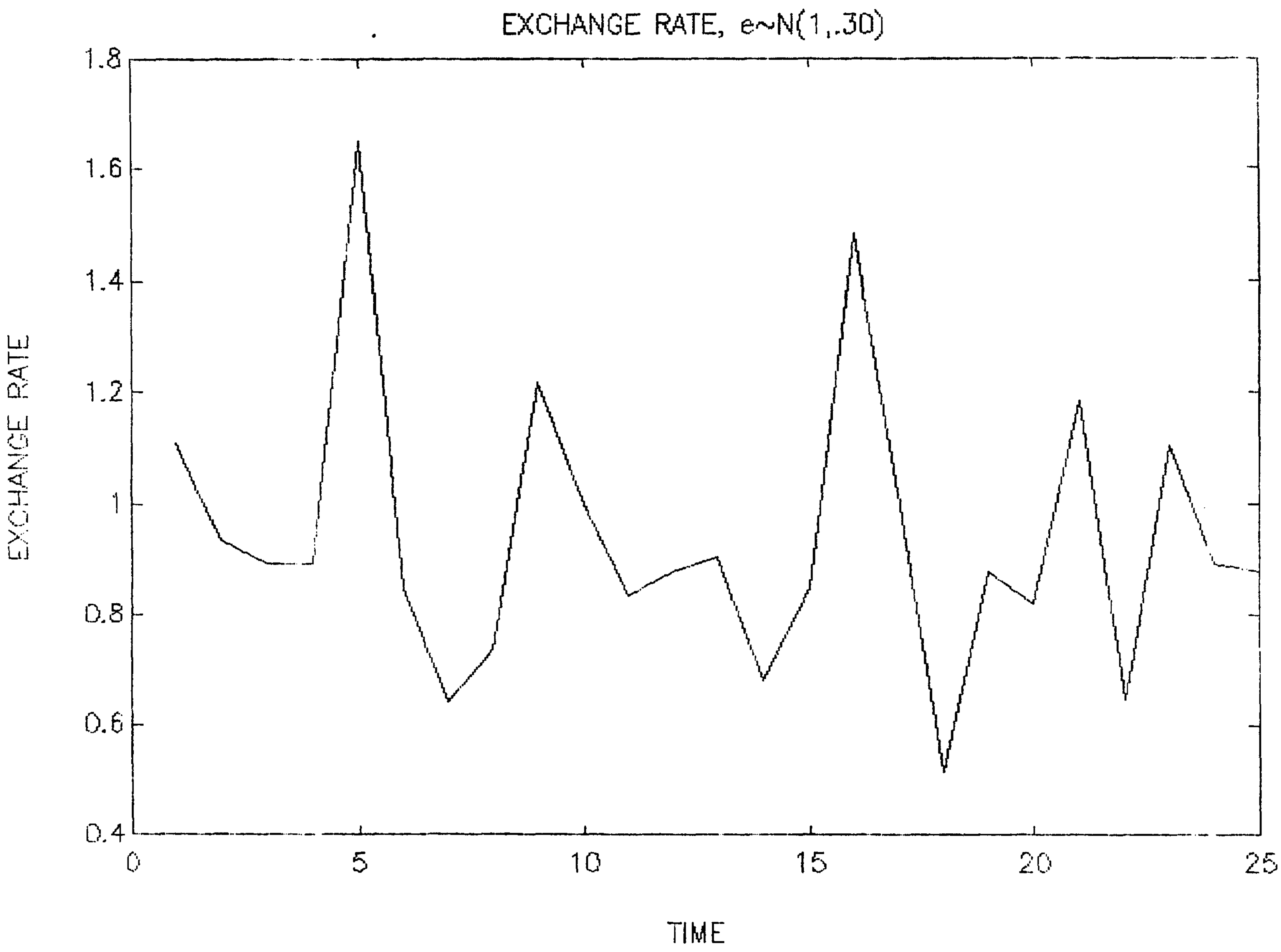
Ap2HC(t) = Price in country 2 expressed in Host Country currency.

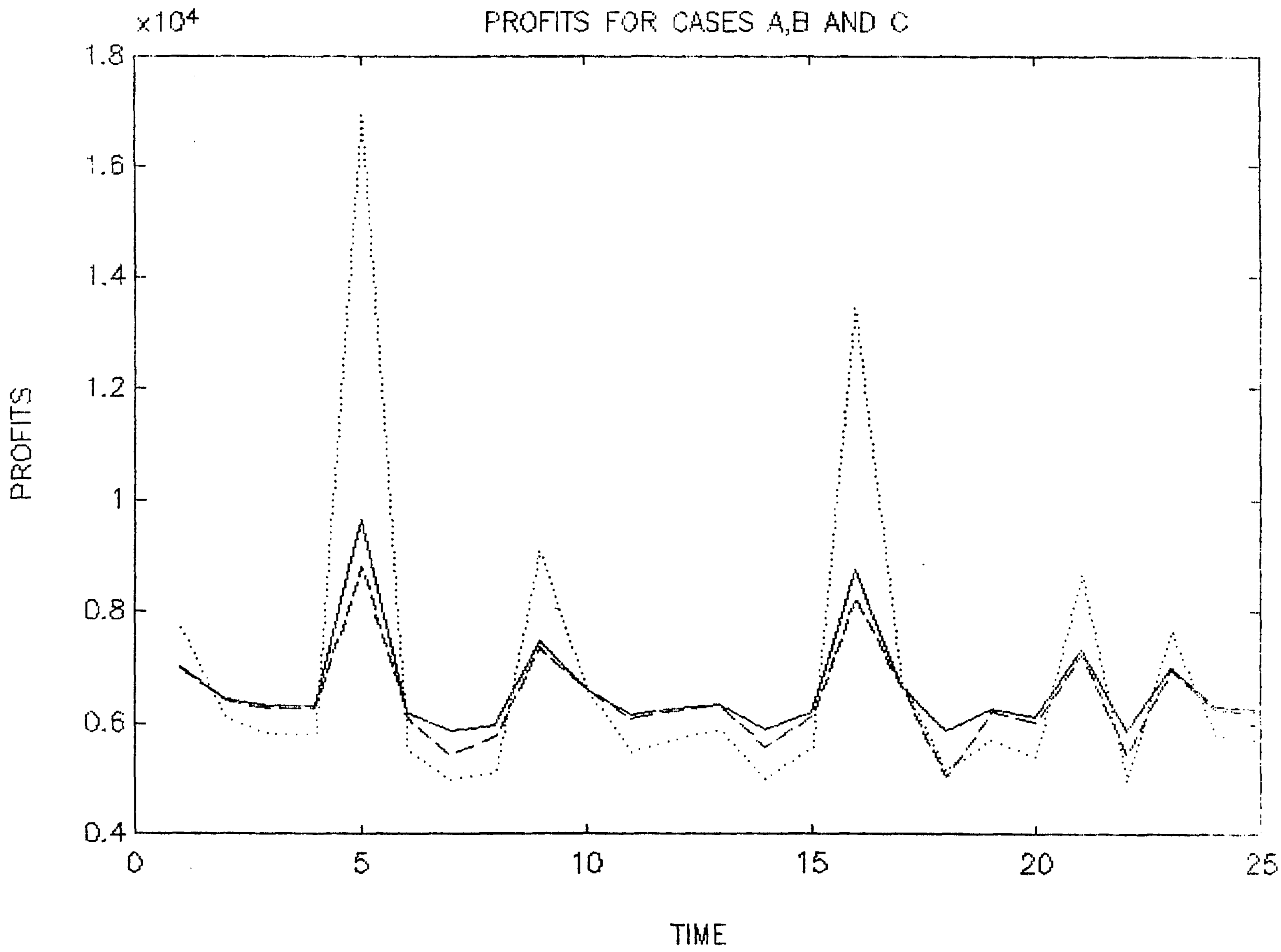
Ap2HC(t) = Ap2(t) / e(t)

Pass throughs are calculated by using local currencies and the exchange rate is defined as the local currency price of one unit of foreign currency.

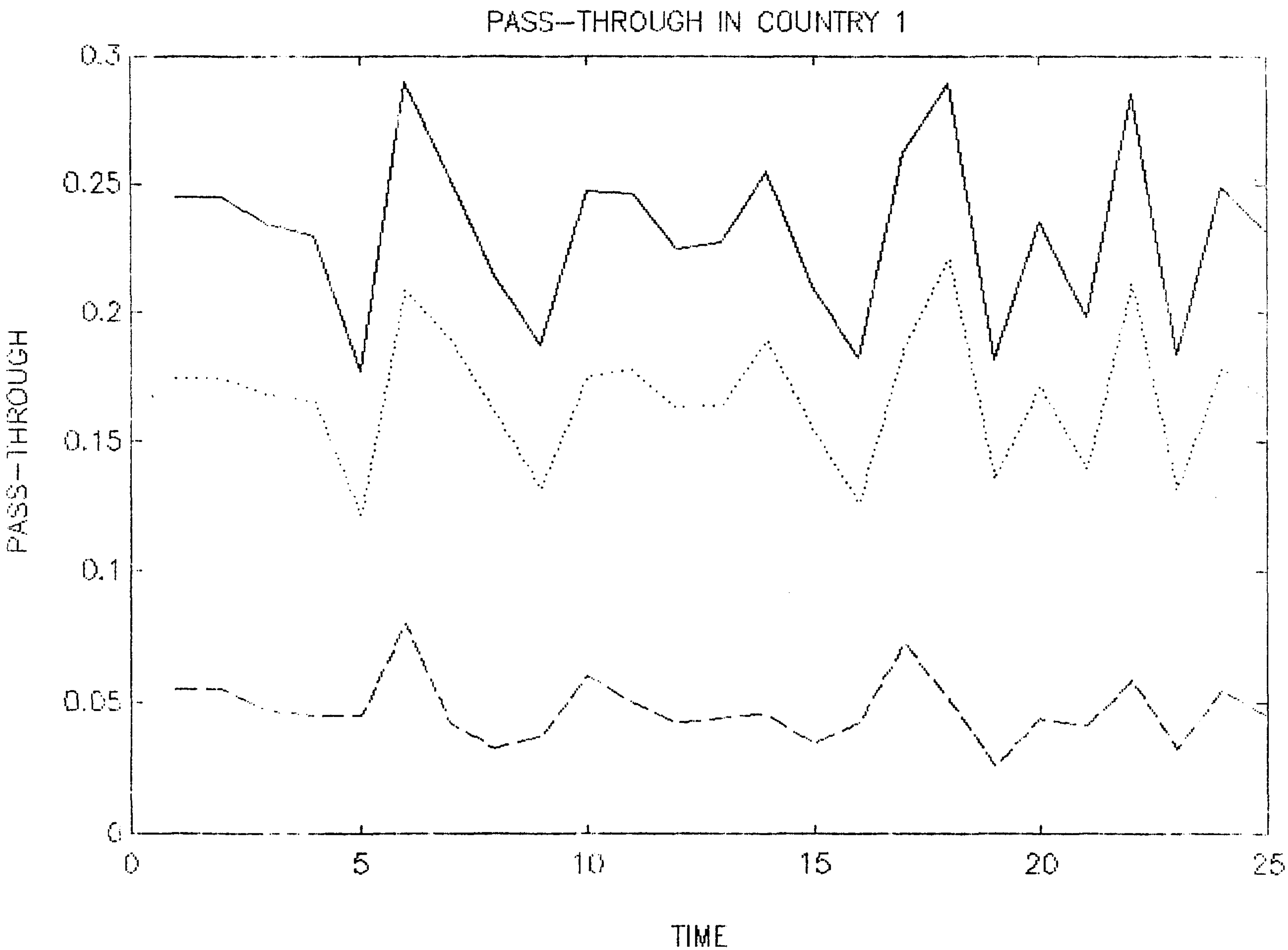
Product in question can either be produced or imported or both. It is sold in a market where there are imperfect substitutes. Depreciation increases the foreign cost of production in terms of local currency and consequently the import price of the product. To bring both MCs to the same level, domestic production increases and foreign production and import decrease. All of these complications in my model differentiate the pass through effects obtained elsewhere in the literature. Basic movements of sales and production in both countries as a result of exchange rate have been investigated in Chapter Two.

If product is completely imported from another country, exchange rate depreciation will increase the cost of imported material without cushioning effect of higher local production

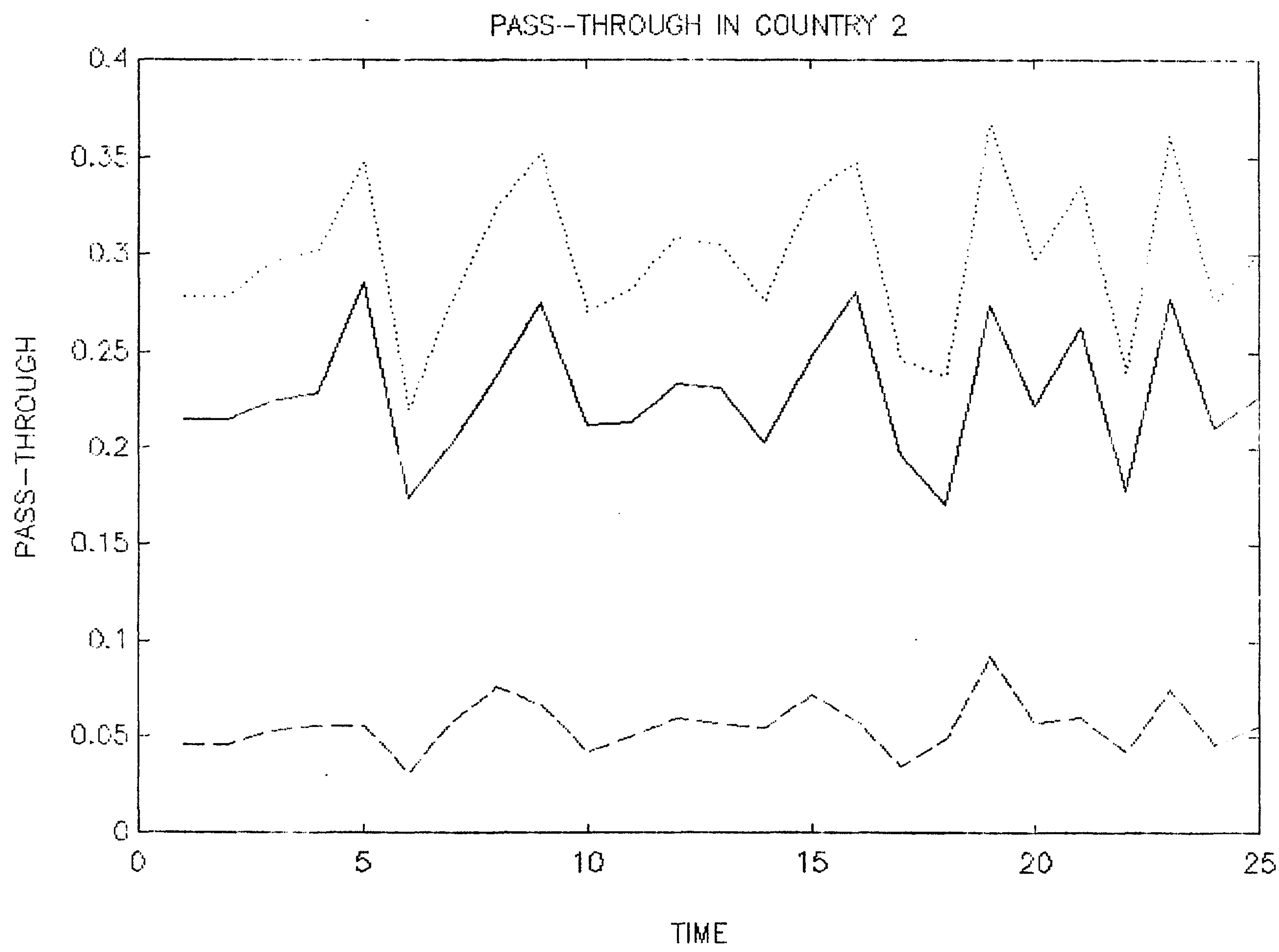

EXCHANGE RATE, e~N(1,.30)
EXCHANGE RATE
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0
5
10
15
20
25
TIME

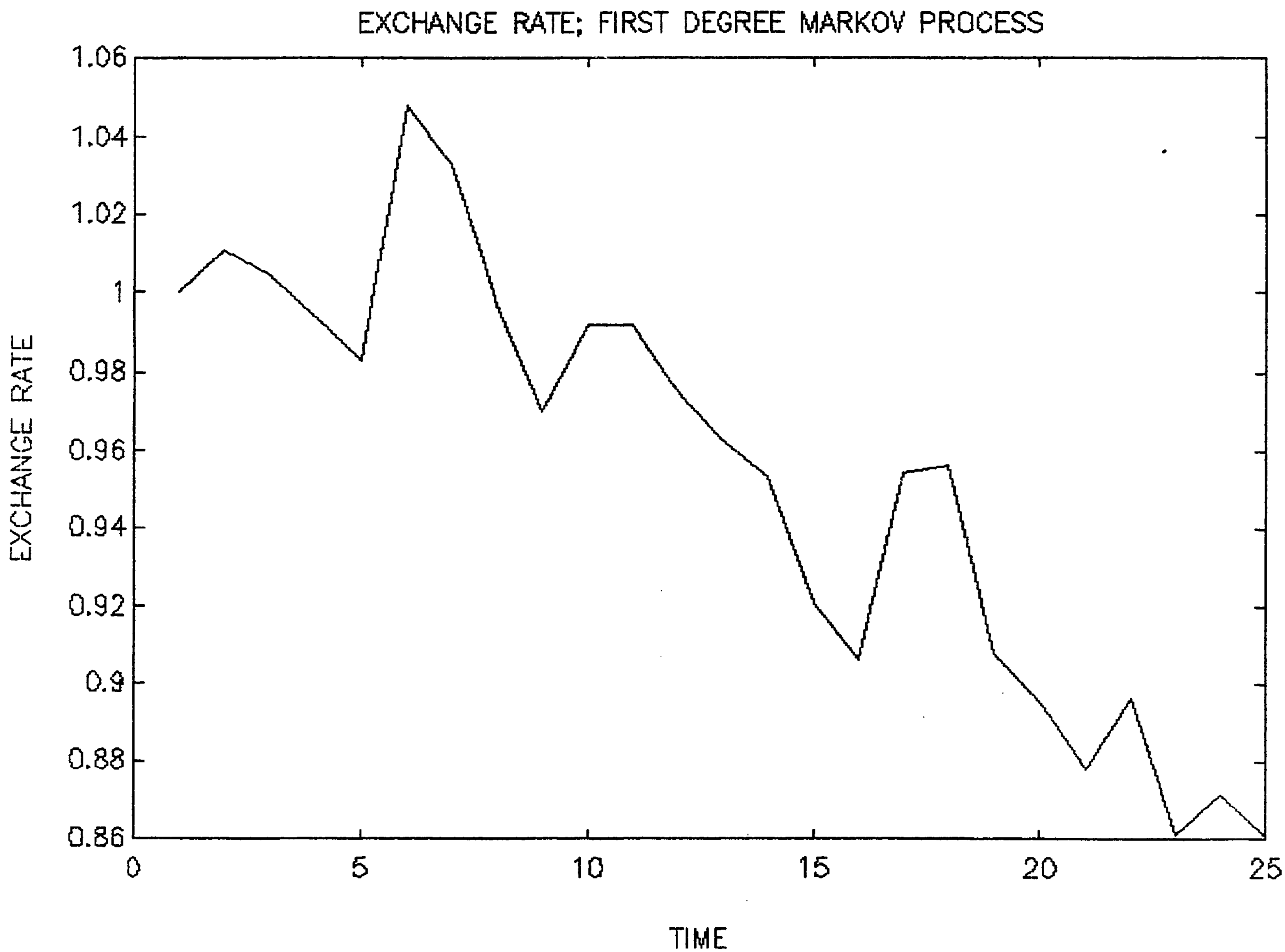


PROFITS FOR CASES A,B AND C
x10⁴
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
PROFITS
0
5
10
15
20
25
TIME

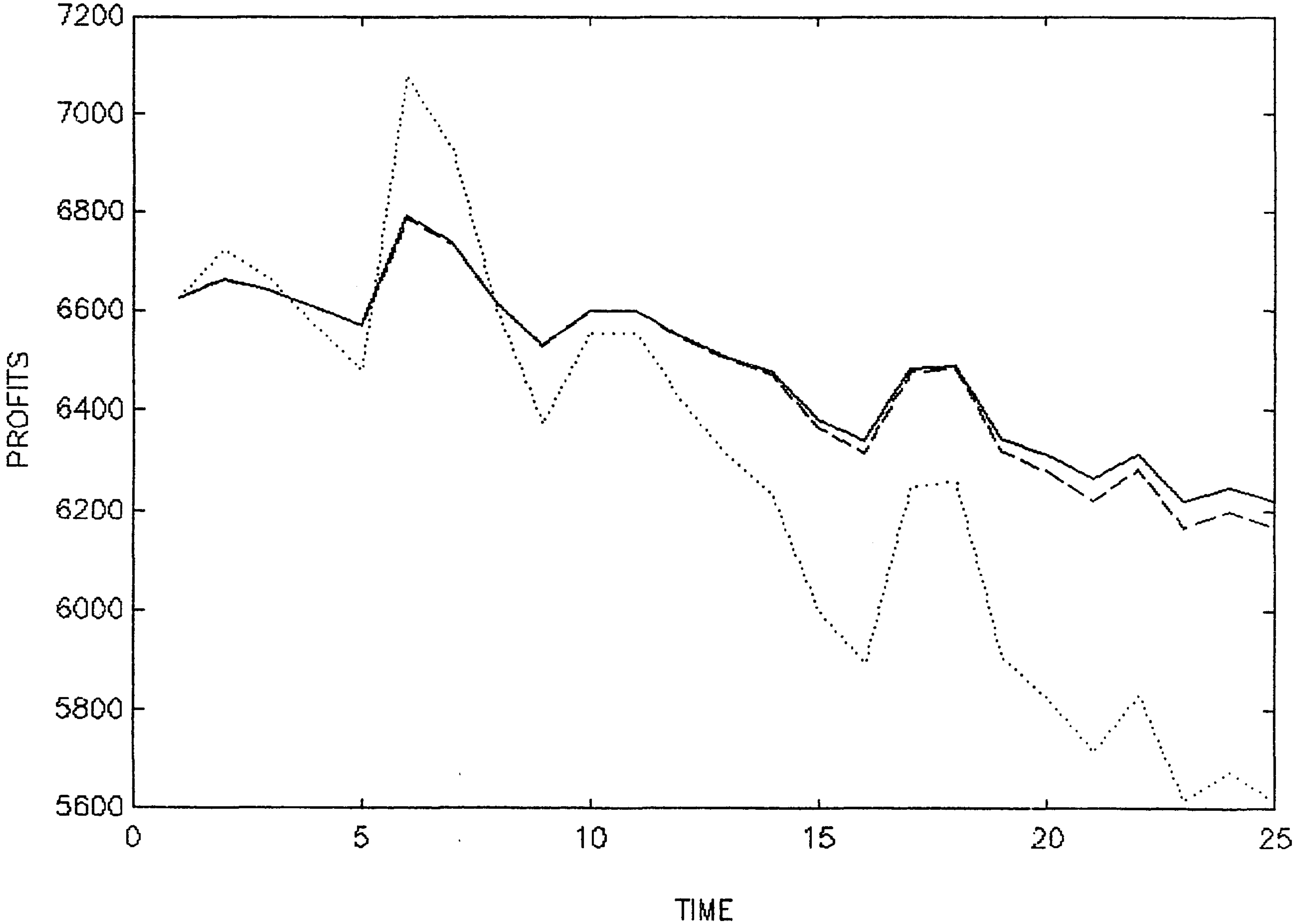


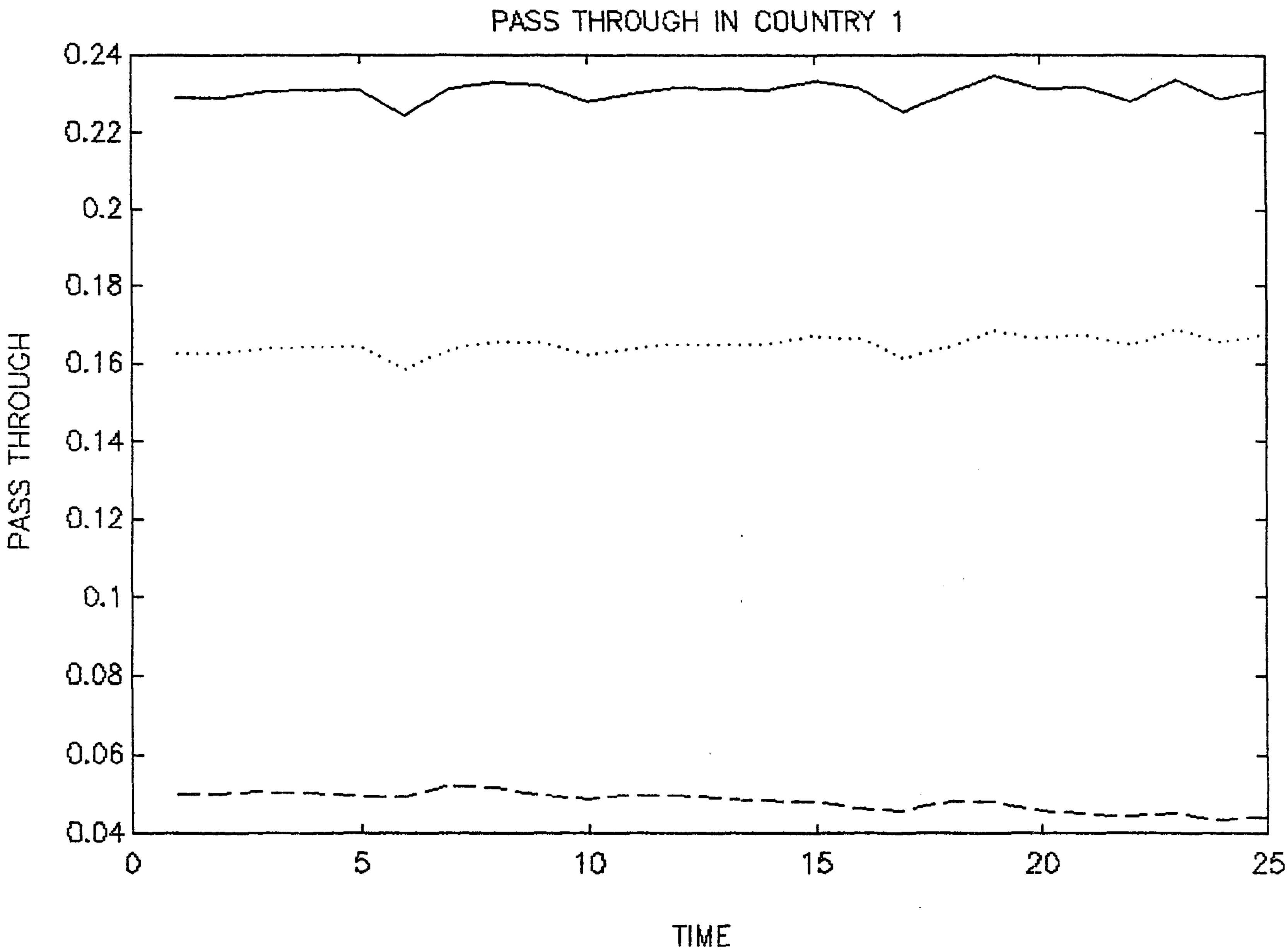
PASS-THROUGH IN COUNTRY 1
PASS-THROUGH
TIME
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25

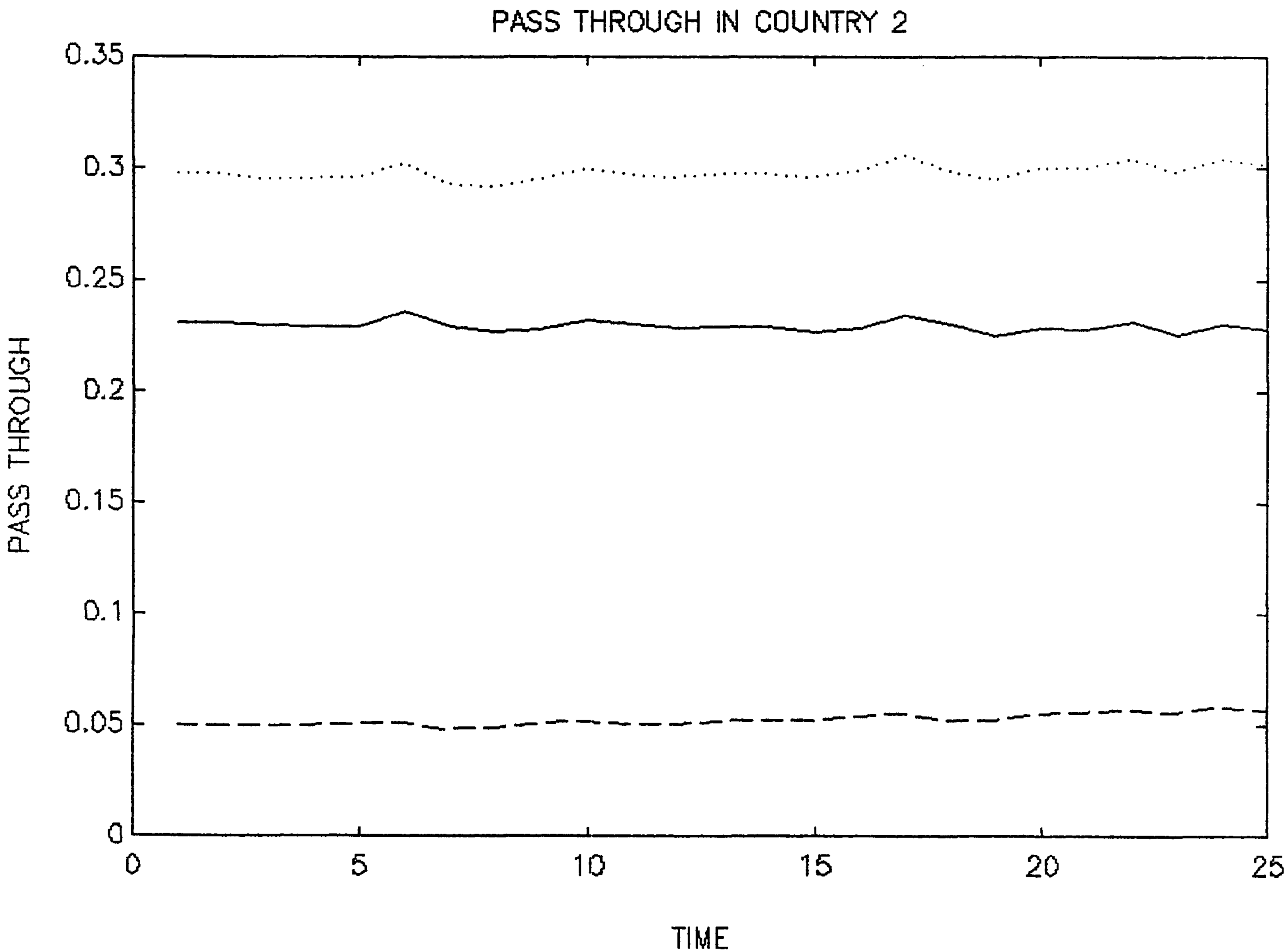

PASS-THROUGH IN COUNTRY 2
PASS-THROUGH
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
TIME


EXCHANGE RATE; FIRST DEGREE MARKOV PROCESS
EXCHANGE RATE
TIME
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0
5
10
15
20
25

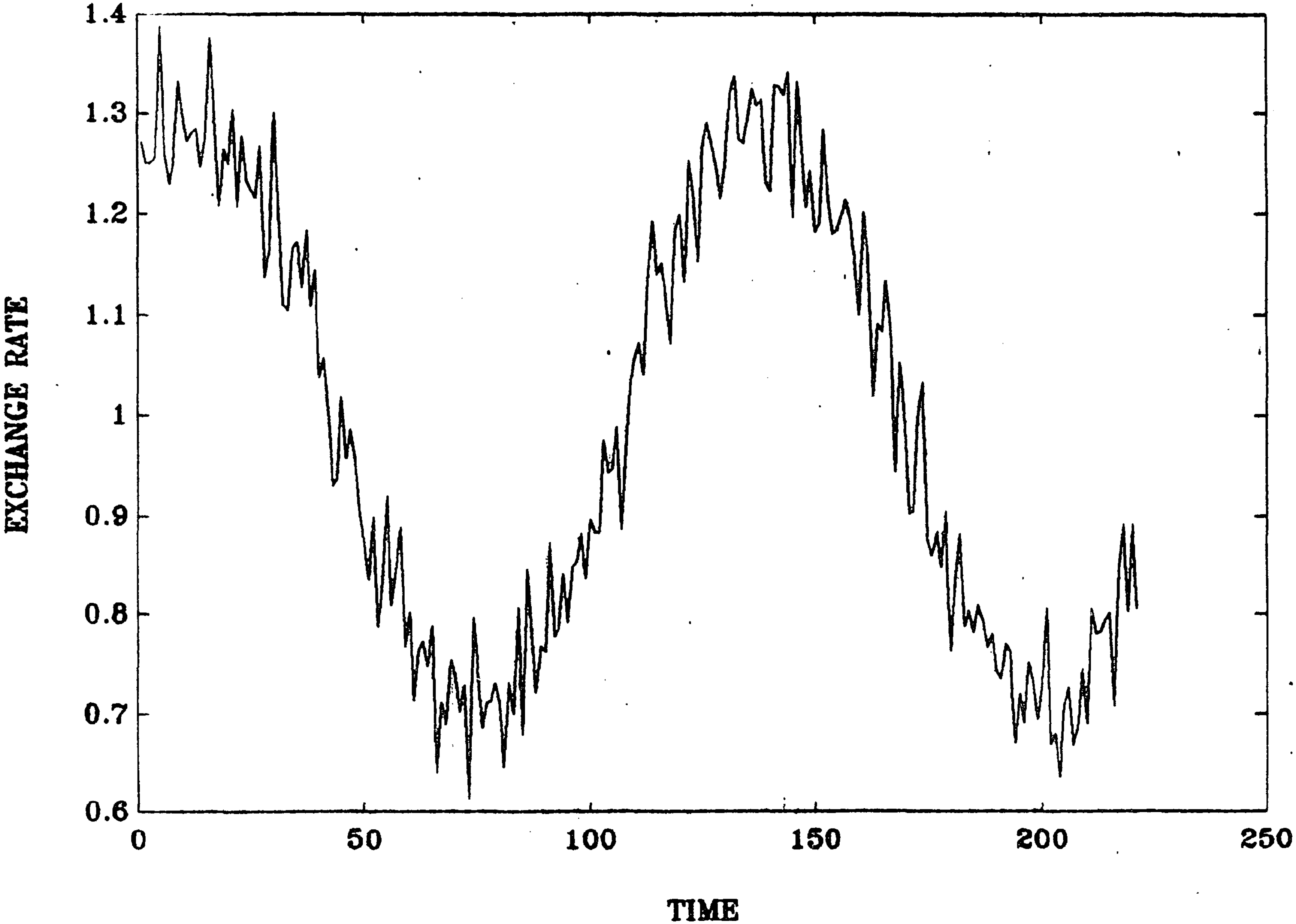
PROFITS FOR CASES A,B AND C. FIRST DEGREE MARKOV PROCESS



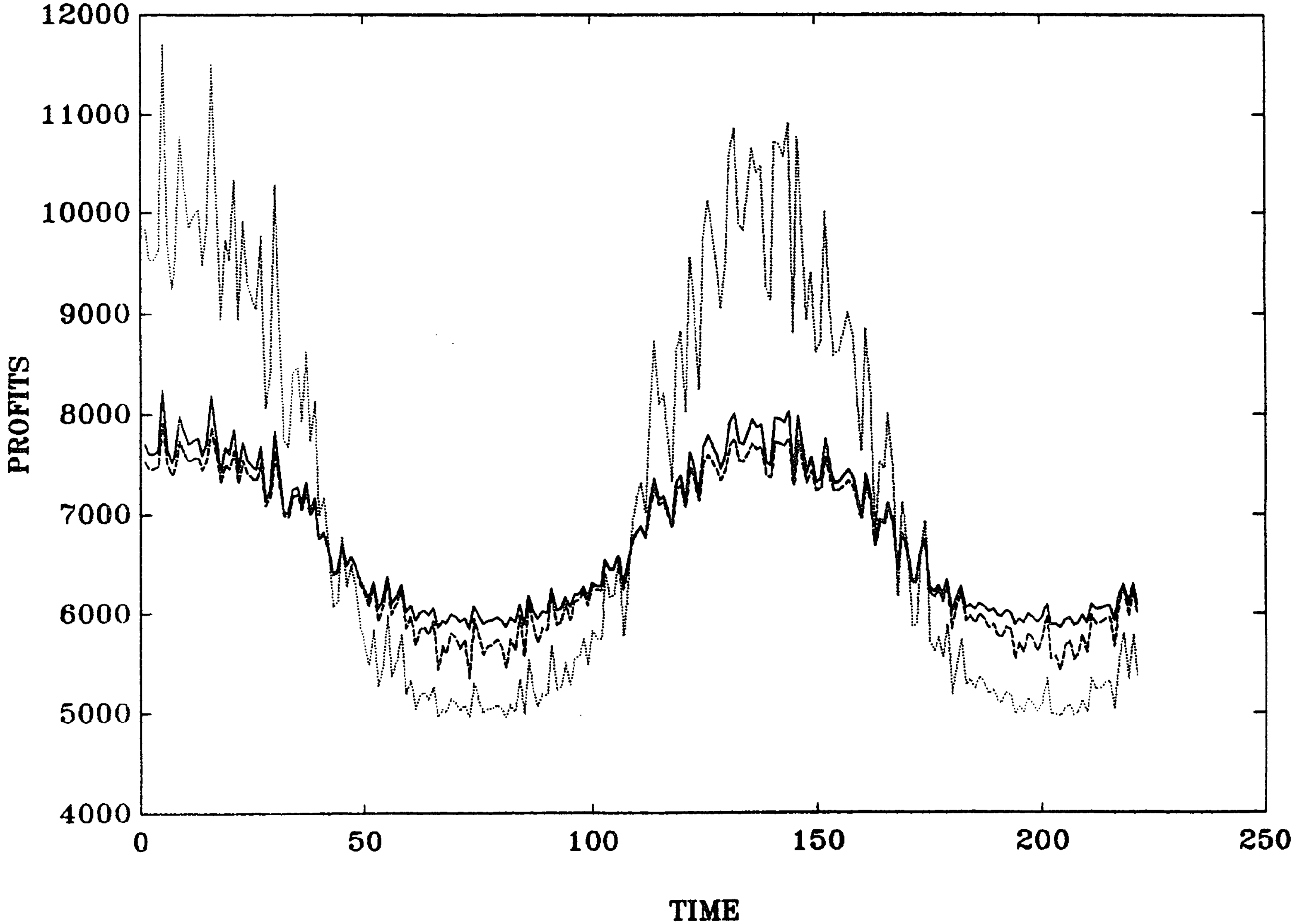

PASS THROUGH IN COUNTRY 1
PASS THROUGH
TIME
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0
5
10
15
20
25

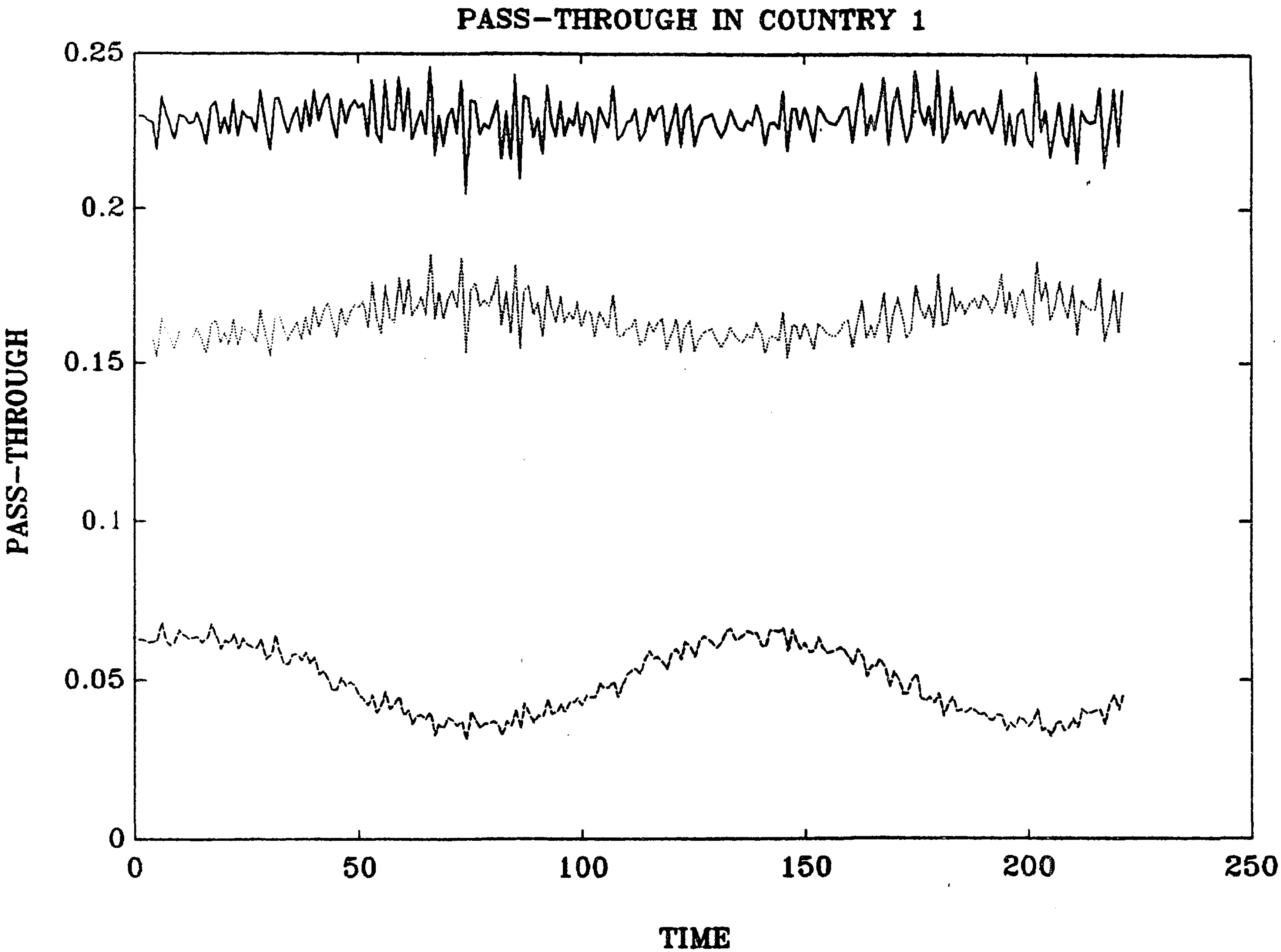

PASS THROUGH IN COUNTRY 2
PASS THROUGH
TIME
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25

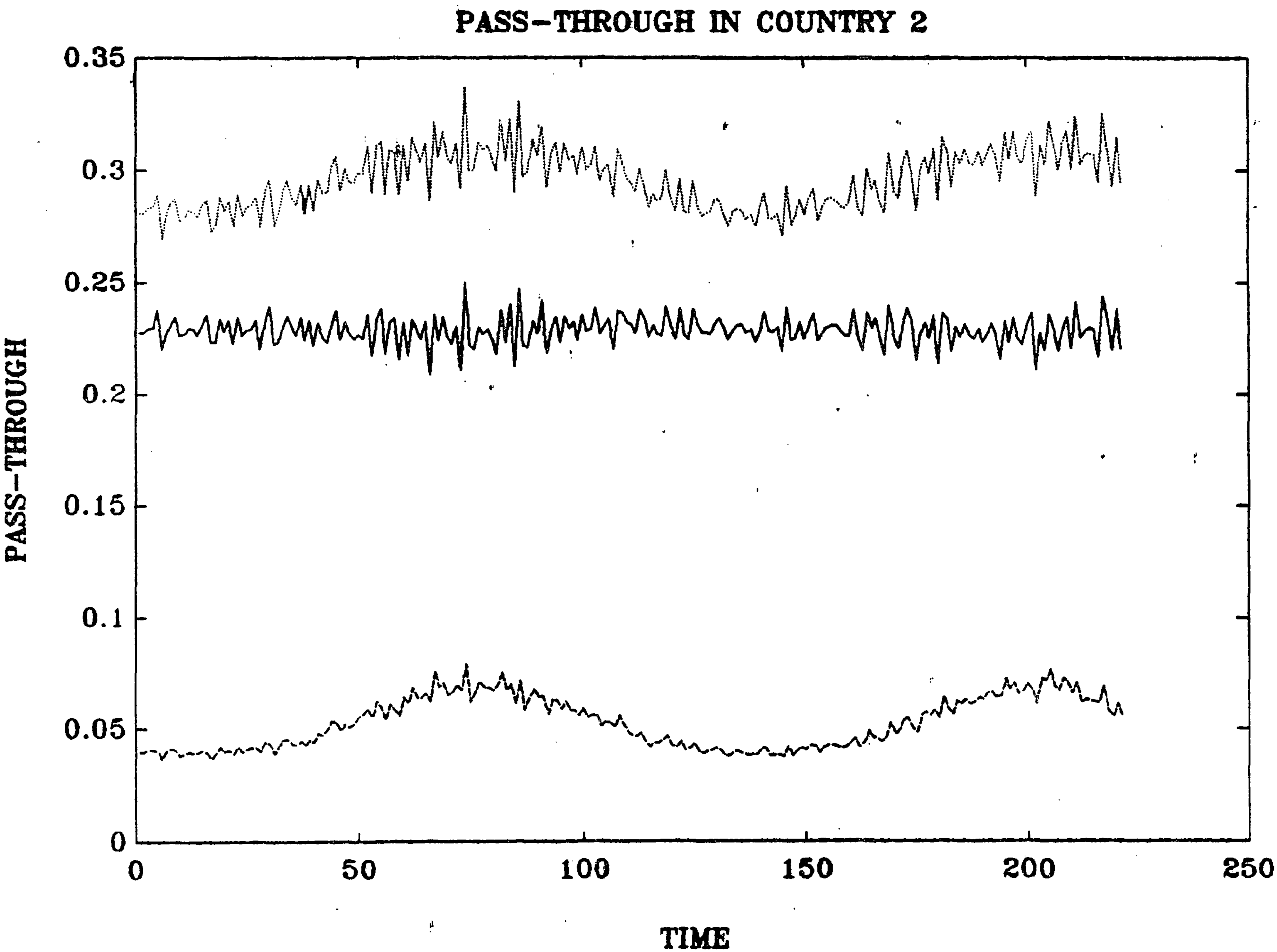
EXCHANGE RATE, SINUS CURVE LOADED WITH WHITE NOISE



PROFITS FOR CASES A,B AND C. SINUS CURVE LOADED WITH WHITE NOISE




PASS-THROUGH IN COUNTRY 1
PASS-THROUGH
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250
TIME


PASS-THROUGH IN COUNTRY 2
PASS-THROUGH
TIME
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150
200
250

as a partial substitute for export. Therefore, one would expect higher pass through in the country with no local production. This is exactly what we observe in figure 10 where Pass through in Country 2 is displayed. Case C (dotted line)is higher than Case A (solid line).

Other observed regularities are reversal of the level of exchange rate pass through between Cases A and C for Country 1 and 2. Also pass throughs are negatively correlated between countries in all three Cases. Pass through for Case B in which no cross shipment is allowed is considerably lower than other Cases and this is due to cross substitution between tradeables and nontradeables. When I simulated Case C without cross substitution effect, pass through effect disappeared. This is what I expected because without global maximization and cross substitution effect, exchange rate is not an argument of the profit function. Cross substitution effect works against the direct adjustments of the multinational corporation and sometimes produces ambiguous results in response to change in exchange rates and become parameter dependent. I tried to sort out possible combinations of parameters to produce some classified results in theoretical model but I ran into equations with so many possibilities in terms of the signs. As a matter of fact that is why I continue my study with simulations.

Another observed phenomenon is that in all Cases, pass through effect is less than one due to imperfect competition. This is consistent with the literature.

When I apply exchange rate shocks in different formats - sinus curves loaded with white noise - I observed some results in terms of the level and the variations of profits. Again, Case A dominates Case B in cycles as well as in white noise. Cyclical domination of profits has been observed for Case C which is the base for the discussion of potential takeovers. If these cycles can be predicted, this domination of profit will be distorted due to stock market arbitrage opportunities. Specifically, in this framework degree of domination enters into the equation of valuation of stocks. I think arbitrage will lower the domination of Case C.

Interesting result emerges when we look at the pass throughs. In Case A, effect of the cycles completely disappeared. In Case C, it is observed but less than Case B. Therefore, different diversification schemes actually provide different filters from exchange rates to pass through effects. All other characteristics are same as the previous Case in which all the fluctuations were random. Level of pass throughs are reversed from one country to another and pass throughs in two countries are negatively correlated.

When we apply Markov process to the model, variance of the pass throughs observed to be lower due to stationary behavior of the process.

III.6.B MEAN-VARIANCE FRONTIER FOR CASES A, B AND C

Description:

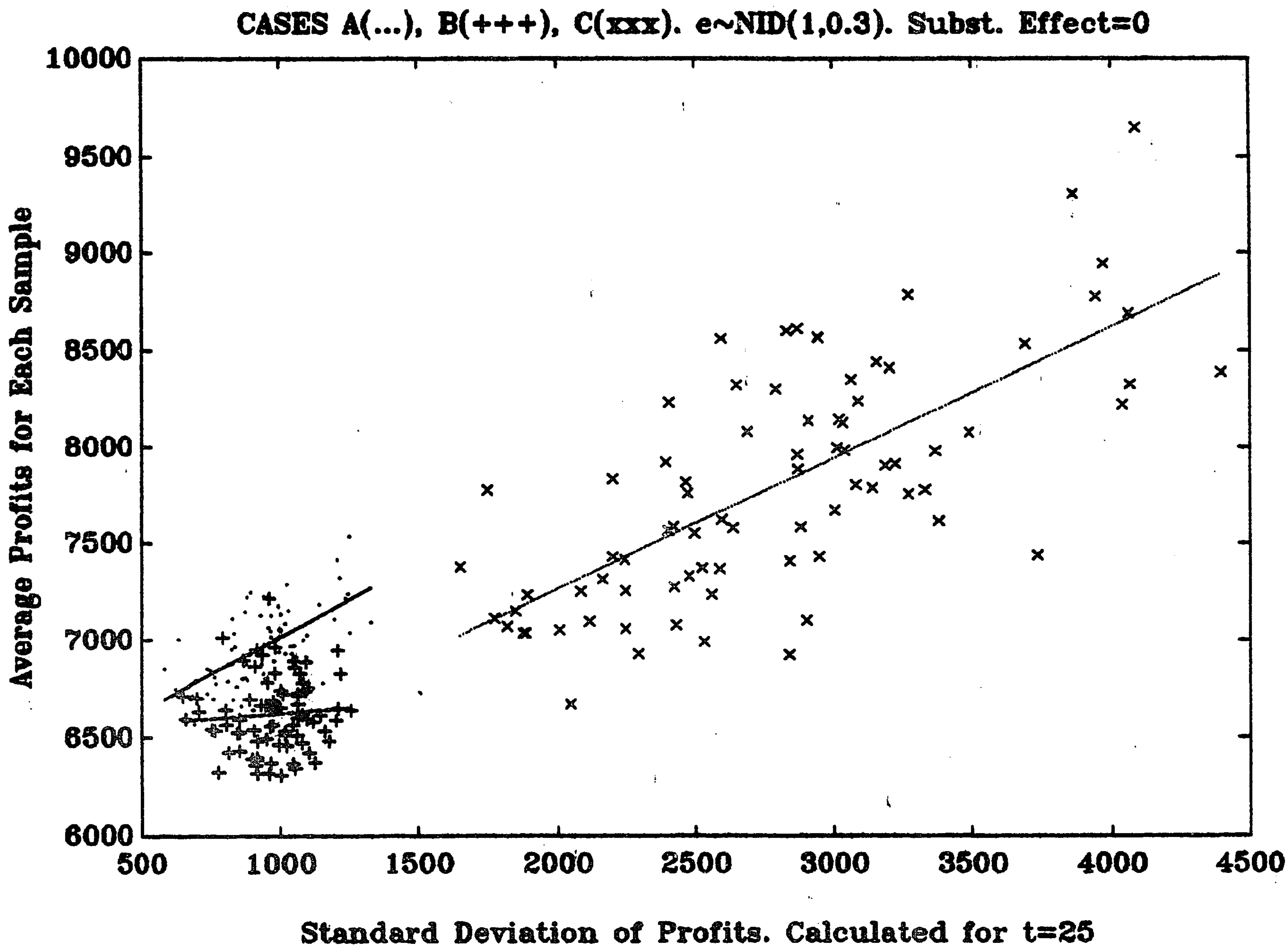
All three cases are simulated 80 times. Each time there was 25 iteration (time period). This is equivalent of having 80 samples from the population with a sample size of 25. Each of the 80 simulations started with a random number produced with different seed at the beginning. Therefore, every sample had a different set of random shocks. However, every observation point for all Cases A, B and C had the same exchange rate shock. This makes comparison between Cases possible without any distortion.

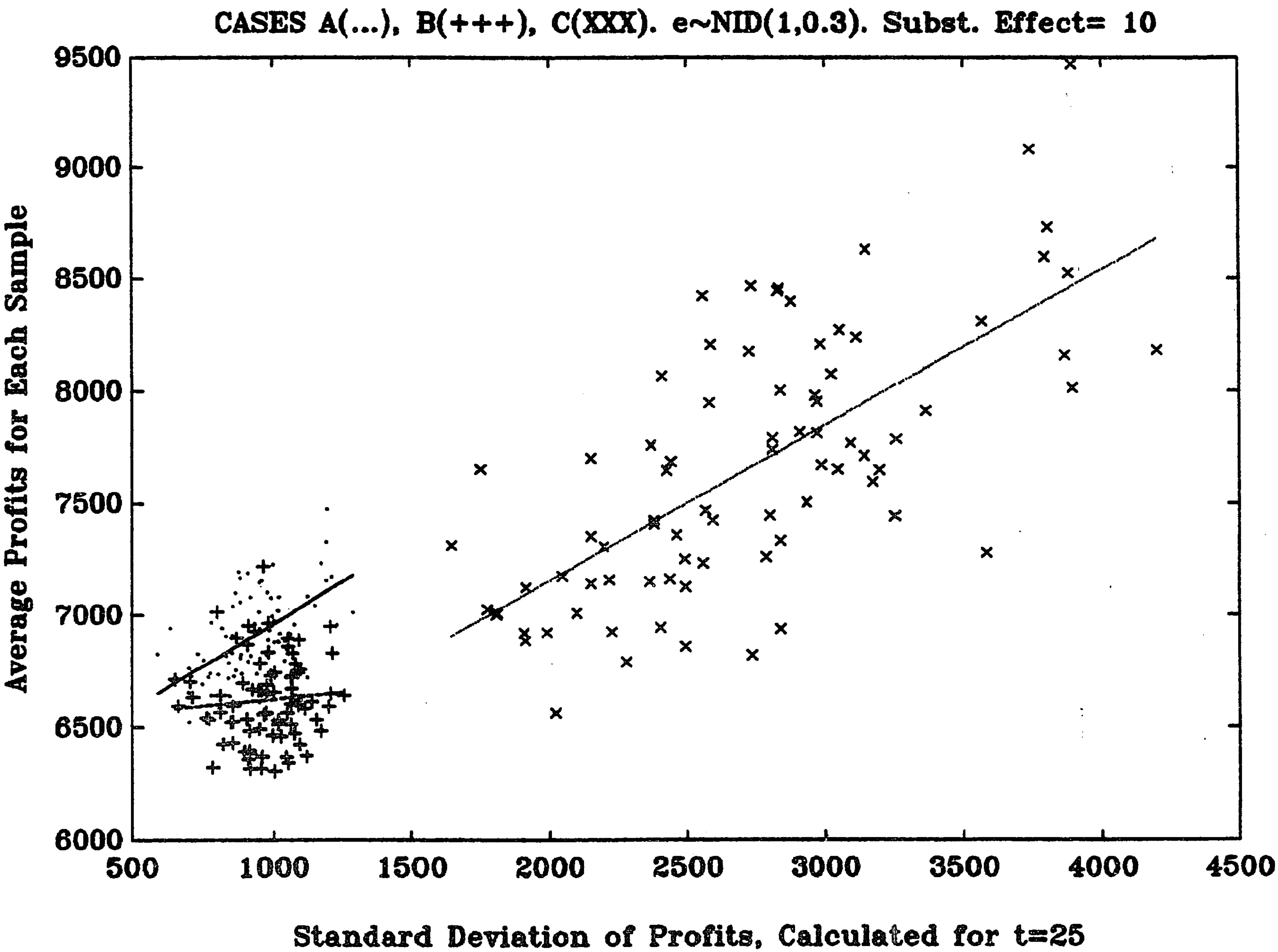
Sample Mean and Sample Variance is calculated for each sample of size 25 for all three Cases and this is repeated 80 times. Results are printed on the same graph with same scale for each Case.

Regression analysis is conducted for each Case. The reason for that is to see whether or not there is positive relationship between risk and variance within each Case itself except Case B which is not a part of efficient portfolio. Positive relationship is at a very high degree of confidence observed. Again, this is what I expected in accordance with the Finance theory.

Results:

Apparently, Case C offers higher return at higher variance than Cases A and B. This is also possible to spot


CASES A(...), B(+++), C(xxx). e~NID(1,0.3). Subst. Effect=0
Average Profits for Each Sample
10000
9500
9000
8500
8000
7500
7000
6500
6000
500
1000
1500
2000
2500
3000
3500
4000
4500
Standard Deviation of Profits. Calculated for t=25


CASES A(...), B(+++), C(XXX). e~NID(1,0.3). Subst. Effect= 10
Average Profits for Each Sample
9500
9000
8500
8000
7500
7000
6500
6000
500
1000
1500
2000
2500
3000
3500
4000
4500
Standard Deviation of Profits, Calculated for t=25

from Mean Variance Graphs. Case A dominates Case B on every point on mean-variance space and A is better strategy than Case B on the average. Again, this is what we expect because Case B is a subset of Case A and this domination is easy to spot from Mean Variance Graphs too.

According to the risk tolerance of the corporation, Case C may still be considered as a viable alternative. This is why some corporations may still prefer to stay as an exporter of their products to diversifying internationally.

Case A offers lower return for lower variance and the difference between returns (Average Return C - Average Return A) is the cost of option or economic hedging. Total risk is not eliminated, however it is greatly reduced at some cost.

It is also evident that stocks of the Case C type of firms will be deirable in formation of efficient portfolios because there is no clear domination between Cases A and C.

Even it is possible for the investor to diversify in International Markets without any friction, Case A or combination of A and C still provides a better return or less variation because it is possible to play with risk and return generated by individual operations in each country. This is an important result in the well known Markowitz Theorem framework in Finance.

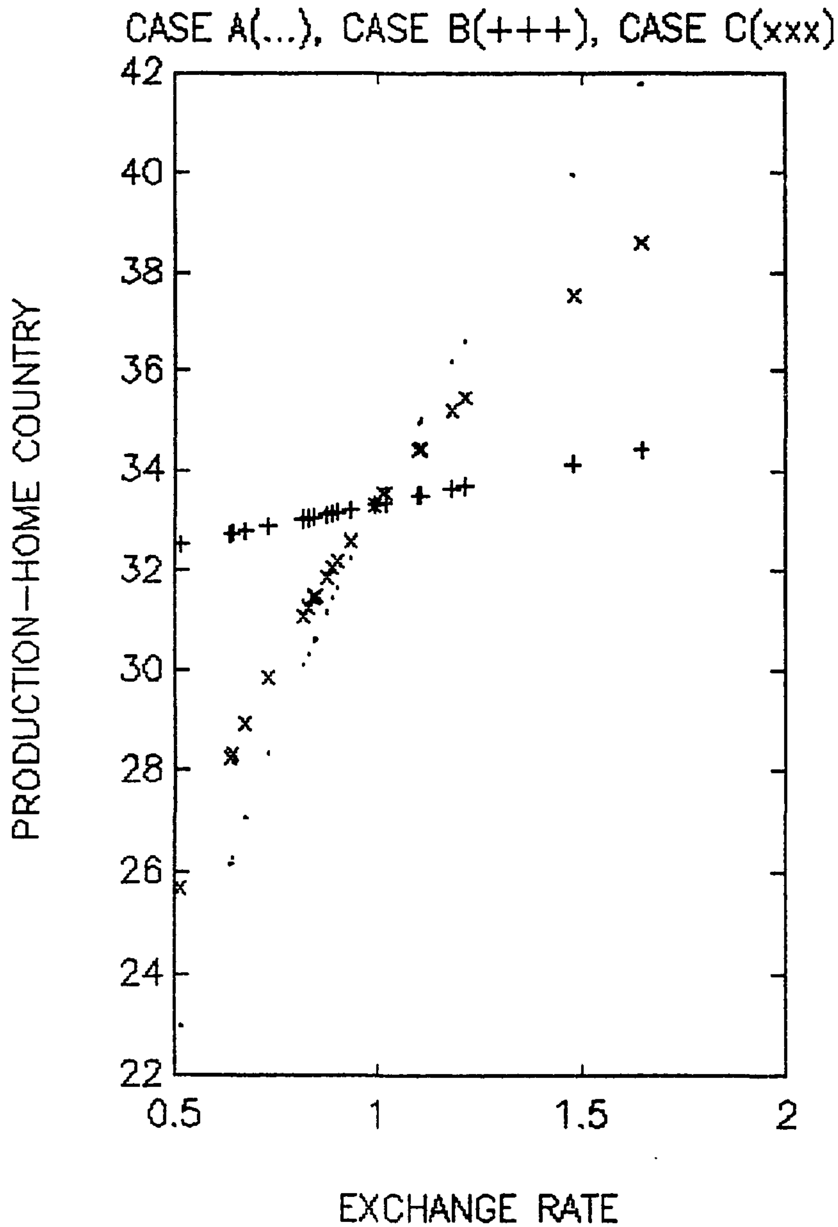
Diversification reduces the variance of the profits. However, they are not completely smoothed out. This leaves room for economically feasible diversification to third countries. This case is not included in this study.

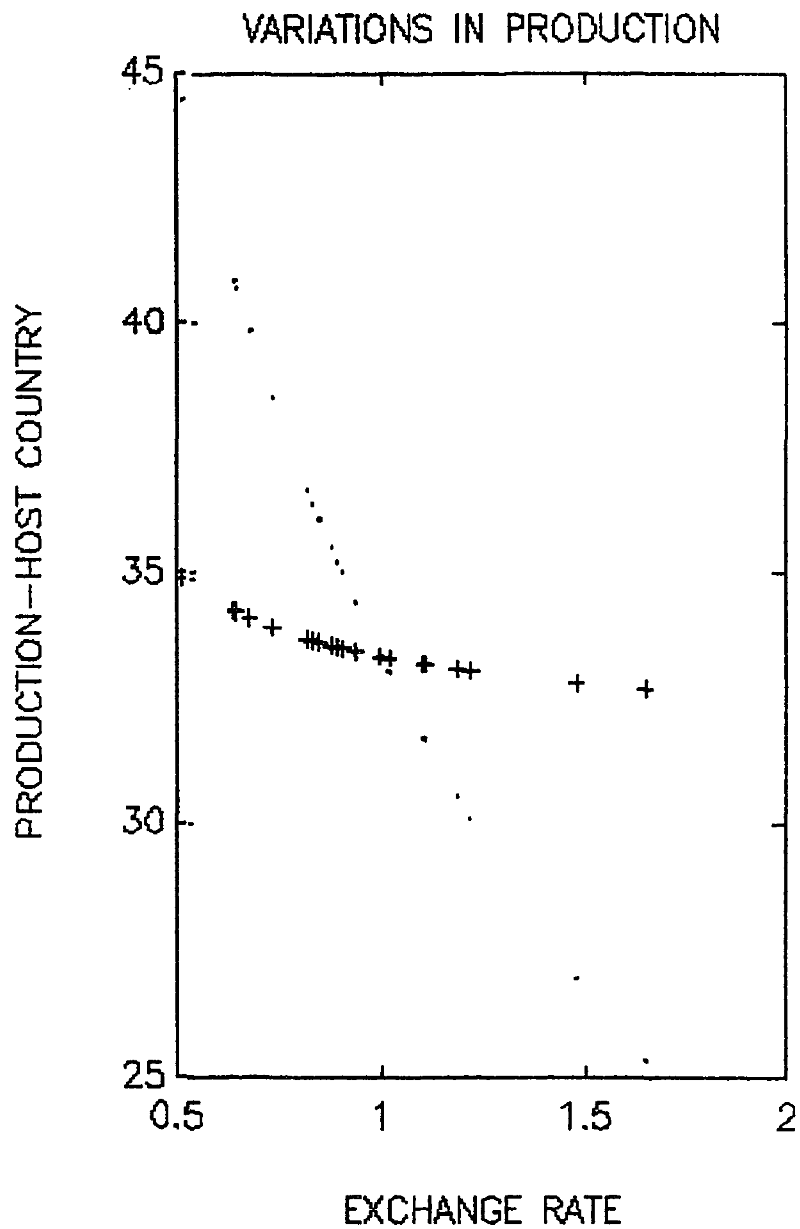
III.6.C. VARIATIONS IN PRODUCTION

Variations in production in response to change in exchange rates are higher in the case with cross shipments (see figure 21). Variation in Case B is lowest and it comes purely from cross substitution effect and with d = 0, it is expected to be straight line. There is no production in Case C in the host country.

Conclusions:

Multinationals with horizontal production diversification magnifies the effects of exchange rates on production by shifting production from one country to another.


CASE A(...), CASE B(+++), CASE C(xxx)
PRODUCTION–HOME COUNTRY
EXCHANGE RATE
42
40
38
36
34
32
30
28
26
24
22
0.5
1
1.5
2


VARIATIONS IN PRODUCTION
PRODUCTION–HOST COUNTRY
EXCHANGE RATE
45
40
35
30
25
0.5
1
1.5
2

CHAPTER FOUR

FURTHER EXTENSIONS OF THE MODEL

IV.1. VERTICAL DIVERSIFICATION

Although I discussed only one form of the diversification - Horizontal Diversification - other forms of diversification are also feasible and already commonly used by MNC's. Vertical diversification either in the form of integration or buying from different sources with negatively correlated prices - exchange rates - stabilizes the cost of production. Homogeneous input demand under price uncertainty in world market is studied by Wolak and Kolstad [1991]. Price uncertainty in their study basically came from domestic inflation and exchange rate. They showed that Japan paid premium for stable prices for standard coal in the world market and bought from different sources with different mean and variance in prices. At home, vertical diversification serves as economic shock absorber for the industry in the world, for Japan by transmitting recession to other countries. "One of the company's [Toyota] biggest strengths is a band of suppliers that perform almost like feudal vassals for Lord Toyota. Its 250 primary suppliers, backed by 15000 subcontractors, provide above 70% of the car's value."[10]

Sudden appreciation of the won 1988 and 1989 forced Korean producers to shift labor-intensive stages to China and Thailand.

IV.2. TRANSMISSION OF BUSINESS CYCLES

Production flexibility built by mulitnational corporations limits the macroeconomic policy power in domestic economies. Kogut in his 1982 article said "Thus the presence of MNCs limits further the ability of governments to pursue independent objectives in an international economy." First, governments will modify their policies once they recognize the different reactions given by MNCs as a result of profit maximization in a global system. MNCs can also use this power to negotiate with national government and play active role in limiting policy making power too. In late 1980's, Ford Motor Company threatened labor strike in his U.K. plant by moving production to somewhere else and shipping to world market from there.

Another related Macroeconomic phenomenon is transmission of business cycles. Lower demand and production in home country will create idle capacity during recession. Shifting production from other countries to home country, MNC will be exporting the recession to host country. The degree of ability to shift production determines the lags in this transmission mechanism.

IV.3. EXCHANGE RATE VARIABILITY, STOCK PRICES AND INTERNATIONAL MERGERS

Following 1985 appreciation of the Japanese yen, firms producing in Japan experienced sharp decline in their profits. Nissan had first time losses in 1986 since World War II.[11] Also recently in U.S., 23.8 percent of their profits coming overseas, up from 19 percent last year and 11.7 percent in 1986 started to feel the effects of exchange rates in stock prices.[12] "That's what happened to companies as varied as the Ford Motor Company and Amdahl Corporation after the dollar soared in February and March and held most of its gains through the summer. The Polaroid Corporation, lost 11 cents per share in the first quarter because of the rise of the dollar."[13]

Variations in exchange rate have two different effects on profitability of the firm; namely, accounting exposure and economic exposure. Financial statements are based on the accounting techniques used by the multinational companies and these techniques went through substantial changes in January 1970. Statement of Financial Accounting Standards No. 8 (FASB-8) and on December 15, 1982 (FASB-12) and reduced the world's savings in the translated earnings of overseas earnings associated with exchange rate movements. One can also assume the efficient market hypothesis in which accounting exposure will be placed in a proper perspective by investors, and therefore variations in accounting value of the firm will not affect the economic value of the multinational firm unless same variables affect the present value of expected future cash flows.

Accounting exposure maybe neglected following either efficient market hypothesis or assuming recent FASB regulations. reduced the impact.Economic exposure to exchange rate risk is still an important factor in determination of the stock prices.

It would be interesting to observe elasticity of value of the firm with respect to exchange rate risk. On the one hand, variations in exchange rates increase the need to diversify. On the other, it creates opportunities for international takeovers by changing relative value of currencies and stock prices of the firms. Approaching this problem in terms of 3 Cases (A, B and C), would provide valuable insight into the problem of protection against hostile takeovers too.

Incremental investment as an adjustment process of capital stock and the form of the adjustment whether it will be buying and building new plants is another interesting subject to investigate. Most interesting study, I believe, would be Tobins q and its change with respect to change in exchange rate, in return providing tools to understand some of the issues I raised above.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

The model developed here is a simple synthesis of few separate lines of thought in economics.

1. Multiplant firm and price discrimination is combined to explain the behavior of multinational companies.

2. Applicability of portfolio theory to multinational companies and advantage of negatively correlated exchange rates have been proposed. Also, possibility of improving efficient frontier in this context has been shown.

In theoretical part, effect of the exchange rate on production and sales in both countries has been proved independent by the parameters for a Multinational company. Although four sets of results are emphasized, it is easy to prove many other effects by using the same model. Main purpose of this Chapter is basically to establish the simple model of the Multinational company.

Differences in pass through have been shown in simulations. Results are different for each Case and considerably different from the literature on pass through.

It has also been shown that for a different stochastic processes, pass throughs differ in some characteristics such as variance of pass throughs.

Profits also have different means and variances for each Case and that motivated me to plot profits in mean variance space and following results as established. Case A always dominates Case B. There is no clear domination for Case C (export case) and inclusion of export firm's stock in portfolios will increase the efficiency of the portfolio. Sensitivity analysis shows that change in substitution effect does not affect the results in terms of the ordering of three Cases and distribution of means and variances. However, all three regression lines slightly moved down without any disturbance on results.

Variation in production is higher in Case C. This magnification in production increases the vulnerability of the national economies to changes in exchange rates.

```
*----------CASE A----------Substitution effect = 0---------

allocate 0 80
open data am00.dat
data(org=obs) / am00
open data as00.dat
data(org=obs) / as00
output noqstat
output nodw
linreg am00
# constant as00


DEPENDENT VARIABLE     1     AM00
TOTAL OBSERVATIONS      80     SKIPPED/MISSING         0
USABLE OBSERVATIONS     80     DEGREES OF FREEDOM     78
R**2            .41193190      RBAR**2          .40439257
SSR          1831047.7         SEE          153.21544
NO.    LABEL     VAR  LAG    COEFFICIENT   STAND. ERROR    T-STATISTIC
***   *******    ***  ***   ************   ************   ************
  1    CONSTANT   0    0   6242.957        97.84445        63.80491
  2    AS00       2    0   .7721779        .1044651        7.391732


cmom(corr,print)
# am00 as00

VARIABLES IN CROSS-MOMENT MATRIX
Series     AM00      (    1 )
Series     AS00      (    2 )

CORRELATION MATRIX
    VARIABLE              AM00           AS00
          SERIES LAG     1    0         2    0
    AM00       1    0    1.0000         .64182
    AS00       2    0    .64182         1.0000
```

```
*----------CASE A----------Substitution effect = 10---------

allocate 0 80
open data am10.dat
data(org=obs) / am10
open data as10.dat
data(org=obs) / as10
output noqstat
output nodw
linreg am10
# constant as10
cmom(corr,print)
# am10 as10


DEPENDENT VARIABLE      1      AM10
TOTAL OBSERVATIONS       80      SKIPPED/MISSING          0
USABLE OBSERVATIONS      80      DEGREES OF FREEDOM      78
R**2             .36369569      RBAR**2          .35553795
SSR          1879790.9          SEE          155.24137
NO.     LABEL     VAR   LAG    COEFFICIENT    STAND. ERROR    T-STATISTIC
***    *******    ***   ***   ***********    ***********    ***********
  1     CONSTANT    0     0    6202.896       104.8817        59.14184
  2     AS10        2     0    .7576748       .1134747        6.677040


VARIABLES IN CROSS-MOMENT MATRIX
Series     AM10      (     1 )
Series     AS10      (     2 )

CORRELATION MATRIX
    VARIABLE              AM10          AS10
          SERIES LAG     1    0         2    0
    AM10       1    0    1.0000        .60307
    AS10       2    0    .60307        1.0000
```

```
*----------CASE B----------Substitution effect = 0---------

allocate 0 80
open data bm00.dat
data(org=obs) / bm00
open data bs00.dat
data(org=obs) / bs00
output noqstat
output nodw
linreg bm00
# constant bs00
cmom(corr,print)
# bm00 bs00
```

```
DEPENDENT VARIABLE      1      BM00
TOTAL OBSERVATIONS       80      SKIPPED/MISSING          0
USABLE OBSERVATIONS      80      DEGREES OF FREEDOM      78
R**2             .00570742      RBAR**2           -.00703992
SSR          2766735.9          SEE            188.33739
NO.      LABEL     VAR  LAG    COEFFICIENT     STAND. ERROR    T-STATISTIC
***     *******    ***  ***   ************     ************    ************
  1     CONSTANT     0    0   6512.953          162.3509        40.11653
  2     BS00         2    0   .1101232          .1645768        .6691292
```

```
VARIABLES IN CROSS-MOMENT MATRIX
Series     BM00      (     1 )
Series     BS00      (     2 )

CORRELATION MATRIX
    VARIABLE              BM00          BS00
          SERIES LAG      1    0        2    0
    BM00       1    0   1.0000        .75547E-01
    BS00       2    0   .75547E-01    1.0000
```

```
*----------CASE B----------Substitution effect = 10---------

allocate 0 80
open data bm10.dat
data(org=obs) / bm10
open data bs10.dat
data(org=obs) / bs10
output noqstat
output nodw
linreg bm10
# constant bs10
cmom(corr,print)
# bm10 bs10
```

```
DEPENDENT VARIABLE      1      BM10
TOTAL OBSERVATIONS       80      SKIPPED/MISSING          0
USABLE OBSERVATIONS      80      DEGREES OF FREEDOM      78
R**2             .00690470      RBAR**2          -.00582729
SSR         2759966.4            SEE           188.10684
NO.     LABEL     VAR  LAG    COEFFICIENT    STAND. ERROR    T-STATISTIC
***    *******    ***  ***   ************    ************    ************
  1     CONSTANT    0    0    6503.970        162.6120        39.99687
  2     BS10        2    0    .1216098        .1651370        .7364178
```

```
VARIABLES IN CROSS-MOMENT MATRIX
Series     BM10      (     1 )
Series     BS10      (     2 )

CORRELATION MATRIX
    VARIABLE              BM10          BS10
          SERIES LAG       1   0         2   0
    BM10       1    0     1.0000        .83095E-01
    BS10       2    0     .83095E-01    1.0000
```

```
*----------CASE C----------Substitution effect = 0---------

allocate 0 80
open data cm00.dat
data(org=obs) / cm00
open data cs00.dat
data(org=obs) / cs00
output noqstat
output nodw
linreg cm00
# constant cs00
cmom(corr,print)
# cm00 cs00


DEPENDENT VARIABLE     1      CM00
TOTAL OBSERVATIONS      80      SKIPPED/MISSING          0
USABLE OBSERVATIONS     80      DEGREES OF FREEDOM      78
R**2              .50444553     RBAR**2           .49809227
SSR           14419283.         SEE           429.95651
NO.      LABEL     VAR  LAG    COEFFICIENT   STAND. ERROR    T-STATISTIC
***     *******    ***  ***   ************   ************   ************
  1      CONSTANT    0    0   5900.362       219.1992        26.91780
  2      CS00        2    0   .6813094       .7646024E-01    8.910637


VARIABLES IN CROSS-MOMENT MATRIX
Series      CM00       (     1 )
Series      CS00       (     2 )

CORRELATION MATRIX
    VARIABLE               CM00          CS00
          SERIES LAG     1    0         2    0
    CM00         1    0   1.0000        .71024
    CS00         2    0   .71024        1.0000
```

```
*----------CASE C----------Substitution effect = 10---------

allocate 0 80
open data cm10.dat
data(org=obs) / cm10
open data cs10.dat
data(org=obs) / cs10
output noqstat
output nodw
linreg cm10
# constant cs10
cmom(corr,print)
# cm10 cs10
```

```
DEPENDENT VARIABLE      1      CM10
TOTAL OBSERVATIONS      80      SKIPPED/MISSING          0
USABLE OBSERVATIONS     80      DEGREES OF FREEDOM      78
R**2             .47870997      RBAR**2            .47202677
SSR          14169693.          SEE           426.21911
NO.      LABEL      VAR  LAG    COEFFICIENT    STAND. ERROR     T-STATISTIC
***     *******     ***  ***   ************    ************    ************
  1     CONSTANT     0    0    5765.726        228.8391         25.19555
  2     CS10         2    0    .6942450        .8202928E-01     8.463380
```

```
VARIABLES IN CROSS-MOMENT MATRIX
Series     CM10      (     1 )
Series     CS10      (     2 )

CORRELATION MATRIX
    VARIABLE              CM10           CS10
          SERIES LAG    1    0         2    0
    CM10       1    0   1.0000         .69189
    CS10       2    0   .69189         1.0000
```

NOTES

1. "The ability to shift exports from a country whose currency is appreciating to one where other plants are located is a valuable option - assuming that pricing is demoninated in the currency of the importing country and factor payments are derived out of overseas revenues.", Kogut [1982].

2. Real Effective Exchange Rate Indexes, Based on Relative Export Unit Values (74 ey. 110), International Financial Statistics, I.M.F., October 1991, page 67.

3. Nominal Exchange Rates, International Financial Statistics, I.M.F., October 1991, page 312, series ae, Japanese yen per U.S.$.

4. Multinational Financial Management, Alan C. Shapiro, page 77.

5. Leaner Japanese Manufacturers, The New York Times, February 18, 1988, page D1.

6. Leaner Japanese Manufacturers, The New York Times, February 18, 1988, page D1.

7. Learning to Dance with a Bouncy Dollar, The New York Times, September 8, 1991.

8. Japan's Auto Makers Shift Strategies, Fortune, August 11, 1980.

9. "

$$u(z_1,z_2) = a_1z_1+a_2z_2 - \frac{b_1z_1^2+2dz_1z_2+b_2z_2^2}{2}$$

where parameters a and b are positive (i = 1, 2) $b_1b_2 - d^2 > 0$ and $a\ b_i - a_j\ d_i > 0$ for $i \neq j$. This utility gives rise to linear ordinary demands, which explains its frequent use. The associated inverse demands are

$$p_1 = a_1 - b_1z_1 - dz_2$$

$$p_2 = a_2 - dz_1 - b_2z_2$$ "

Clement G. Krouse, Theory of Industrial Economics.

10 Japan's Auto Makers Shift Strategies, Fortune, August 11, 1980.

11 Leaner Japanese Manufacturers, The New York Times, February 18, 1988, page D1.

12. Learning to Dance with a Bouncy Dollar, The New York Times, September 8, 1991.

13. Learning to Dance with a Bouncy Dollar, The New York Times, September 8, 1991.

APPENDIX A

COMPUTER PROGRAMS

Normal Dist.and Markov Pro. Prog

```
clc
echo on
%-------------PARAMETERS--------------------------------------
a=200;
b=1;
c=2;
k=20;
d=10;
pause % HIT RETURN FOR INITIALIZATIONS
clc

%-------------INITIALIZATIONS---------------------------------
input('enter the number of iterations| ');
Last=ans;
clear ans;
Init=zeros(1,Last);
e=Init;

Ax1=Init; Ax2=Init; Aq1=Init; Aq2=Init; %---Case A-------------
Atr1=Init; Atr2=Init; Atc1=Init; Atc2=Init;
Ap1=Init;  Ap2=Init;  Ap2HC=Init; Api1=Init; Api2=Init; API=Init;
APas1=Init;APas2=Init; Ex=Init;

Bq1=Init; Bq2=Init; Bp1=Init; Bp2=Init; Bp2HC=Init; %---CASE B------
Btr1=Init; Btr2=Init; Btc1=Init; Btc2=Init;
Bpi1=Init; Bpi2=Init; BPI=Init;
BPas1=Init; BPas2=Init;

Cq1=Init; Cq2=Init; Cp1=Init; Cp2=Init; Cp2HC=Init; %---CASE C------
Ctr1=Init; Ctr2=Init; Ctc1=Init; Ctc2=Init;
Cpi1=Init; Cpi2=Init; CPI=Init;
CPas1=Init; CPas2=Init;

pause % HIT RETURN FOR GENERATIONS OF RANDOM NUMBERS---------------
clc

%---------------GENERATION OF RANDOM NUMBERS------------------------
rand('normal');
rand('seed') %Seed in the beginning of generation is
input('Enter 0 for normal dist. or 1 for First degree Markov proc: ');
clc;
pause(3) %SIMULATION STARTS NOW. PLEASE WAIT.
for t=1:Last;
if ans==0;
          e(t)=rand*.3+1;
else ans==1;
    if t==1;
       e(t)=1;
    else
        e(t)=e(t-1)+rand*.03;
    end
end

%-------------OPTIMAL SOLUTIONS----------------------------------
```

Normal Dist.and Markov Pro. Prog

```
%--------------Case A-----------
A=[2*b 0 0 0 1;0 2*b*e(t) 0 0 1;0 0 -2*c 0 1;0 0 0 -2*c*e(t) 1;-1 -1  1 1 0];
B=[ a+d*(e(t)-1) a*e(t)-d*((e(t)-1)) 0 0 0];
OUT=A\B';
Ax1(t)=OUT(1);
Ax2(t)=OUT(2);
Aq1(t)=OUT(3);
Aq2(t)=OUT(4);
%--------------Case B-----------
Bq1(t)=(a+d*(e(t)-1))/(2*b+2*c);
Bq2(t)=(a*e(t)-d*(e(t)-1))/(2*b*e(t)+2*c*e(t));
%---------------Case C------
A3=[2*b 0 0 0 1;0 2*b*e(t) 0 0 1;0 0 -2*c 0 1;0 0 0 -2*c 1;-1 -1 1 1  0];
B3=[a+d*(e(t)-1) a*e(t)-d*((e(t)-1)) 0 0 0];
OUT3=A3\B3';
Cx1(t)=OUT3(1);
Cx2(t)=OUT3(2);
Cq1(t)=OUT3(3);
Cq2(t)=OUT3(4);

%--------------CALCULATIONS-----------------------------------------
%--------------Case A------
Ap1(t)=a-b*Ax1(t)+d*(e(t)-1);
Ap2(t)=a*e(t)-b*e(t)*Ax2(t)-d*(e(t)-1);
Ap2HC(t)=Ap2(t)/e(t);
Atr1(t)=Ap1(t)*Ax1(t);
Atr2(t)=(Ap2(t)*Ax2(t));
Atc1(t)=k+c*Aq1(t)^2;
Atc2(t)=(k+c*Aq2(t)^2)*e(t);
API(t)=Atr1(t)-Atc1(t)+Atr2(t)-Atc2(t);
Ex(t)=Aq1(t)-Ax1(t);
%---------------Case B------
Bp1(t)=a-b*Bq1(t)+d*(e(t)-1);
Bp2(t)=a*e(t)-b*e(t)*Bq2(t)-d*(e(t)-1);
Bp2HC(t)=Bp2(t)/e(t);
Btr1(t)=Bp1(t)*Bq1(t);
Btr2(t)=Bp2(t)*Bq2(t);
Btc1(t)=k+c*Bq1(t)^2;
Btc2(t)=(k+c*Bq2(t)^2)*e(t);
BPI(t)=Btr1(t)-Btc1(t)+Btr2(t)-Btc2(t);
%----------------Case C------
Cp1(t)=a-b*Cx1(t)+d*(e(t)-1);
Cp2(t)=a*e(t)-b*e(t)*Cx2(t)-d*(e(t)-1);
Cp2HC(t)=Cp2(t)/e(t);
Ctr1(t)=Cp1(t)*Cx1(t);
Ctr2(t)=(Cp2(t)*Cx2(t))*e(t);
Ctc1(t)=k+c*Cq1(t)^2;
Ctc2(t)=(k+c*Cq2(t)^2)*e(t);
CPI(t)=Ctr1(t)-Ctc1(t)+Ctr2(t)-Ctc2(t);
CEx(t)=Cx2(t);
end % Please wait while I crunch the numbers.
for t=2:Last
APas1(t)=((Ap1(t)-Ap1(t-1))/Ap1(t-1))/((e(t)-e(t-1))/e(t-1));
APas2(t)=((Ap2HC(t)-Ap2HC(t-1))/Ap2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)));
```

```
BPas1(t)=((Bp1(t)-Bp1(t-1))/Bp1(t-1))/((e(t)-e(t-1))/e(t-1));
BPas2(t)=((Bp2HC(t)-Bp2HC(t-1))/Bp2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)))
CPas1(t)=((Cp1(t)-Cp1(t-1))/Cp1(t-1))/((e(t)-e(t-1))/e(t-1));
CPas2(t)=((Cp2HC(t)-Cp2HC(t-1))/Cp2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)))
end % Please wait while I crunch the numbers.
APas1(1)=APas1(2); APas2(1)=APas2(2);
BPas1(1)=BPas1(2); BPas2(1)=BPas2(2);
CPas1(1)=CPas1(2); CPas2(1)=CPas2(2);

%--------------PREPARATIONS FOR GRAPHS------------------------------
t=1:Last;
who;
pause
echo off
plot(t,API,t,BPI,t,CPI);
pause
plot(t,APas1,t,BPas1,t,CPas1);
pause
plot(t,APas2,t,BPas2,t,CPas2);
```

Sinus Curve Plus White Noise

```
clc
echo on
%--------------PARAMETERS-----------------------------------------
a=200;
b=1;
c=2;
k=20;
d=10;
pause % HIT RETURN FOR INITIALIZATIONS
clc

%--------------INITIALIZATIONS------------------------------------
Init=zeros(1:0.05:12);
e=Init;

Ax1=Init; Ax2=Init; Aq1=Init; Aq2=Init; %---Case A---------------
Atr1=Init; Atr2=Init; Atc1=Init; Atc2=Init;
Ap1=Init;  Ap2=Init;  Ap2HC=Init; Api1=Init; Api2=Init; API=Init;
APas1=Init;APas2=Init; Ex=Init;

Bq1=Init; Bq2=Init; Bp1=Init; Bp2=Init; Bp2HC=Init; %---CASE B------
Btr1=Init; Btr2=Init; Btc1=Init; Btc2=Init;
Bpi1=Init; Bpi2=Init; BPI=Init;
BPas1=Init; BPas2=Init;

Cq1=Init; Cq2=Init; Cp1=Init; Cp2=Init; Cp2HC=Init; %---CASE C------
Ctr1=Init; Ctr2=Init; Ctc1=Init; Ctc2=Init;
Cpi1=Init; Cpi2=Init; CPI=Init;
CPas1=Init; CPas2=Init;

pause % HIT RETURN FOR GENERATIONS OF RANDOM NUMBERS---------------
clc

%---------------GENERATION OF RANDOM NUMBERS-------------------------
rand('normal');
rand('seed') %Seed in the beginning of generation is
t=1:.05:12;
e=sin(t)*.3+1+rand(t)*0.05;
clc;
pause(3) %SIMULATION STARTS NOW. PLEASE WAIT.
for t=1:Length(e);

%--------------OPTIMAL SOLUTIONS-------------------------------------
%--------------Case A-----------
A=[2*b 0 0 0 1;0 2*b*e(t) 0 0 1;0 0 -2*c 0 1;0 0 0 -2*c*e(t) 1;-1 -1  1 1 0];
B=[ a+d*(e(t)-1) a*e(t)-d*((e(t)-1)) 0 0 0];
OUT=A\B';
Ax1(t)=OUT(1);
Ax2(t)=OUT(2);
Aq1(t)=OUT(3);
Aq2(t)=OUT(4);
%--------------Case B-----------
Bq1(t)=(a+d*(e(t)-1))/(2*b+2*c);
Bq2(t)=(a*e(t)-d*(e(t)-1))/(2*b*e(t)+2*c*e(t));
```

Sinus Curve Plus White Noise

```
%---------------Case C------
A3=[2*b 0 0 0 1;0 2*b*e(t) 0 0 1;0 0 -2*c 0 1;0 0 0 -2*c 1;-1 -1 1 1  0];
B3=[a+d*(e(t)-1) a*e(t)-d*((e(t)-1)) 0 0 0];
OUT3=A3\B3';
Cx1(t)=OUT3(1);
Cx2(t)=OUT3(2);
Cq1(t)=OUT3(3);
Cq2(t)=OUT3(4);
%--------------CALCULATIONS---------------------------------------
%--------------Case A------
Ap1(t)=a-b*Ax1(t)+d*(e(t)-1);
Ap2(t)=a*e(t)-b*e(t)*Ax2(t)-d*(e(t)-1);
Ap2HC(t)=Ap2(t)/e(t);
Atr1(t)=Ap1(t)*Ax1(t);
Atr2(t)=(Ap2(t)*Ax2(t));
Atc1(t)=k+c*Aq1(t)^2;
Atc2(t)=(k+c*Aq2(t)^2)*e(t);
API(t)=Atr1(t)-Atc1(t)+Atr2(t)-Atc2(t);
Ex(t)=Aq1(t)-Ax1(t);
%---------------Case B------
Bp1(t)=a-b*Bq1(t)+d*(e(t)-1);
Bp2(t)=a*e(t)-b*e(t)*Bq2(t)-d*(e(t)-1);
Bp2HC(t)=Bp2(t)/e(t);
Btr1(t)=Bp1(t)*Bq1(t);
Btr2(t)=Bp2(t)*Bq2(t);
Btc1(t)=k+c*Bq1(t)^2;
Btc2(t)=(k+c*Bq2(t)^2)*e(t);
BPI(t)=Btr1(t)-Btc1(t)+Btr2(t)-Btc2(t);
%----------------Case C------
Cp1(t)=a-b*Cx1(t)+d*(e(t)-1);
Cp2(t)=a*e(t)-b*e(t)*Cx2(t)-d*(e(t)-1);
Cp2HC(t)=Cp2(t)/e(t);
Ctr1(t)=Cp1(t)*Cx1(t);
Ctr2(t)=(Cp2(t)*Cx2(t))*e(t);
Ctc1(t)=k+c*Cq1(t)^2;
Ctc2(t)=(k+c*Cq2(t)^2)*e(t);
CPI(t)=Ctr1(t)-Ctc1(t)+Ctr2(t)-Ctc2(t);
CEx(t)=Cx2(t);
end % Please wait while I crunch the numbers.
for t=2:length(e);
APas1(t)=((Ap1(t)-Ap1(t-1))/Ap1(t-1))/((e(t)-e(t-1))/e(t-1));
APas2(t)=((Ap2HC(t)-Ap2HC(t-1))/Ap2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)));
BPas1(t)=((Bp1(t)-Bp1(t-1))/Bp1(t-1))/((e(t)-e(t-1))/e(t-1));
BPas2(t)=((Bp2HC(t)-Bp2HC(t-1))/Bp2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)));
CPas1(t)=((Cp1(t)-Cp1(t-1))/Cp1(t-1))/((e(t)-e(t-1))/e(t-1));
CPas2(t)=((Cp2HC(t)-Cp2HC(t-1))/Cp2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)));
end % Please wait while I crunch the numbers.
APas1(1)=APas1(2); APas2(1)=APas2(2);
BPas1(1)=BPas1(2); BPas2(1)=BPas2(2);
CPas1(1)=CPas1(2); CPas2(1)=CPas2(2);

%--------------PREPARATIONS FOR GRAPHS-------------------------------
t=1:length(e);
who;
```

```
pause
echo off
plot(t,API,t,BPI,t,CPI);
pause
plot(t,APas1,t,BPas1,t,CPas1);
pause
plot(t,APas2,t,BPas2,t,CPas2);
```

Production of Artificial Data

```
echo on
for s= 1:80;
s
%--------------PARAMETERS------------------------------------------
a=200;
b=1;
c=2;
k=20;
d=0;

%--------------INITIALIZATIONS-------------------------------------
Last=25;
clear ans;
Init=zeros(1,Last);
e=Init;

Ax1=Init; Ax2=Init; Aq1=Init; Aq2=Init; %---Case A---------------
Atr1=Init; Atr2=Init; Atc1=Init; Atc2=Init;
Ap1=Init;  Ap2=Init;  Ap2HC=Init; Api1=Init; Api2=Init; API=Init;
APas1=Init;APas2=Init; Ex=Init;

Bq1=Init; Bq2=Init; Bp1=Init; Bp2=Init; Bp2HC=Init; %---CASE B------
Btr1=Init; Btr2=Init; Btc1=Init; Btc2=Init;
Bpi1=Init; Bpi2=Init; BPI=Init;
BPas1=Init; BPas2=Init;

Cq1=Init; Cq2=Init; Cp1=Init; Cp2=Init; Cp2HC=Init; %---CASE C------
Ctr1=Init; Ctr2=Init; Ctc1=Init; Ctc2=Init;
Cpi1=Init; Cpi2=Init; CPI=Init;
CPas1=Init; CPas2=Init;


%---------------GENERATION OF RANDOM NUMBERS------------------------
rand('normal')
ans=0;
for t=1:Last;
if ans==0;
          e(t)=rand*.3+1;
else ans==1;
    if t==1;
       e(t)=1;
    else
        e(t)=e(t-1)+rand*.03;
    end
end

%--------------OPTIMAL SOLUTIONS------------------------------------
%--------------Case A-----------
A=[2*b 0 0 0 1;0 2*b*e(t) 0 0 1;0 0 -2*c 0 1;0 0 0 -2*c*e(t) 1;-1 -1  1 1 0]
B=[ a+d*(e(t)-1) a*e(t)-d*((e(t)-1)) 0 0 0];
OUT=A\B';
Ax1(t)=OUT(1);
Ax2(t)=OUT(2);
Aq1(t)=OUT(3);
```

Production of Artificial Data

```
Aq2(t)=OUT(4);
%--------------Case B-----------
Bq1(t)=(a+d*(e(t)-1))/(2*b+2*c);
Bq2(t)=(a*e(t)-d*(e(t)-1))/(2*b*e(t)+2*c*e(t));
%---------------Case C------
A3=[2*b 0 0 0 1;0 2*b*e(t) 0 0 1;0 0 -2*c 0 1;0 0 0 -2*c 1;-1 -1 1 1  0];
B3=[a+d*(e(t)-1) a*e(t)-d*((e(t)-1)) 0 0 0];
OUT3=A3\B3';
Cx1(t)=OUT3(1);
Cx2(t)=OUT3(2);
Cq1(t)=OUT3(3);
Cq2(t)=OUT3(4);
%--------------CALCULATIONS----------------------------------------
%--------------Case A------
Ap1(t)=a-b*Ax1(t)+d*(e(t)-1);
Ap2(t)=a*e(t)-b*e(t)*Ax2(t)-d*(e(t)-1);
Ap2HC(t)=Ap2(t)/e(t);
Atr1(t)=Ap1(t)*Ax1(t);
Atr2(t)=(Ap2(t)*Ax2(t));
Atc1(t)=k+c*Aq1(t)^2;
Atc2(t)=(k+c*Aq2(t)^2)*e(t);
API(t)=Atr1(t)-Atc1(t)+Atr2(t)-Atc2(t);
Ex(t)=Aq1(t)-Ax1(t);
%---------------Case B------
Bp1(t)=a-b*Bq1(t)+d*(e(t)-1);
Bp2(t)=a*e(t)-b*e(t)*Bq2(t)-d*(e(t)-1);
Bp2HC(t)=Bp2(t)/e(t);
Btr1(t)=Bp1(t)*Bq1(t);
Btr2(t)=Bp2(t)*Bq2(t);
Btc1(t)=k+c*Bq1(t)^2;
Btc2(t)=(k+c*Bq2(t)^2)*e(t);
BPI(t)=Btr1(t)-Btc1(t)+Btr2(t)-Btc2(t);
%----------------Case C------
Cp1(t)=a-b*Cx1(t)+d*(e(t)-1);
Cp2(t)=a*e(t)-b*e(t)*Cx2(t)-d*(e(t)-1);
Cp2HC(t)=Cp2(t)/e(t);
Ctr1(t)=Cp1(t)*Cx1(t);
Ctr2(t)=(Cp2(t)*Cx2(t))*e(t);
Ctc1(t)=k+c*Cq1(t)^2;
Ctc2(t)=(k+c*Cq2(t)^2)*e(t);
CPI(t)=Ctr1(t)-Ctc1(t)+Ctr2(t)-Ctc2(t);
CEx(t)=Cx2(t);
end % Please wait while I crunch the numbers.
for t=2:Last
APas1(t)=((Ap1(t)-Ap1(t-1))/Ap1(t-1))/((e(t)-e(t-1))/e(t-1));
APas2(t)=((Ap2HC(t)-Ap2HC(t-1))/Ap2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)))
BPas1(t)=((Bp1(t)-Bp1(t-1))/Bp1(t-1))/((e(t)-e(t-1))/e(t-1));
BPas2(t)=((Bp2HC(t)-Bp2HC(t-1))/Bp2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)))
CPas1(t)=((Cp1(t)-Cp1(t-1))/Cp1(t-1))/((e(t)-e(t-1))/e(t-1));
CPas2(t)=((Cp2HC(t)-Cp2HC(t-1))/Cp2HC(t-1))/((1/e(t)-1/e(t-1))/(1/e(t-1)))
end % Please wait while I crunch the numbers.
APas1(1)=APas1(2); APas2(1)=APas2(2);
BPas1(1)=BPas1(2); BPas2(1)=BPas2(2);
CPas1(1)=CPas1(2); CPas2(1)=CPas2(2);
```

Production of Artificial Data

```
%--------------PREPARATIONS FOR GRAPHS-------------------------------
AM(s)=mean(API);
BM(s)=mean(BPI);
CM(s)=mean(CPI);
AS(s)=std(API);
BS(s)=std(BPI);
CS(s)=std(CPI);
end
```

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