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A MULTI-COUNTRY LINK VECTOR AUTOREGRESSIVE MODEL THEORY AND EVIDENCE

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A MULTI-COUNTRY LINK VECTOR AUTOREGRESSIVE MODEL
THEORY AND EVIDENCE

BY

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ABSTRACT

A MULTI-COUNTRY LINK VECTOR AUTOREGRESSION MODEL

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Vector Autoregression (VAR) is an alternative to structural econometric model building, specifically in forecasting. The challenge of the VAR technique has been, however, limited to models of national and regional economies.

This dissertation extends the scope of the VAR technique with the construction of a multi-country Link Vector Autoregressive (LINK-VAR) model based on eighteen OECD economies. It offers a unique way of combining the linkage specifications of global structural econometric models with the VAR technique. Each national economy in the LINK-VAR model is specified by four macroeconomic variables: output, nominal money supply, prices, and a short-term interest rate. Linkages among countries are formulated through link variables created from IMF's multilateral trade weighting scheme. The dissertation empirically investigates the extent to which an international VAR model can improve forecasting over VAR

models which are limited to domestic influences.

Two alternative linkage mechanisms were developed. The first mechanism links the four domestic variables of the typical country model to the other countries with a different link variable: an output link, a money supply link, a price link, and an effective exchange rate link. The second linkage mechanism includes both a foreign demand variable using the output link and an economic/financial price variable using the effective exchange rate link in each equation of the domestic model. Using monthly data for the period July 1972-June 1984, the two versions of the LINK-VAR model and individual country closed economy VAR models are estimated to generate twelve period ahead ex-post forecasts for statistical evaluation.

The results from both linkage experiments emphatically suggest that forecasts of domestic variables improve substantially when a linkage mechanism is added to domestic VAR models. This argument is more forceful when the forecast evaluation focuses on country-by-country comparisons.

INTRODUCTION

Large scale structural macroeconometric national models have been widely used for forecasting and economic policy analysis by public and private decision makers. Starting about 1968, the scope of macroeconomic model building has been extended to world wide models. In part this extension recognized the growing economic interdependence among countries. As a remedy for the oversimplified treatment of the foreign sector in domestic models, multi-country structural econometric models have been constructed, to explicitly capture the international transmission of economic fluctuations.

Nevertheless, in recent years there has been a growing controversy concerning the accuracy and usefulness of structural econometric models. Time series methods have been introduced by some economists as an alternative to structural econometric model building. One method which has received a substantial amount of interest in the late 1970's has been the vector autoregression (VAR) technique. Several studies have shown that equally accurate short term forecasts could be generated for economic variables using the VAR method. This challenge of the VAR modeling is becoming more and more acceptable even by the proponents of large-scale structural econometric models.

On the other hand, until now, the issue of incorporating the international transmission of economic fluctuations into domestic models has not been addressed by the VAR model builders. The scope of this relatively new technique had been kept in the contexts of country and regional models and there has been no successful attempt to extend this method on a multi-country scale. Disregarding the international effects on domestic economies seems to be a serious limitation.

The objective of this study is to build an international macroeconomic model in which individual country models are represented by small-scale "vector autoregressions." This research introduces a unique way to develop a vector autoregressive multi-country model by combining the VAR technique with a method of specifying economic inter-country linkages which are utilized by the structural multi-country model builders. The proposed Multi-country Link Vector Autoregressive (LINK-VAR) model demonstrates the significance of incorporating the international transmission of economic fluctuations in projecting economic activity in individual countries.

This dissertation is traditionally organized. Chapter I reviews structural international macroeconomic model building. Chapter II discusses the problems concerning large-scale structural econometric models. The theory of vector autoregressions is detailed in Chapter III. Chapter IV presents a survey of the studies which use the VAR modeling technique. Chapter V describes the main features of the proposed LINK-VAR Model. A discussion of the data and the model estimation is provided in Chapter VI. Chapter VII is devoted to the presentation and interpretation of the research results. The final chapter summarizes the results and includes some concluding remarks.

CHAPTER I

AN OVERVIEW OF INTERNATIONAL MACROECONOMETRIC MODELING

Introduction

Since the end of World War II, there has been a growing interest in international econometric modeling. World wide models have been built to study the interdependence of economic activity among countries and regions. The models that were built before 1968 were basically designed to analyze the structure of international trade.[1] They were developed because of the inherent interest in the flow of resources from country to country (or from region to region) and, to rectify the oversimplified specification of the foreign sector in national models.[2] Among these early models the studies of Metzler (1950), Polak (1954), Beckerman (1956), Tinbergen (1962) and Woolley (1965) investigated the transmission of short-term fluctuations among countries.

The first and probably the most ambitious work in international modeling was the Project LINK, which opened the way

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[1] See for instance Taplin (1967) for an excellent survey of world trade models.

[2] In most national models foreign sector is specified as exogenous or as a function of domestic variables.

to the construction of large scale and detailed world models. It was established in 1968 under the direction of R.A. Gordon, B. Hickman, L. Klein and R. Rhomberg and is the largest and most ambitious international modeling effort to date.[3] The Project Link was the first attempt that undertook the building of a world model by linking existing national short-run structural econometric models. The pioneering Project LINK and most of the efforts that followed, all included national or regional disaggregation of the world economy with linkages and interactions among the regions emphasizing the different aspects of the world economy. A summary of the main features of the major macroeconometric link models is presented in Table 1.1, which is an update of a similar table that appeared in Hickman (1983, p.4). It should be noted that, in addition to the six major models presented in Table 1.1, there are also other modeling efforts that should be mentioned such as the Netherlands

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[3] There has been a growing literature on the progress of Project Link since it was established in 1968. The detailed exposition of the model can be found in three volumes edited by Ball (1973a), Waelbroeck (1976), and Sawyer (1979). The different aspects of the model and its performance has been discussed in Ball (1973b), Hickman (1973), Klein and Van Peetersen (1973), Moriguchi (1973), Waelbroeck (1973), Klein and Keith (1974a, 1974b), Hickman and Schleicher (1978), Klein, Hickman and Filatov (1983). For the most recent developments in Project LINK see Hickman and Klein (1985). Hickman and Klein (1985) report that recently some 35 new models for developing countries have been added into the model. These models have been built at the University of Pennsylvania using some guidance from Third World scholars.

TABLE 1.1. A SUMMARY OF MAIN FEATURES OF MAJOR MULTI-COUNTRY MODELS

MODEL	NUMBER OF REGIONS (NO. OF VAR.)	PRINCIPAL ENDOGENOUS VARIABLES	PRINCIPAL EXOGENOUS VARIABLES	PURPOSES OF MODEL
PROJECT LINK	32 (6,000)	Regional macro variables (GNP, prices, employm., trade balances), trade flows and prices, exchange rates	Regional policy variables, population, oil prices.	1. Ex-ante Forecasting of world trade, GNP, inflation, balance of trade. 2. Simulation studies of international transmission mechanism and policies. 3. Long-run simulation of the world economy.
OECD INTERLINK MODEL	31 (1,400)	Regional macro variables (GNP, prices, employm.) trade and capital flows, interest and exchange rates.	Regional policy variables, population, oil prices.	1. To explain economic links within OECD and with non-OECD 2. Simulation studies of international transmission mechanism. 3. Short-term forecasting of economic activity in OECD countries.
TSUKUBA-FAIS	15 (800)	Regional macro variables (GDP, prices, trade flows, exchange rates, interest rates.	Regional policy variables, official discount rate, oil prices.	1. Simulation studies of international transmission mechanism. 2. Short and medium term projections and policy analy. 3. Comparative studies of macroeconomic behaviour.
DESMOS MODEL	10 (450)	Regional macro variables (GNP, prices, employm.) trade flows and prices.	Regional policy variables, interest rates exchange rates	1. To model the coordination of economic policies in the EEC countries.
FEDERAL RESERVE MULTI-COUNTRY MODEL	6 (950)	National accounts capital accounts, balance of paym., trade and capital flows, interest and exchange rates.	Regional policy variables, population, oil prices.	1. To model the international influence on the US economy. 2. To model US influence on other economies. 3. Ex-ante forecasting of world trade, GNP, inflation, exchange and interest rates.
FAIR MULTI-COUNTRY MODEL	42 (900)	Regional macro variables (GNP, prices, money, balance of paym.) trade and capital flows, exchange and interest rates.	Regional policy variables, population, oil prices.	1. To estimate output, price, interest rate and exchange rate linkages among countries

Central Bureau's METEOR model, the European Economic Community's COMET and EUROLINK models, and the Economic Planning Agency of Japan's EPA World Econometric Model. All of the multi-country models are large-scale systems usually linking a substantial number of countries and regions, and contain hundreds of endogenous variables. They differ significantly in methodology, scope, purpose, and stage of development. In order to see the differences and similarities between the major models of Table 1.1, a brief discussion of the main features and linkage mechanisms of each model will be presented below, followed by an assesment of their overall characteristics.

Project LINK

Project LINK is an ongoing international research project which brings structural national econometric models of eighteen developed market economies, eight centrally planned socialist countries, and five regions of less developed countries (LDCs) into a model of the world economy and world trade. The individual models and research institutions involved in the project are listed in Table 1.2.

The Project LINK model provides integrated projections for the world and individual economies and, at the same time, studies the international transmission of policies and other 'shocks' to the world economic system. It is a unique

TABLE 1.2 THE PARTICIPANTS OF THE PROJECT LINK

COUNTRY	THE INSTITUTION CONSTRUCTING THE NATIONAL MODEL
OECD COUNTRIES	
Australia..........	University of Melbourne
Austria............	Institute of Advanced Studies, Vienna
Belgium............	Free University of Brussels
Canada.............	University of Toronto
Denmark............	Central Bureau of Statistics, Copenhagen
Finland............	Bank of Finland, Helsinki
France.............	INSEE, Paris
Germany (West).....	Bonn University
Greece.............	Center for Econ. Plan. and Res., Athens
Italy..............	University of Bologna
Japan..............	Kyoto University
Netherlands........	Central Planning Bureau, The Hague
Norway.............	LINK Central, Philadelphia
Spain..............	Universidad Autonoma de Madrid
Sweden.............	Stockholm School of Economics
Switzerland........	University of Lausanne
United Kingdom.....	London Business School
United States......	U. of Philadelphia, Wharton EFA, Phil.
CENTRALLY PLANNED COUNTRIES	
Bulgaria...........	United Nations
Czechoslovakia.....	United Nations
Germany (East).....	University of Lodz
Hungary............	Market Research Institute, Budapest
Poland.............	United Nations
Romania............	United Nations
Soviet Union.......	Wharton EFA, Philadelphia
People' Republic of China...........	Stanford University
DEVELOPING REGIONS	
Africa.............	United Nations
Asia...............	United Nations
Latin America......	United Nations
Middle East........	United Nations
Pacific Far East...	United Nations

Source: The Outlook from Project Link, unpublished memo, Institute For Policy Analysis, University of Toronto, p.5.

effort in bringing together the existing large-scale, country maintained national models which have been constructed by various national research centers around the globe. In this respect, it has the advantage that each national model is constructed and run by modelers familiar with the special characteristics and properties of their own economies. The national models of Developed Market Economies (DMEs) in Project LINK are large-scale, dynamic, disaggregated models and vary considerably in terms of size and specification. The demand side of the models are characterized by the Keynesian income-expenditure approach and, in most of the models, money is an important determinant of aggregate demand through interest rates or real balances. The supply- side of the models are typically formulated by labor supply equations and production functions with capacity utilization constraints. Money wages are explained by domestic prices using a mark-up hypothesis, as well as by oil and other raw materials prices coupled with a structural labor market Phillips curve.

The regional models for LDCs are modeled differently than the DMEs models. Output is supply determined by production functions which incorporate capital stock and non-fuel imports in the non-oil exporting countries. On the demand-side, fixed investment is partly determined by imports, while imports themselves are constrained by foreign-exchange reserves except for the oil-exporting countries. Domestic prices are primarily determined by monetary balances and import prices, with the nominal money supply assumed to be exogenous.

The models of the centrally planned countries are also supply oriented. The domestic price level is a function of unit labor costs and import prices.

These three blocks of countries are linked into a world system predominantly through their trade, endogenizing all trade prices and quantities through a central trade model. Hickman and Klein (1985) report research efforts towards integrating monetary and exchange rate linkages into the LINK model.

OECD INTERLINK Model

INTERLINK is a large-scale multi-country model developed by OECD mainly as a tool for short-term forecasting and policy analysis.[4] A recent version of INTERLINK is presented in OECD (1982). This version brings together relatively detailed medium size structural models (approximately one-hundred and forty equations each) for each of the twenty three OECD countries with reduced-form models for each of

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[4] See OECD (1982) for a detailed presentation of equations and parameter values. The different aspects of the model have been discussed in OECD (1979, 1980, 1983). The trade model which is an integral part of the OECD model is discussed in Samuelson (1973).

the eight non-OECD regions. World trade and financial linkage models link the OECD countries to the non-OECD regions. An illustration of the structure of INTERLINK is provided in Exhibit 1.1.[a]

The OECD member country models are basically Keynesian income-expenditure models which include blocks of equations determining the main components of demand; prices and wages; the distribution of income and output; and, employment and key financial variables. The supply-block determines employment, industrial production, unit labor cost, productivity and a measure of GNP gap. The eight non-OECD region models are much less detailed including neither domestic expenditure nor income distribution equations. Trade volumes and prices are the model's most significant linkage channels. These are determined by a world trade model which is integrated into the INTERLINK system. Within each country model, import volumes and export prices are determined as a function of domestic demand, costs and international competitiveness. The international financial linkage block is designed along the same basic principles as the world trade model. In this case, the linkage channel is net international capital flows, which for each country are a function

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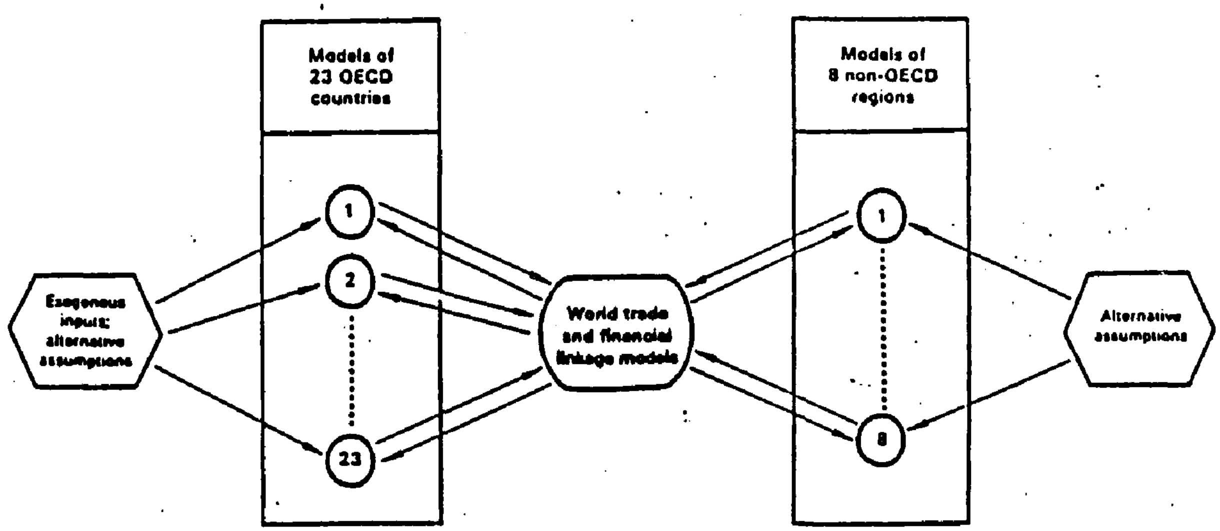
[a] The twenty three OECD country models are for Australia, Austria, Belgium and Luxembourg, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and USA.

EXHIBIT 1.1. THE BASIC STRUCTURE OF THE OECD INTERLINK MODEL



Source: OECD (1983), p.65.

of short-term interest rate differentials, the expected rate of currency depreciation/appreciation, and foreign current account balances. Changes in the exchange rate, interest rate, and money supply for any single country feed via capital flows to other countries affecting their exchange rates and interest rates through the system.

TSUKUBA-FAIS Model

TSUKUBA-FAIS Model was developed in 1974 by the University of Tsukuba and the Foundation for the Advancement of International Science (FAIS). The model has been most commonly used for simulation studies of international transmission of domestic economic policies, the assessment of the international impacts of oil-price increases, and the analysis of the impact of floating versus fixed exchange-rate regimes.[6]

The demand-side of the model for the developed countries is specified by the Keynesian income-expenditure approach. The supply-side of each model includes the potential GNP which is determined by a production function and serves as a

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[6] TSUKUBA-FAIS Model covers eight developed countries (Australia, Canada, Federal Republic of Germany, France, Italy, Japan, United Kingdom, and United States), five major developing countries (Brazil, India, Indonesia, Iran and South Korea) and two remaining regions (i.e., the socialist and other developing regions.) See Shishido (1980) for the exposition of the model, also see Shishido (1983) for the discussion on the use of the model for long-term analysis.

target for demand management policies.

The money supply in the developed countries is specified as a function of the balance of payments surplus (or deficit), government surpluses (or deficits), the private demand for investment and the monetary policies of the central bank. In the developing countries money supply is treated as exogenous. Prices in both developed and developing countries are explained by the rate of capacity utilization, the supply of money, import prices and price expectations.

The linkage mechanism in the TSUKUBA-FAIS Model is through commodity trade flow matrices for two commodity groups (primary and manufactured). Imports are determined by income, import and domestic prices, and exchange rates, while global supply and demand models determine exports and imports for each region. Exchange rates are endogenous for developed countries and are determined by relative prices, current balances, expected real rates of interest, and market intervention by the central bank. Exchange rates are treated as exogenous in the developing country models.

DESMOS Model

DESMOS Model is a multi-country linked system developed to study the coordination of economic policies in the European Economic Community (EEC) countries. Unlike Project LINK the national country models are small-scale and the economies of each country are described by similar equations.[7] The model is designed in terms of four blocks of equations formulating the interdependence of real variables and prices in EEC countries, where the economic activity outside of EEC countries is treated as exogenous.

There is an income and expenditure block representing the demand-side, which is characterized by the Keynesian approach. The factor demand block constitutes the supply-side and is represented by factor demand equations with a single production function and capacity utilization constraints. The wage-price block links wages to both unemployment and prices by Phillips curves and explains prices by cost-push formulas.

The linkage between EEC countries are represented by the trade block. Each countries' imports are determined by its output and by its relative prices. Imports are then allocated as exports by bilateral trade flow equations. The DESMOS Model specifically studies the mechanisms through which policy instruments affect the economies of the EEC countries. It also studies how the model's dynamic multipli-

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[7] DESMOS (Link in Greek) Model was first built by Dr. M. Grinwis covering the six initial EEC countries. DESMOS II. which is an extension of the initial model was built by Dr. A. Dramais covering the nine EEC countries as of 1974 (Belgium, Denmark, Federal Republic of Germany, France, Ireland, Italy, Luxemburg, Netherlands and United Kingdom. See Dramais and Waelbroeck (1974) for a detailed exposition of the model.

ers might be used to formulate a coordinated economic policy for EEC.

The Federal Reserve Multi-Country Model

The Federal Reserve's Multi-country Model (MCM) is a system of linked national macroeconomic models for five major industrial countries with an abbreviated model for the rest of the world.[a] The MCM is a short-run model and the simulations are limited to an eight quarter horizon. The model is designed to study the international transmission of economic policies among the five major countries. Dynamic multipliers are calculated for a fiscal shock originating in each of the five countries in pre-linkage (closed-economy) and post-linkage (open-economy) modes. The basic structures of each national model have substantial similarities, however, there are several differences which largely reflect the differences in institutional detail. Each country in the system is modeled as five markets, domestically produced goods, labor, money and short-term and long-term bonds, with varying degrees of complexity.

The demand-side of the goods market is modeled using the

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[a] The five country macroeconometric models are for Canada, Federal Republic of Germany, Japan, the United Kingdom and the United States. See Kwack, Sung, Berner, Clark, Hernandez-Cata, Howe and Stevens (1983) for a discussion of the theoretical structure and simulation properties of the model.

Keynesian income—expenditure approach. The supply—side is represented by the potential GNP, which is related to the capital stock and potential employment via a Cobb—Douglas production function with capacity utilization constraints.

Domestic prices are explained by mark—ups over wage costs, changes in labor productivity, and the cost of imports. Wage rate in manufacturing and the unemployment rate are determined in the labor market. The rate of change in nominal wages is a function of the unemployment rate and the expected rate of inflation. The rationale behind the equations of the labor market is that because of minimum wage laws and the existence of union contracts, wages do not adjust rapidly, therefore, there is an excess labor supply in the market.

In the monetary sector, the demand of the commercial banks for free reserves depends on the short-term interest rate and the official discount rate. For a given stock of the unborrowed base, the short—term interest rate will adjust so as to equalize the existing supply with direct and indirect demand for base money.

The international linkages between the countries are specified in considerable detail in the MCM. Linkages through trade and capital flows, as well as changes in international reserves, exchange rates and prices, are included in the model.

Fair Multi-country Model

Fair Multi-country Model which contains equations for forty four countries, differs from previous models in the following ways: (1) It accounts for exchange rate linkages between countries along with the usual trade linkages. (2) In the theoretical model the concepts of stock and flow effects are completely integrated. (3) The core number of countries in the model is larger than the other models and the all data are quarterly. (4) Unlike the previous link models, i.e., Project LINK, where existing national models are linked together, Fair links small scale national models which are very similar in their specification.*

Each country is assumed to produce one good (a one sector approach) and the demand for imports is a function of prices, income, and interest rates. Standard demand for money and the term structure equations are estimated for each country. The demand for money is a function of the short-term interest rate and income. The long-term interest rate is a function of current and lagged short-term interest rates and an expected future inflation term.

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* See Fair (1979b, 1982, 1983, 1984) for a detailed exposition of the model and the developments over the years.

An Assessment of The Major Multi-country Models

The most common aspect of the multi-country models in the previous section, is the way in which economic structures are represented in each national econometric model. The demand-side of the models are characterized by the Keynesian income-expenditure approach where, the aggregate demand is broken into four major components; personal consumption, gross private domestic investment, exports, and imports. The equations representing these components are specified under the assumptions of the Keynesian framework.

The supply-side of the models is typically formulated by labor supply equations and production functions with capacity utilization constraints. Money wages are typically explained by domestic prices and the mark-up pricing hypothesis. Oil and other foreign prices as well as labor markets are analyzed with the help of the Phillips curve.

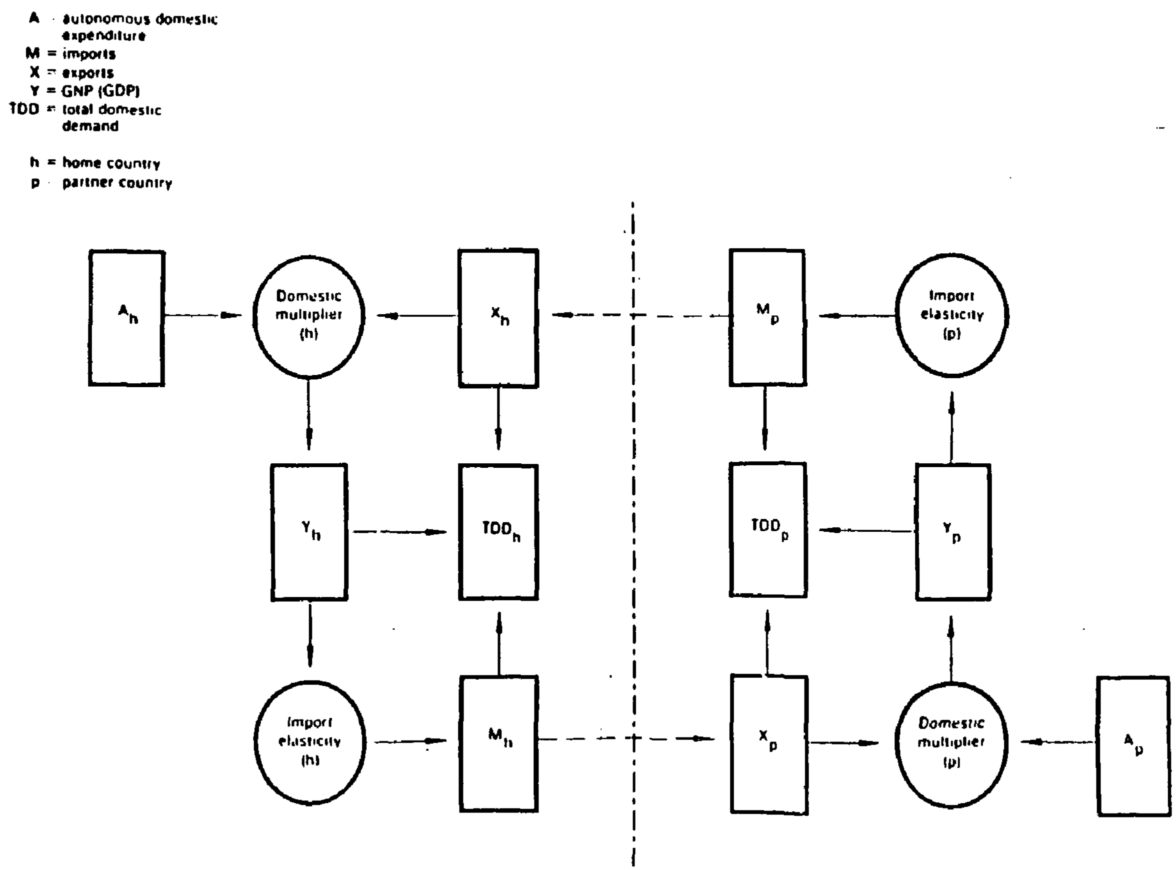
The novel element in international modeling is the way each national econometric model is linked to the other national econometric models, i.e., the linkage mechanisms. A common feature of all the link models is the linkage through trade flows, which allows for the domestic shocks to be transmitted abroad through the resulting changes in import demands and export prices of the initiating country. Foreign and domestic price linkages as well as exchange rates and other monetary linkages are an integral part of the linkage mechanism among the countries. A selected summary of the linkages in the multi-country models is presented in Table 1.3 which is a modified version of Hickman's (1983, p.12) table on linkages in multi-country models.

The trade linkages in the multi-country models are typically represented by a world trade model. This world trade model usually determines exports from a central trade-share matrix that allocates each *region's* imports to the various exporting regions. Thus, the world trade identity (the sum of all exports must equal the sum of all imports) is satisfied in the simultaneous solution of the link model. A simple flow-chart showing the trade linkage mechanism in a hypothetical two-country model is presented in Exhibit 1.2. The trade linkage mechanism has two important aspects. First, from the point of view of each country's model, integration with the world trade model makes each country's exports endogenous. Second, from the point of view of the world trade model, integration with single country models results in making each country's domestic economic activity endogenous as well. For instance, a disturbance to the home country's exports could lead to changes in the home country's economic activity with domestic multiplier effects. This in turn, induces changes in the home country's imports, thereby affecting the partner country's exports and the levels of economic activity. As a result, the link models,

TABLE 1.3. A SUMMARY OF THE LINKAGES IN THE MAJOR MULTI-COUNTRY MODELS

MODEL	TRADE LINKAGES	PRICE LINKAGES	EXCHANGE RATE LINKAGES	MONETARY LINKAGES
PROJECT LINK	Imports determined by domestic income domestic & foreign prices. Endogenous share matrix distributes imports as exports	Export and domestic prices are markups over factor costs including oil, unit labor costs & import prices also affected by money.	Developed count.: determined by relative prices, current accounts, and interest rate differentials.	————
OECD INTERLINK MODEL	Imports determined by domestic income import & domestic prices and international competitiveness. Endogenous share matrix distributes imports as exports.	Exports and domes. prices are markups over factor costs including imports.	OECD countries: Determined by relative prices, current accounts, and interest rate differentials.	Money supply is affected by changes in foreign reserves.
TSUKUBA-FAIS MODEL	Imports determined by income, domestic & import price and exchange rate. Endogenous share matrix distributes imports as exports	Exports and domes. prices determined by import prices, capacity utilization, and money.	Developed count.: Determined by relative prices, current accounts, interest rates, and central bank intervention.	Money supply is affected by changes in foreign reserves to extent determined by intervention policy
DESMOS MODEL	Imports determined by domestic income relative prices. Endogenous share matrix distributes imports as exports	Export and domes. prices determined by wages and import prices.	Exchange rates are exogenous.	————
FEDERAL RESERVE MULTI-COUNTRY MODEL	Bilateral goods and service flows determined by income, prices and exchange rates.	Export and domes. prices are markups over wages, changes in labor productivity and import prices.	Exchange rate equilibriates the balance of payments.	Net foreign assets of central bank affect monetary base to extent determined by intervention.
FAIR MULTI-COUNTRY MODEL	Imports determined by prices, income, interest rates and wealth. Exogenous share matrix distributes imports as exports	Export and domes. prices determined by income, import prices and interest rates.	The spot rate is determined by own-country and US interest rates, incomes and prices.	Interest rates determined by central bank reaction function which includes US interest rates in some national models.

EXHIBIT 1.2. THE INTERNATIONAL LINKAGES OF ECONOMIC ACTIVITY IN A TWO COUNTRY MODEL



Source: OECD (1979), p.10.

through the trade linkage mechanism, take into account not only the direct own country effects of changes in policy variables, but also both the succeeding rounds of effects resulting from changes induced in the other country's economic activity and the effects of changes in policy variables in the other countries of the system. A mathematical representation of the workings of trade linkages for a hypothetical simple two-country model is presented in Appendix A.

With the exception of the Fair model, trade linkages constitute the basis of the linkage mechanism in multi-country models. Linkages among countries with respect to exchange rates, interest rates, and prices appear to be more important than the trade linkages in the Fair model. This is due to the fact that the primary purpose of the Fair model is to estimate the economic linkages among countries using relatively small national country models. As Fair (1982, p.509) indicates:

> The advantage of the present approach is that the person constructing the individual models knows from the beginning that they are to be linked together and this may lead to better specification of the linkages.... Whether this possible gain in the linkage specification outweighs the loss of having to deal with small models of each country is an open question.

In recent years, the importance of linkages other than trade linkages has been recognized and has already been incorporated in some of the existing international models.

For instance, a recent version of the OECD's INTERLINK model has introduced a financial linkage model along the same basic principles as the world trade model. In the case of financial linkages, net international capital flows constitute the linkage channel. Changes in the exchange rate, interest rate, and the money supply for any single country feed through capital flows to other countries, affecting exchange rates and interest rates throughout the system. The financial linkage model, therefore, ensures consistency of net capital flows in the world balance of payments accounts.

Hickman and Klein (1985) reported that specification of financial linkages has been the recent development in Project LINK. A considerable amount of work has been done for the LINK model in modeling exchange rate equations for the major industrial countries and the research efforts continue on the estimation of capital flows.

In concluding this chapter, the following observations can be made about the state of structural international econometric modeling: (1) There has been an increasing amount of research done in the area of structural international macroeconometric modeling over the last fifteen years. (2) The novel element in structural international econometric modeling is the specification of linkages among countries and regions. (3) Until recently, the international linkages in most multi-country models had been based only on trade linkages. (4) The most recent development in the area of international modeling is the specification of more elaborate linkages among country models by introducing financial and exchange rate linkages. (5) The multi-country econometric models, just like individual country econometric models, are used for short-term and long-term forecasting and policy analysis.

The next chapter will focus on the problems of large-scale structural macroeconometric modeling efforts and discuss the recently suggested alternative model building techniques.

CHAPTER II

PROBLEMS IN STRUCTURAL ECONOMETRIC MODELS

Introduction

The previous chapter was devoted to a review of the important aspects of the major multi-country structural macroeconometric models, which are constructed by first building national models and then linking them through different linkage mechanisms. The methodology used in both international and national model building is usually referred to as the 'structural' approach. It is structural in the sense that the models are built as a system of equations representing the structure of the economy, where each equation deals with a different sector. In order to build such models, the model builders first need some 'a priori' knowledge as to how the structure of the economy can be represented. In other words, what they need is a 'coherent' economic theory explaining the behavior patterns of economic agents within the economic system. The economic theory would indicate which variables should be included in which equations, thus allowing the model builders to impose some restrictions on the specification of the models. Prior to the estimation process, the model builders should make sure the models are 'identified' so that given the reduce-form coefficients of the model, the structural form coefficients can be found. Once the model is fully identified, it can be estimated and used for forecasting and policy analysis.

In recent years, there has been a substantial amount of discussion about the accuracy and usefulness of structural macroeconometric models. Several studies have addressed such issues as the size and purpose of the models, assessment of forecasting accuracy, as well as general evaluation and comparison of alternative models.[1] One area of concern was the inability of large scale macroeconometric models to produce accurate forecasts. Unlike in the 1950's and 1960's, the predictive performance of these large-scale models started deteriorating in the 1970's as most models predicted economic activity well below actual rates. The emergence of simultaneous high rates of unemployment and inflation could not be forecasted and explained by these models. More recently, the strong recovery out of the 1982 recession was significantly underpredicted by most large-scale models.[2]

The breakdown of the predictive power of structural macroeconometric models in recent years created skepticism

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[1] See for instance, Kmenta and Ramsey (1981), Spivey and Wrobleski (1979), McNees (1973a, 1973b, 1974, 1975, 1981, 1983, 1985, 1986), Fair (1979a), Zarnowitz (1978).

[2] See Hakkio and Morris (1984), p.2.

about the construction and use of these models. In a major study, Sims (1980a) challenged the use of large scale structural macroeconometric models for forecasting and policy evaluation on empirical grounds. Another group of economists, which became known as the "new classical economists", attacked the theoretical foundations of large-scale structural macroeconometric models, specifically the Keynesian theory on which most models are based.[3]

Lucas (1976) argued that these models do not take into account the structural changes that may result from policy changes. Thus, the models cannot be useful for conditional forecasting and policy analysis. Furthermore, Granger (1981) criticized the estimation techniques and statistical tests used by the model builders of the structural models. For the purposes of our study, the discussion on the problems of structural econometric models will be limited to only the Sims' and Lucas' critiques.

The Sims' Critique of Large-Scale Macroeconometric Models

Sims, in his major study, "Macroeconomics and Reality", criticized the structural macroeconomic models in the way

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[3] The reference here is to the 'rational expectations, school whose leading advocates are Thomas Sargent, Neil Wallace and Robert Lucas. See for instance, Sargent and Lucas (1978), Sargent (1973) and, Sargent and Wallace (1976).

they are identified by their builders. Sims (1980a, p.1) wrote:

> ..the style in which their builders construct claims for a connection between these models and reality- the style in which "identification" is achieved for these models cannot be taken seriously.... the restrictions imposed in the usual style of identification are neither essential to constructing a model which can perform these functions nor innocuous.

Sims raised three basic issues concerning his objection to the way structural econometric models are built: (1) 'A priori' restrictions; (2) Dynamic aspects of the models and exogeneity assumptions; and (3) Treatment of expectations.

'A Priori Restrictions'

The structural equations in an econometric model are specified using 'a priori' knowledge about what the structure of the economy could be. This a priori information is claimed to be the economic theory, which explicitly suggests a certain set of relationship between the variables of interest. Using this theory in model specification implies that certain variables will be included in certain equations and not included in some others. In other words, if some explanatory variables appear on the right hand side of some equations and not in the others, this would indicate that their coefficients are restricted to zero thus excluding them from the other equations. Sims (1980a, p.4) argued that some of the restrictions that are imposed are well founded and theoretically justified and gave the following example for such restrictions:

> The idea that weather affects grain supply and not (much) grain demand, while the ethnic and demographic structure of the population affects grain demand but not (much) grain supply, is a powerful source of identifying restrictions.

Sims (1980a, p.4) claimed that only a few of the equations are specified by using only theoretically justified restrictions and most of the restrictions in the large macroeconometric models are "normalizations rather than truly structural distinctions".*

Sims (1980a, p.3) wrote,

> If large blocks of equations, running across "sectors" of the model which are ordinarily treated as separate specification problems, are in fact distinguished from one another only by normalization, what "economic theory" tells us about them is mainly that any variable which appears on the right-hand side of one of these equations belongs in principle on the right-hand-side of all of them. To the extent that models end up with very different sets of variables on the right-hand-sides of these equations, they do so not by invoking economic theory, but (in the case of demand equations) by invoking an intuitive, econometrician's version of psychological and sociological theory since constraining utility functions is what is involved here.

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* Sims(1980a,p.2) explains what he means by "normalization" in the following way "If a parameterization we derive from economic theory (which is usually what we mean by a "structural form" for a model) fails to be identified, we can always transform the parameter space so that all points in the original parameter space which imply equivalent behavior are mapped into the same point in the new parameter space. This is called normalization. The obvious example is the case where, not having an identified simultaneous equation model in structural form, we estimate a reduced form instead."

The large-scale structural models are typically specified one equation at a time. Since the equations of the model are not considered as a system in the process of specification, the theoretical foundation of the restrictions on the entire system may be much less reasonable than the restrictions on any one equation alone. As a result the final specifications of the equations in the large macroeconometric models sometimes do not actually represent the economic theory behind their formulations.

In essence Sims seems to argue that structural model builders are more concerned with empirical aspects of model building rather than the theoretical ones. The model specification in most cases is done without paying much attention to what economic theory suggests. Furthermore, since specification is done equation by equation, the restrictions imposed on any equation alone might not be justified in the context of the model as a whole.

Dynamic aspects of large-scale structural econometric models and exogeneity

Sims claimed that model builders, in their efforts to make their large macroeconometric models dynamic, imposed 'spurious a priori' restrictions. Since most of these models make the assumption that markets do not clear instantaneously, they have to incorporate lagged dependent variables in the specification of many equations. Identification in the presence of lagged dependent variables and serially correlated residuals does not pose a serious problem if the exact lag lengths and orders of the serial correlation in the model are known a priori. Since economic theory does not provide any information on lag lengths or shapes of lag distributions, these structures cannot be known a priori. Therefore, some of the restrictions that are imposed in terms of lag structures are often times unfounded.

Another issue concerning econometric model building is as Sims (1980a, p.5) pointed out is the labeling of certain variables as strictly exogenous "by default rather than as a result of there being good reason to believe them strictly exogenous." Some of the variables are treated as exogenous because explaining them would require additional equations, thus complicating the model even further, which might not be necessary for the purposes of the model (e.g., agricultural prices, volume of exports, etc.) Some other variables are treated as exogenous because these variables are policy variables (e.g., money supply, government spending, etc.). There is a problem with this approach since it can be argued that these variables could have endogenous components. In other words, given the fact that the policy makers base their decisions on how they perceive the economic environment, it is doubtful that these policy variables would strictly be exogenous. Sims made the claim that a statistical test for exogeneity for many of these variables would indicate that most of them are in fact not exogenous.

Treatment of Expectations

A third issue that Sims brought forth was the treatment of expectations in large scale macroeconometric models. Sims made the claim that the expectations of the households or businesses about the future of the economy which enter into structural econometric models are not specified correctly. Since expectations of economic agents are not readily observable, expectations raise a difficult problem for model builders. A careful and well thought out specification of expectations may very well complicate the model and make identification very difficult. On the other hand, simplifying the treatment of expectations, as it is done with many zero restrictions might make the identification easier, but undermines the reliability of the model. Sims (1980a, p.6) stressed this point with an example:

> However certain we are that the tastes of consumers in the U.S are unaffected by the temperature in Brazil, we must admit that it is possible that U.S consumers, upon reading of a frost in Brazil in the newspapers might attempt to stockpile coffee in anticipation of the frost's effect on price. Thus variables known to affect supply enter the demand equation and vice versa, through terms in expected price.

Sims' critique of the treatment of expectations in structural models is not necessarily a re-iteration of the position of the so called "new classical" economists (i.e, rational expectations). As Sims (1980a, p.6) argued,

> Whether or not one agrees that economic models ought always to assume rational behavior under uncertainty, i.e, "rational expectations," one must agree that any sensible treatment of expectations is likely to undermine many of the exclusion restrictions econometricians had been used to thinking of as most reliable.

Given the above problems, Sims claimed that structural econometric models are still useful, as structural identification restrictions do not greatly affect the estimated reduced form. Therefore, even a badly misspecified model can still be helpful for forecasting and policy analysis.

Sims (1980a, p.12) wrote,

> When a policy variable is an exogenous variable in the system, the reduced form is itself a structure and is identified. In a supply and demand example, if we contemplate introducing an excise tax into a market where none has before existed, then we need to be able to estimate supply and demand curves separately. But if there has previously been an excise tax, and it has varied exogenously, reduced form estimation will allow us accurately to predict the effects of further changes in the tax. Policy analysis in macro models is more often in the latter mode, projecting the effect of a change in a policy variable, than in the mode of projecting the effect of changing the parameters of a model equation.

He finally referred to what has became known as the "Lucas Critique" as a more fundamental problem with structural econometric models.

Lucas Critique

Lucas (1976) argued that structural relationships may change over time as the expectations of the economic agents change in response to changes in economic policies. If the economic agents alter their historical behavior patterns in response to new economic policy changes, the usefulness of large scale structural econometric models as a tool for forecasting and policy analysis would be drastically reduced. This is due to the fact that a change in behavior patterns would indicate a change in the relationships between the economic variables, thus changing the structural parameters of the econometric model. If the structure of the economy changes as a result of a change in economic policy, the econometric models, based on the assumption that the structure of the economy will remain the same after the policy change, would not be able to make accurate predictions. Sims (1980a) argued that Lucas' position is correct, however, the seriousness of this problem depends on how rapidly the structure of the economy changes in reaction to policy changes.

Given the problems outlined by Sims and the Lucas' Critique, Sims (1980a, p.15) argued that "it should be feasible to estimate large scale macro-models as unrestricted reduced forms, treating all variables as endogenous." He suggested the use of a system of linear stochastic difference equations, more commonly referred as Vector Autoregression (VAR), as an alternative specification. Such specification unlike structural econometric models attaches a minimum role to economic theory and thus *does* not impose the theoretical restrictions of the structural models. The interesting aspect of these type of models, as Hakkio and Morris (1984) have suggested, is that both Keynesians and Monetarists could use the *same* model to predict the future course of the economy regardless of the fact that they have a different view about the structural relationships among economic variables.

In concluding this chapter concerning structural econometric models, those issues specifically raised by Sims and Lucas can be summarized as: (1) structural models impose restrictions which are not theoretically justified. (2) lag structures and exogeneity assumptions in these models are spurious. (3) expectations treatments are too simplified. (4) structural models cannot account for structural changes.

As an alternative to structural econometric model building, Sims introduced the Vector Autoregression (VAR). The next chapter is devoted entirely to the discussion of the VAR technique.

CHAPTER III

THE VECTOR AUTOREGRESSION TECHNIQUE

Introduction

In recent years 'time-series models' introduced by Box and Jenkins (1970) have become a popular modeling strategy for economic and business forecasting.[1] A time series model is built to capture the systematic patterns in the past movements of a particular variable and use this information to predict future movements of that variable. This modeling technique, unlike structural econometric models, does not seek to explain the structural behavior of economic variables but does reproduce their past behavior in order to predict the future.

Vector Autoregression (VAR), introduced by Sims (1980a), is a particular form of a multi-variate time series model. This technique was popularized by the researchers at the Federal Reserve Bank of Minneapolis. Since Sims' seminal study there has been an ever growing literature concerning the VAR technique. The theory of VAR has been outlined in

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[1] For a detailed exposition of time-series analysis refer to Box and Jenkins (1970). A less technical presentation is provided in Pindyck and Rubinfeld (1981).

Sims (1980a, 1982), Litterman (1979, 1980, 1982), and Sargent (1979). Relatively simplified expositions can be found in Gordon and King (1982), and Hakkio and Morris (1984).

The exposition of the VAR Models in this chapter is organized as follows: The next section outlines the basic features of VAR models and it is followed by a section describing uses of VAR models. The last part of the chapter is devoted to the discussion on the relationship between structural econometric and VAR models.

Vector Autoregression (VAR) Models

Similar to structural econometric models, a VAR model is built as a system of equations that can be used particularly to forecast the future paths of economic variables. Like other time series models, VAR relies exclusively on the systematic patterns in the past behavior of economic variables. 'Autoregression', in the context of this technique refers to the fact that the current value of a variable is generated by its past values. 'Vector autoregression', refers to a process where the current values of a vector of variables are generated by the past values of that vector. Thus, a VAR model is a dynamic equation system where each variable included in the system is allowed to depend upon not only its own past, but the past of the other variables in the system.

An n-variable and m^{th} order VAR model can be represented as:

$$\underset{n \times 1}{X_t} = \underset{n \times 1}{Z_t} + \sum_{i=1}^{m} \underset{n \times n}{A_i} \underset{n \times 1}{X_{t-i}} + \underset{n \times 1}{e_t} \qquad (3.1)$$

$E(e_t) = 0$

$E(e_t e_{t'}) = \Sigma$

$E(e_t e_{s'}) = 0 \quad t \neq s$

where X_t is a vector of n-variables which depends on its past as given by $\Sigma A_i X_{t-i}$ and another vector Z_t which captures the deterministic component of X_t. Z_t is a linear function of an nxz matrix of parameters, B. For instance, if there is a constant and trend in the equations in which case z = 2, $B = (\underset{n \times 1}{B_0}, \underset{n \times 1}{B_1})$ and $Z_t = B_0 + B_1 t$.[a] e_t is the vector of random disturbance terms and Σ is the variance-covariance matrix of e's.

The different features of the VAR technique can be analyzed with a simple example. Assume a two variable, first order VAR model:

$$\underset{2 \times 1}{X_t} = \underset{2 \times 1}{Z_t} + \sum_{i=1}^{m} \underset{2 \times 2}{A_i} \underset{2 \times 1}{X_{t-i}} + \underset{2 \times 1}{e_t} \qquad (3.2)$$

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[a] See Litterman (1979), p.105.

where X_t contains two major macroeconomic variables M = Money Supply and Y = GNP, Z_t has a constant term for each equation and e_t is the vector of disturbance terms. This system can be written in matrix form as:

$$\begin{bmatrix} M_t \\ Y_t \end{bmatrix} = \begin{bmatrix} m \\ y \end{bmatrix} + \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} M_{t-1} \\ Y_{t-1} \end{bmatrix} + \begin{bmatrix} u_t \\ v_t \end{bmatrix} \qquad (3.3)$$

where m, y, a, b, c, d are coefficients to be estimated. Equation (3.3) would have the following scalar form.

$$M_t = m + a\,M_{t-1} + b\,Y_{t-1} + u_t \qquad (3.4)$$

$$Y_t = y + c\,M_{t-1} + d\,Y_{t-1} + v_t \qquad (3.5)$$

VAR Models, as represented above are reduced form models where each endogenous variable is determined by constants and pre-determined endogenous variables. Therefore VAR models resemble the structural models. However, the relationships that are *specified* in VAR models do not stem from economic theory as in the case of structural models. The role of economic theory in the specification of VAR models is fairly limited. In fact, this aspect of VAR models made some economists to classify these types of models as 'atheoretical'.[3] A VAR model can be viewed as an unconstrained reduced

[3] *See Cooley and LeRoy (1985).*

form of an underlying but unknown, structural system of equations. Economic theory becomes important in the selection of variables. VAR models impose fewer restrictions compared to Structural Econometric Models (SEM), since they are not based on economic theory as explicitly as the SEMs are. The order of the VAR process, i.e., the lag structure, is determined by using statistical criteria. The coefficient estimates of individual right-hand side variables do not have any direct economic meaning. On the other hand the joint explanatory power of the lag structure of each variable can indicate the relationships between the variables which constitute the system.

In the two variable example represented by Equations (3.4) and (3.5) each variable was allowed to be determined by its own past and the past of the other variable in the system, but not by the current value of the other variable! An order of one was assumed to make this example very simple. If for instance there is evidence to believe that the money supply is exogenous to the system, the VAR model can be modified. If M is exogenous, it means that the coefficient of Y_{t-1} (c) is restricted to be zero and M is determined only by its own past. There are cases where some variables are in fact only determined by their own past but at the same time can determine other variables in the system. This kind of variables can be classified as 'driving variables', such as M in this example. On the other hand, the variables which influence and at the same time are influenced by the other variables, Y in this example, can be classified as 'responding variables'. It is important to note that the selection of driving variables are made based on statistical testing and not due to prior beliefs based on economic theory. This point will be elaborated more in part three of this chapter.

USES of VAR Models*

The VAR models are reduced form equation systems of underlying but unknown, structural system of equations. Since the structures are unknown, VAR models can not be used for conventional policy analysis, which is the task exclusively claimed by SEMs. On the other hand there are several significant uses of VAR models which make this modeling strategy a powerful competitor to the traditional SEMs. In this section the uses of VAR models will be presented under four broad categories as: Unconditional and conditional forecasting; tests for causality; the moving average representation of VAR and Impulse response analysis; and variance decomposition and exogeneity.

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* In this section all the uses of VAR technique is discussed in order to give a complete survey of the literature on the theory of vector autoregression. The section which is relevant to the empirical research of this dissertation is the first part presented under the heading "Unconditional and Conditional Forecasting with VAR Models."

<u>Unconditional and Conditional Forecasting with VAR Models</u>

The most practical use of VAR models is in the area of business and economic forecasting. Since VAR models are exclusively designed to capture the systematic patterns in the historical data with a fairly flexible specification, they are very useful in projecting the future paths of variables, assuming the past patterns will recur in the future. The simple two variable model described by Equations (3.4) and (3.5) can be utilized to demonstrate the use of VAR models in forecasting. Excluding the constant terms for simplicity, the simplified system can be written as:

$$M_t = a\, M_{t-1} + b\, Y_{t-1} + u_t \qquad (3.6)$$

$$Y_t = c\, M_{t-1} + d\, Y_{t-1} + v_t \qquad (3.7)$$

$$u_t \sim N(0, \sigma_u^2)$$

$$v_t \sim N(0, \sigma_v^2)$$

This model can now be used to generate unconditional forecasts for k period-ahead using all the current and past information on M and Y. The values of M and Y at one period-ahead will be:

$$M_{t+1} = a\, M_t + b\, Y_t + u_{t+1} \qquad (3.8)$$

$$Y_{t+1} = c\, M_t + d\, Y_t + v_{t+1} \qquad (3.9)$$

The optimal linear forecast of M_{t+1} and Y_{t+1}, given all the information available at time t, t-1, t-2, ... is the conditional expectation of M_{t+1} and Y_{t+1}

$$\hat{M}_{t+1} = E_t (M_{t+1}) = a M_t + b Y_t \quad (3.10)$$

$$\hat{Y}_{t+1} = E_t (Y_{t+1}) = c M_t + d Y_t \quad (3.11)$$

where the expected value of the unanticipated component in each equation at time t is zero, $E_t (u_{t+1}) = E_t (v_{t+1}) = 0$. Using the chain rule of forecasting, according to which forecasts of M_{t+1} and Y_{t+1} are used to generate forecasts for M_{t+2} and Y_{t+2}, etc., the future values of M and Y can be generated. The values of M and Y in k periods ahead will be:

$$M_{t+k} = a M_{t+k-1} + b Y_{t+k-1} + u_{t+k} \quad (3.12)$$

$$Y_{t+k} = c M_{t+k-1} + d Y_{t+k-1} + v_{t+k} \quad (3.13)$$

Taking the expectation of M_{t+k} and Y_{t+k} conditional on all information available at time t yields k period-ahead forecasts for m and Y,

$$\hat{M}_{t+k} = E_t (M_{t+k}) = a M_{t+k-1} + b Y_{t+k-1} \quad (3.14)$$

$$\hat{Y}_{t+k} = E_t (Y_{t+k}) = c M_{t+k-1} + d Y_{t+k-1} \quad (3.15)$$

$$E_t (u_{t+k}) = E_t (v_{t+k}) = 0.$$

where, the expected value of the future unanticipated component in each equation at time t is zero. Therefore, once the two variable model is estimated and the values for parameters a, b, c, and d are found, these values can be used to generate optimal linear forecasts of the variables of interest, M and Y. Since for k period-ahead forecasts only the information available at the time t is used, then the forecasts for M and Y are unconditional.[5] Note that even if there is a reason to believe M is a driving variable for the system (assuming b = 0) the model will still generate unconditional forecasts. The forecasted values of M will depend only upon its own past and the forecasts of Y will depend on the past values of both variables M and Y.

VAR models can also be used to generate conditional forecasts. For instance the two variable model can produce k period-ahead forecasts for Y given assigned future values for M. In this case the future path of Y is generated using the chain rule of forecasting where future values instead of forecasted values of M are used.

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[5] Hakkio and Morris (1984, p. 18) indicates that the term "conditional" takes on a different meaning when it refers to "forecast" than when it refers to "expectation". Note that, the <u>conditional expectation</u> of for instance M_{t+k} at time t conditional on all information available at time t is referred as the <u>unconditional forecast</u> of M_{t+k}.

Tests for Causality

VAR models can be used to determine the direction of causality between economic variables. This can be shown by using the simple model represented by Equations (3.6) and (3.7) which are reproduced below:

$$M_t = a M_{t-1} + b Y_{t-1} + u_t \quad (3.6)$$

$$Y_t = c M_{t-1} + d Y_{t-1} + v_t \quad (3.7)$$

For instance, according to Granger (1969), if in the M equation the coefficient of the lagged Y, b, is statistically not different from zero and in the Y equation the coefficient of the lagged M, c, is statistically different from zero, there is a unidirectional causality from M to Y. Unidirectional causality runs from Y to M if the reverse is true (i.e., both $b \neq 0$, $c = 0$). Feedback between Y and M exists if $b \neq 0$ and $c \neq 0$. There is no relationship between M and Y if $b = 0$ and $c = 0$.

Moving Average Representation of VAR and Impulse Response Analysis

A different way to present the information contained in a VAR model is the Vector Moving Average (VMA) representation. Referring again to the two variable first order VAR model described by Equations (3.6) and (3.7) and reproducing them again as Equations (3.16) and (3.17) with the addition of Equation (3.18) which illustrates the variance co-variance matrix of the error terms:

$$M_t = a\,M_{t-1} + b\,Y_{t-1} + u_t \qquad (3.16)$$

$$Y_t = c\,M_{t-1} + d\,Y_{t-1} + v_t \qquad (3.17)$$

$$E\begin{bmatrix} u_t \\ v_t \end{bmatrix}\begin{bmatrix} u_t & v_t \end{bmatrix} = \Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{bmatrix} \qquad (3.18)$$

Each variable is determined by its own past and the past values of the other variables. In each equation there is a disturbance term accounting for the unexplained variation. Since the right-hand-side variables include observations only prior to the current period, u and v capture the contemporaneous contributions to the dependent variable in each equation. For the current period, at time t, the contemporaneous disturbance term is called the 'innovation' or 'shock' to the dependent variable, since this term represent that part of the dependent variable that is not predictable from the information on the past history of the variables in the system. The (VMA) representation of a VAR model is a transformed system, where the dependent variables are determined by current and lagged values of the innovations in the system. The VMA representation exists only if the VAR process is invertible. That is, if the VAR process is invariant with respect to time, i.e, stationary.[6]

The moving average representation for the model can be obtained by recursive substitution using Equations (3.16) and (3.17).

$$M_t = u_t + a\, u_{t-1} + (a^2 + bc)\, u_{t-2} + \ldots\ldots \quad (3.19)$$
$$+\, b\, v_{t-1} + (ab + bd)\, v_{t-2} + \ldots\ldots$$
$$Y_t = c\, u_{t-1} + (ac + cd)\, u_{t-2} + \ldots\ldots \quad (3.20)$$
$$+\, v_t + d\, v_{t-1} + (bc + d^2)\, v_{t-2} + \ldots\ldots$$

The above VMA representation can be used to study the effects on each variable of given innovations to each of the variables. For instance the effects of M innovations on M as well as on Y can be analyzed. This VMA representation provides a time path for any given variable resulting from the effect of any given innovation. This time path of effects of one innovation on one variable is called an 'impulse response' function. There will be an impulse response function for each variable given an innovation of one variable. For instance M has an impulse response function for its own innovation and for an innovation in Y, etc.

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[6] Stationarity is a very important pre-requisite for time-series analysis. If the characteristics of a time-series process change over time, it is often difficult to represent the time-series over past and future intervals of time by a single algebraic model. See Pindyck and Rubinfeld (1981), p.497-498.

The impulse response function will be meaningful under the assumption that the innovations across the equations are contemporaneously uncorrelated. If u and v are correlated then their effects can not be isolated. For simplicity, assume that the variance of u_t and v_t equal 1 and the covariance equals r[7]. Then, if u_t increases by 1, v_t will increase by r and Y_t will increase by r. The resulting impulse response function for Y will not only have changes due to u, but at the same time will have changes due to v as well. Therefore, if u and v are correlated, changes in u will change v so that a change in v cannot be attributed entirely to an M innovation.

A solution to this problem requires a transformation of the system to another system with uncorrelated innovations. This can be done by premultiplying both sides of Equations (3.16) and (3.17) by the unique triangular matrix with units on the main diagonal that diagonalizes the error variance-covariance matrix.

Assuming again, that the variance of u_t and v_t equal to one and the contemporaneous correlation between the innovations in the system to be r, (3.18) can be rewritten as,

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[7] Note that if the variance of u_t and v_t are assumed to be 1, the covariance of u_t and v_t will equal to the correlation coefficient between u and v.

$$r = \frac{Cov(u_t v_t)}{\sigma_u \ \sigma_v} = Cov(u_t v_t)$$

$$E \begin{bmatrix} u_t \\ v \end{bmatrix} \begin{bmatrix} u_t & v_t \end{bmatrix} = \Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{bmatrix} = \begin{bmatrix} 1 & r \\ r & 1 \end{bmatrix} \qquad (3.21)$$

Given the Cholesky decomposition of Σ[8]

$$\Sigma = H^{-1'} H^{-1}$$

where H^{-1} is a lower triangular matrix

$$H^{-1} = \begin{bmatrix} 1 & 0 \\ r & \sqrt{1-r^2} \end{bmatrix} \quad \text{and} \quad H = \begin{bmatrix} 1 & 0 \\ -r / \sqrt{1-r^2} & 1 / \sqrt{1-r^2} \end{bmatrix}$$

The transformed model can be obtained by premultiplying both sides of Equations (3.16) and (3.17) by H.

$$M_t = a M_{t-1} + b Y_{t-1} + w_t \qquad (3.22)$$

$$Y_t = r M_t + (c-ra) M_{t-1} + (d-rb) Y_{t-1} + \sqrt{1-r^2}\, z_t \qquad (3.23)$$

$$w_t = u_t \qquad (3.24)$$

$$z_t = (-ru_t + v_t) / \sqrt{1-r^2} \qquad (3.25)$$

$$E(w_t z_t) = 0 \text{ and } E(w_t^2) = E(z_t^2) = 1. \qquad (3.26)$$

Equations (3.22) and (3.23) form a recursive system of equations, where M and Y are jointly determined. The contemparenous value of M is a determinant of Y and the correla-

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[8] See Hakkio and Morris (1984), p.14.

tion between the so called 'orthogonalized innovations' w and z equals zero.

Consider the effects of a one unit increase in u in the transformed model. An increase in u will increase v by r as indicated in Equation (3.20). According to Equation (3.25), since u increases by 1, -ru decreases by r and v increases by r which amounts to a no change in z. In other words, z and w are not contemporaneously correlated and according to Equations (3.24) and (3.25) the variance of w and z equals 1 regardless of the variance of u and v.

The same transformation can be examined with a moving average representation. After recursive substitutions Equations (3.22) and (3.23) will yield,

$$M_t = w_t + (a+br)w_{t-1} + (a^2+bc+br(a+d))w_{t-2} + \ldots \quad (3.27)$$
$$+ b\sqrt{1-r^2}\,z_{t-1} + b(a+d)\sqrt{1-r^2}\,z_{t-2} + \ldots$$
$$Y_t = rw_t + (c+dr)w_{t-1} + (c(a+d)+r(bc+d^2))w_{t-2} + \ldots \quad (3.28)$$
$$+ \sqrt{1-r^2}\,z_t + d\sqrt{1-r^2}\,z_{t-1} + (bc+d^2)\sqrt{1-r^2}\,z_{t-2} + \ldots$$

Since w and z are not correlated an increase of, for example, one unit in w, increases Y by r units. Therefore in the transformed model the effect of given innovations can be isolated and impulse response functions can be generated.

The innovations w and z of the transformed model of Equations (3.22) and (3.23) using the conditional expectations formula, can be represented as,

$$w_t = M_t - E(M_t \mid M_{t-1}, Y_{t-1}) \tag{3.29}$$

$$z_t = (Y_t - E(Y_t \mid M_t, M_{t-1}, Y_{t-1})) / \sqrt{1-r^2} \tag{3.30}$$

Notice that the information available in the two equations are different. z_t depends not only on the lags of M and Y but it also depends on the contemporaneous value of M. These orthogonalized innovations can be compared with the innovations of the model before the transformation.

The innovations in Equations (3.16) and (3.17) can be defined as,

$$u_t = M_t - E(M_t \mid M_{t-1}, Y_{t-1}) \tag{3.31}$$

$$v_t = Y_t - E(Y_t \mid M_{t-1}, Y_{t-1}) \tag{3.32}$$

The information set for both innovations is the same. This comparison indicates that the transformed system will have a set of equations conditional on different information sets. Furthermore, this transformation is not 'unique' and the outcome depends on the ordering of the variables. For instance, if the order of the variables is reversed in the two equation system and the same transformation is made, a different information set for each orthogonalized innovation will be obtained. The resulting recursive system will have contemporaneous values of Y in the M equation and not vice versa. The immediate implication of the non-uniqueness of the transformation is a different impulse response pattern emerging from each possible ordering of the variables. This could be a serious drawback, particularly if the innovations in the initial model are highly correlated.

The impulse response analysis is in fact the most controversial aspect of VAR models. This problem will be discussed further in the last section of this chapter.

Variance Decomposition and Exogeneity

The moving average representation of a VAR model can also be used to determine the degree to which a set of variables is exogenous with respect to another set of variables. It was indicated earlier that the effect of any given innovation on any given variable can be traced out as the impulse response function. The impulse response functions are in fact a decomposition of the values of the variables in the system, into components due to the various innovations to these variables. The variation in the system can also be decomposed into components in terms of the k-period-ahead forecast error variances, due to the variation in the innovations.

Referring back to the VMA representation of the transformed model in Equations (3.27) and (3.28), two steps ahead values and forecasts of M and Y can be written as;

$$M_{t+2} = w_{t+2} + (a+br)w_{t+1} + (a^2+bc+br(a+d))w_t + \ldots \quad (3.33)$$
$$+ b\sqrt{1-r^2}\,z_{t+1} + b(a+d)\sqrt{1-r^2}\,z_t + \ldots$$

$$\hat{M}_{t+2} = E_t\,(\,M_{t+2}\,) = (a^2+bc+br(a+d))w_t + \ldots$$
$$+ b(a+d)\sqrt{1-r^2}\,z_t + \ldots$$

$$Y_{t+2} = rw_{t+2} + (c+dr)w_{t+1} + (c(a+d)+r(bc+d^2))w_t + \ldots \quad (3.34)$$
$$+ \sqrt{1-r^2}\,z_{t+2} + d\sqrt{1-r^2}\,z_{t+1} + (bc+d^2)\sqrt{1-r^2}\,z_t + \ldots$$

$$\hat{Y}_{t+2} = E_t\,(\,Y_{t+2}\,) = (c(a+d) + r(bc+d^2))w_t + \ldots$$
$$+ (bc+d^2)\sqrt{1-r^2}\,z_t + \ldots$$

where conditional expectation of the 1 and 2 step ahead unanticipated components at time t equal to zero.

$$E_t\,(w_{t+2}) = E_t\,(w_{t+1}) = E_t\,(z_{t+2}) = E_t\,(z_{t+1}) = 0.$$

The two step forecast errors are,

$$M_{t+2} - \hat{M}_{t+2} = w_{t+2} + (a+br)w_{t+1} + b\sqrt{1-r^2}\,z_{t+1} \qquad (3.35)$$

$$Y_{t+2} - \hat{Y}_{t+2} = rw_{t+2} + (c+dr)w_{t+1} + \sqrt{1-r^2}\,z_{t+2} + d\sqrt{1-r^2}\,z_{t+1} \qquad (3.36)$$

The variance of the two-step ahead forecast errors, given from Equation (3.25) that the variance of the innovations are 1 and their covariance is 0.

$$E\,(M_{t+2} - \hat{M}_{t+2}\,)^2 = 1 + (a+br)^2 + b^2(1-r^2) \qquad (3.37)$$

$$E\,(Y_{t+2} - \hat{Y}_{t+2}\,)^2 = r^2 + (c+dr)^2 + (1-r^2) + d^2(1-r^2) \qquad (3.38)$$

Using Equations (3.37) and (3.38) one can determine the decomposition of the variance of the two-step-ahead forecast errors. For instance the percentage of the variance of the two-step-ahead forecast error of M explained by the M innovation, w, is,

$$\frac{\text{Variance explained by M innovation}}{\text{Total variance of the two-step-ahead forecast error of M}} = \frac{100 * (1+(a+br)^2)}{1 + (a+br)^2 + b^2(1-r^2)} \tag{3.39}$$

The percentage of the variance explained by the Y innovation (z) in M is given by,

$$\frac{\text{Variance explained by Y innovation}}{\text{Total variance of the two-step-ahead forecast error of M}} = \frac{100 * (b^2(1-r^2))}{1 + (a+br)^2 + b^2(1-r^2)} \tag{3.40}$$

Suppose that M is strictly exogenous with respect to Y. According to Equation (3.4) this would imply that the coefficient of Y_{t-1} is equal to zero (b = 0). Substituting this into Equation (3.39) one can find that 100 percent of the variance of the two-step ahead forecast error in M is explained by the M innovation. Similarly, substituting zero for b in Equation (3.40) it can be found that zero percent is explained by the Y innovation. These two cases are in fact, examples for the extreme case of strict exogeneity. Equations (3.39) and (3.40) therefore, show that the degree of exogeneity of a variable in terms of another can be determined by computing the percentage of the expected k-period ahead squared prediction error of a variable produced by an innovation in another variable.

The variance decomposition of the forecast errors of the variables of a VAR model provide useful information as to which variables have relatively bigger influence on other variables in the system. As in the case of impulse response analysis however, variance decomposition analysis runs into the same problem. Different ordering of variables may imply different decomposition of the forecast error variances.

The Relationship Between Structural Econometric Models and VAR Models

It was indicated in the section on VAR models that there are certain similarities between structural econometric models (SEM) and VAR models. In fact any SEM can be viewed as a special case of a VAR model. Zellner and Palm (1974) and Zellner (1979) have demonstrated that any SEM is a restricted vector time-series model. In building both SEMs and VAR models certain restrictions are imposed when specifying the models. The restrictions imposed by the SEMs are based on some economic theory, while VAR imposes restrictions mainly based on statistical criteria. The key difference is that given a same size model, in terms of number of variables, VAR imposes less restrictions than SEM. This can be illustrated with a simple example. Given the following structural demand-supply model.

$$\text{Supply} \quad Q_t = a_0 + a_1 P_t + a_2 P_{t-1} + u_t \tag{3.41}$$

$$\text{Demand} \quad Q_t = b_0 + b_1 P_t + b_2 Z_t + v_t \tag{3.42}$$

where Q measures quantity; P, price; Z, an exogenous variable (say population); and u and v are the disturbance terms. This model assumes that the quantity supplied of a product is determined by its price at the current period and at the previous period. The quantity demanded, on the other hand, is determined by the price at the current period and the number of willing buyers (population). This is a relatively typical text-book example of a demand-supply model. The reduced form of the system given market equilibrium can be represented as:

$$Q_t = c_0 + c_1 Z_t + c_2 P_{t-1} + w_t \tag{3.43}$$

$$P_t = d_0 + d_1 Z_t + d_2 P_{t-1} + z_t \tag{3.44}$$

$$\text{where } c_0 = b_0 + \frac{b_1 (b_0 - a_0)}{a_1 - b_1}, \quad c_1 = \frac{a_2 b_1}{a_1 - b_1},$$

$$c_2 = \frac{b_1 b_2}{a_1 - b_1} + b_2 \quad , \quad w_t = \frac{b_1 (u_t - v_t)}{a_1 - b_1} + u_t \quad , \quad d_0 = \frac{b_0 - a_0}{a_1 - b_1}$$

$$d_1 = \frac{a_2}{a_1 - b_1} \quad , \quad d_2 = \frac{b_2}{a_1 - b_1} \quad , \quad z_t = \frac{u_t - v_t}{a_1 - b_1}$$

Once Equations (3.43) and (3.44) are estimated the values for the reduced form coefficients can be found. Using the relationships between the reduced form coefficients and structural form coefficients specified above, the structural coefficients can be calculated.

A VAR model can be specified for the same set of variables under certain assumptions. Making the same assumption for Z_t, to be exogenous, including only its current value into the system and assuming that the VAR process is of the first order, the model can be written as:

$$Q_t = \alpha_0 + \alpha_1 Z_t + \alpha_2 P_{t-1} + \alpha_3 Q_{t-1} + e_{1t} \qquad (3.45)$$

$$P_t = \beta_0 + \beta_1 Z_t + \beta_2 P_{t-1} + \beta_3 Q_{t-1} + e_{2t} \qquad (3.46)$$

Equations (3.45) and (3.46) can be written in matrix notation as,

$$\begin{bmatrix} Q_t \\ P_t \end{bmatrix} = \begin{bmatrix} \alpha_0 \\ \beta_0 \end{bmatrix} + \begin{bmatrix} \alpha_1 & \alpha_2 & \alpha_3 \\ \beta_1 & \beta_2 & \beta_3 \end{bmatrix} \begin{bmatrix} Z_t \\ P_{t-1} \\ Q_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \qquad (3.47)$$

The reduced form of the structural model described by Equation (3.43) and (3.44) can also be represented in matrix notation as;

$$\begin{bmatrix} Q_t \\ P_t \end{bmatrix} = \begin{bmatrix} c_0 \\ d_0 \end{bmatrix} + \begin{bmatrix} c_1 & c_2 \\ d_1 & d_2 \end{bmatrix} \begin{bmatrix} Z_t \\ P_{t-1} \end{bmatrix} + \begin{bmatrix} v_t \\ z_t \end{bmatrix} \qquad (3.48)$$

Comparing Equations (3.47) and (3.48), it is evident that Q_{t-1} is not a right hand side variable in (3.48). That is, the SEM has the same reduced form equations except for the fact that the coefficients on Q_{t-1} are restricted to zero. If in the VAR specification the coefficients of Q_{t-1} are restricted to zero, $\alpha_3 = \beta_3 = 0$, then the VAR model becomes identical with the reduced form of the SEM, Equation (3.48). Therefore, this example illustrates that the SEM is more restrictive than the VAR given the same set of variables in model specification.

The VAR model in Equation (3.47) compared with the reduced form model of the SEM model in Equation (3.47) is not the true reduced form of the SEM since it includes Q_{t-1}. Thus, we can view the VAR model as an unconstrained reduced form of an underlying but unknown, structural system of equations.[10] This is the 'atheoretical' aspect of the VAR

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[10] Note that Z_t is included in the VAR model as an exogenous variable for the purpose of making the two models comparable. Normally, this would be justified only if Z_t is found exogenous after conducting the test for exogeneity.

modeling technique, where the underlying structural model is assumed to be unknown.

The VAR approach has some advantages over SEMs concerning data, accuracy and cost. VAR models are typically small-scale models built with few major economic variables, hence, less data are needed to construct and use them. The size aspect also becomes important in terms of cost in model building. The cost of a VAR model is much less than a typical SEM in terms of labor time and computer use for both model construction and model use to generate forecasts. VAR models often provide equally accurate or, at times, more accurate forecasts than SEMs without a need for subjective adjustment.[11]

On the other hand, the VAR approach has some limitations. The most significant limitation of the VAR approach is the problem of 'overparameterization'. VAR models are constrained in terms of number of variables that can be used in model building because, as Sims (1980a, p.16) indicated, "If every variable is allowed to influence every other variable with a distributed lag of reasonable length without restriction, the number of parameters grows with the square of the number of variables and quickly exhausts degrees of freedom." Overparameterization can be a serious problem even if the model builder is interested in a model with only a

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[11] See Litterman (1986).

few variables. The lag structure of the model which is determined by statistical criteria may contain information about not only the systematic patterns in the historical data but also some random relationships which would not recur. As a result, often times, the VAR models suffer from 'overfitting' and the coefficients of the model have some extra useless information that would disturb the forecast performance of the variables. This problem, obviously, becomes more serious as the size of VAR models increases.

One way of dealing with the problem of overparameterization is to enter fewer lags on the right-hand-side of the 60 equations. This approach could be useful if there is no relevant information in longer lags. However, if longer lags contain important information, then excluding longer lags could result in 'underparameterization'. In this case, the model is misspecified since it does not incorporate all the relevant information that exists in the historical data.

A second way to deal with the problem of overparameterization is to use Bayesian estimation technique which imposes restrictions on the coefficient estimates. This method was first suggested by Sims (1980a) and developed as well as applied in the studies made by Litterman (1979, 1981, 1982, 1984, 1986). The Bayesian approach uses the prior beliefs of the model builder on the probability of future path of the economy in imposing restrictions. These restrictions are not based on economic theory as in the case of SEMs . They are based on the idea that more recent lags are more likely to be useful in forecasting than less recent lags. Instead of excluding the longer lags, with this approach the equations are specified such that "the parameters are assumed to have means of zero except the coefficient on the first lag of the dependent variable which is given a priori mean of one." [18] In essence, these kinds of restrictions are similar to a coefficient weighting scheme, where the recent lags are given more weight than longer lags in estimation and forecasting. This type of models, commonly known as the Bayesian Vector Autoregressions (BVAR), seems to overcome the problem of overfitting and, as McNees (1986) has reported, a BVAR model developed by the Federal Reserve Bank of Minneapolis constitutes a major challenge to subjectively adjusted SEMs.

A second limitation of VAR models is that they are designed exclusively for forecasting and not for policy analysis in the traditional sense. The VAR models are not reduced-forms of identified SEMs and therefore they can not be used to make inferences about the structure of the economy. For instance, they can not be used to generate dynamic multipliers from changes in different policy variables like the SEMs. Sims (1982, 1986) and Litterman (1984) took exception to this position and claimed that VAR models can be used to

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[18] See Litterman (1986), p.29.

analyze the outcome of different policy measures similar to SEMs. According to this view, VAR models can be used to generate conditional forecasts on some given policy measure, which would permit the investigator to study the likely impacts of unexpected shocks or changes in policy actions to the economy. Litterman (1984, p.35) stated that before a VAR model can be used for policy analysis, 'a policy measure' in the context of a VAR should be defined.

> As it turns out, we can answer this kind of policy question if we can define a type of shock that represents the contemporaneous impact of a one-time Fed action, such as an unexpected open market operation. Once we have defined that shock, we can use the impulse response functions to map out the entire dynamic impact of this shock, which we call a Fed policy action. We then define what we usually refer to as monetary policy as a sequence of Fed policy actions. Finally, by summing up the dynamic response caused by a sequence of policy actions, we generate the response of the system due to the impact of that monetary policy. (Italics are the author's)

In essence the innovation accounting and impulse response analysis as described above is the method used to do policy analysis in the context of VAR models. As indicated in the previous section this kind of a policy analysis is some what problematic, since the results of impulse response analysis are sensitive to ordering of the variables. Also, since VAR models do not allow for policy instruments like the SEMs, they can not answer such questions, as McNees (1986, p.7) indicates, "should an innovation in the interest rate equation be regarded as a change in policy or a change in money demand?"

A third limitation of VAR models is that they are as vulnerable as the SEMs to the Lucas critique. The time invariant coefficients of a VAR model could not capture the structural change due to policy changes just like SEMs. There are conditions however, in which the Lucas critique is not seriously applicable, and a VAR model can produce accurate forecasts. If the proposed future values of policy variables are similar to the actual past values of these variables the coefficients of the model will not be altered. As a result the forecasting accuracy will be preserved.[13] If there has been a structural change, however, one way to get around the problem is to allow the parameters of the model to vary according to time. Litterman (1979), Sims (1982) and Doan, Litterman, and Sims (1983), showed that time variation of parameters can be incorporated into VAR models and the forecasting accuracy can be improved.

Given the advantages and limitations of VAR models, can they be seen as a complete alternative to SEMs? McNees (1986, p.15) seems to have the appropriate answer to this question,

> It would seem more fruitful to regard the two approaches less as rivals than as complementary tools that can shed different kinds of light on our murky view of what the future will be like and what we can do about it.

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[13] See Hakkio and Morris (1984), p.18.

This chapter has presented the most important aspects of the VAR technique. It was shown that VAR models can be used for: (1) unconditional and conditional forecasting; (2) tests for causality between variables; (3) impulse response analysis; and, (4) variance decomposition and exogeneity. Also, the similarities of SEMs and VAR models as well as the advantages and disadvantages of the VAR technique over the SEMs has been discussed. A literature survey of major empirical VAR studies will be presented in the next chapter.

CHAPTER IV

A SURVEY OF THE VECTOR AUTOREGRESSION LITERATURE

Introduction

Following the pioneering study by Sims (1980a), there has been a growing interest in the VAR technique. Since then, it has become a widely accepted new approach to economic model building. Models of different scope, size, and lag structures have been built by using the VAR technique, addressing a variety of different issues in many areas of economics. The purpose of this chapter is to survey the VAR literature by dividing the empirical studies into two broad categories in terms of the scope of analysis, as national and regional studies.

National Studies

A substantial amount of work has been done in recent years in the area of VAR modeling of national economies. An up to date survey of different aspects of the VAR studies is presented in Table 4.1, which includes: the data frequency, number of variables under investigation, the names of the variables, and the purpose(s) of the model(s).

TABLE 4.1. A SURVEY OF DIFFERENT ASPECTS OF VECTOR-AUTOREGRESSION STUDIES

STUDY	MODEL(S)	DATA FREQUENCY (NUMBER OF VAR.)	VARIABLES	PURPOSES OF MODEL
ASHENFELTER AND CARD (1982)	Model for the U.S. labor market	Quarterly (4)	Wages, Prices, Unemployment rate, Interest rate	Studying alternative labor market models for U.S.
BRANSON (1984, 1985)	Models for U.S. West Germany, UK, Japan	Quarterly and Monthly (6 and 7)	Effective Exchange Rate, Relative Prices, Money, Current Account Bal., Interest Rate, Reserves Industrial Prod.	Analyzing the determination of Exchange Rates.
CLARIDA AND FRIEDMAN (1984)	Model for U.S.	Quarterly (6)	Money, Non-financial credit, Budget Deficit, GNP, GNP Deflator, Interest Rate	Unconditional and Conditional forecasting for Interest rate.
DOAN, LITTERMAN AND SIMS (1983)	Model for U.S.	Monthly (10)	Money, Stock Prices, Interest Rate, Flow of Total Debt, GNP GNP Def., Federal Outlays, Federal Receipts, Inventor. Trade Weighted $.	Unconditional and Conditional forecasting for 10 major macroeconomic variables.
DWYER (1982)	Model for U.S.	Quarterly (6 and 8)	Prices, GNP, Debt held by Federal Res Debt help by public Interest rate, Money.	Testing different hypothesis on the relationship between inflation and government deficits.

TABLE 4.1 (Continued)

STUDY	MODEL(S)	DATA FREQUENCY (NUMBER OF VAR.)	VARIABLES	PURPOSES OF MODEL
ECKSTEIN (1984)	Model for U.S	Annual (2)	Cotton crop area, Relative price.	Modelling the agricultural supply with a bi-variate VAR model.
ECKSTEIN, SCHULTZ AND WOLAN (1985)	Model for Sweden	Annual (10)	Crude birth rate, Infant death rate, Non-infant death r. Crop yields, wages, Mean temperature for the four season Rain.	Studying the short-run fluctuations in fertility and mortality in pre-industrial Sweden.
FACKLER AND KRIEGER (1986)	Model for U.S.	Quarterly (5)	GNP, Money, Interest rate, GNP Def. Total credit.	Unconditional short-term forecasting for the five macro variables.
FISHER (1981)	Models for U.S. West Germany, and Japan	Quarterly (6 and 8)	Full emp. surp./GNP Money, Inflation, Price variability, GNP, Interest rate, and four other price variables.	Studying the relationship between inflation and price variability in U.S., Germany and Japan.
FRIEDMAN (1981)	Models for U.S.	Quarterly (2,3,4)	GNP, Financial var. (for 2 var.) plus Price (for 3 var.) plus Interest rate (for 4 var.)	To show that credit market, should be incorporated in macroeconomic analysis and Money is not the sole representative of financial variables.

TABLE 4.1 (Continued)

STUDY	MODEL(S)	DATA FREQUENCY (NUMBER OF VAR.)	VARIABLES	PURPOSES OF MODEL
GORDON AND KING (1982)	Models for U.S.	Quarterly (7)	GNP, Output ratio, Productivity, Relative Price of food and energy, Relat. Price of Imports, GNP Def, Effective Exchange Rate.	To compare the dynamic response patterns of prices and output using SEM and VAR models.
HSIAO (1979)	Model for Canada.	Quarterly (2)	GNP, Money (M1 and M2)	Studying the causality between money and income in Canada.
HAKKIO AND MORRIS (1984)	Model for U.S.	Quarterly (3)	GNP, Money and Price.	A theoretical and empirical exposition on VAR modeling technique.
KUMCU (1983)	Models for U.S. UK, West Ger., France and Canada	Monthly (7)	Exchange rates, Money differential, Income differential Interest rate diff.	Studying the exchange rate movements using VAR models applied to five pairs of countries.
LEIDERMAN (1984)	Models for Columbia and Mexico	Annual (3)	GNP, Money and Price.	Studying the dynamic interrelationships among money growth, inflation and output growth for Colombia and Mexico.

TABLE 4.1. (Continued)

STUDY	MODEL(S)	DATA FREQUENCY (NUMBER OF VAR.)	VARIABLES	PURPOSES OF MODEL
LITTERMAN (1979)	Models for U.S.	Quarterly (3,6,11,15)	GNP, Money, Price, Interest rate, Import prices, Wages, Components of GNP (Cons, Inv., Exports, Gov. Sp.)	Studying the uses of VAR models with several different size VAR models.
LITTERMAN (1981)	Model for U.S.	Quarterly (7)	GNP, GNP Def., Unemployment rate, Money, Investment, Interest rate, change in Inventories.	Studying the forecasting accuracy of a VAR model using Bayesian Restrictions on the coefficients.
LITTERMAN (1982)	Model for U.S.	Monthly (7)	Output, Prices, Interest rate, Money, Stock Price, Total nonfinancial debt, change in business Inventories.	Building a short-run forecasting model with Bayesian restrictions on the coefficients.
LITTERMAN (1984a, 1984b)	Model for U.S.	Monthly (47)	Federal Reserve Bank of Minneapolis Model. (Sectoral var for 8 major sectors core, production, labor, finance, Gov Cons, trade and Pri.	Short-term and Long-term Forecasting and Policy analysis using the Minnesota Federal Reserve BVAR Model.
LITTERMAN (1986)	Model for U.S.	Quarterly (7)	GNP, GNP Def, Unemp Money, Investment, Interest rate, change in Inventories	Short-term forecasting with a BVAR model and comparison of forecasting performance with major SEMs.

TABLE 4.1. (Continued)

STUDY	MODEL(S)	DATA FREQUENCY (NUMBER OF VAR.)	VARIABLES	PURPOSES OF MODEL
LUPOLETTI AND WEBB (1984)	Model for U.S.	Quarterly (5)	Monetary base, GNP, GNP Def, Capacity utilization rate, Interest rate.	Short-term forecasting with a VAR model and comparison of forecast performance with SEMs.
MEESE AND ROGOFF (1983)	Exchange Rate Models for U.S. paired with West Germany, UKG and Japan	Monthly (11)	Spot exchange rate, Interest rate(long and short term), Monetary aggregates (M1-B, M2, etc), trade balance	Comparison of forecasting accuracy of various structural and time-series exchange rate models.
MILLER, SUPEL AND TURNER (1980)	Model for U.S. (giving prominance to the role of energy prices)	Quarterly (12)	4 driving variables (Gov Deficit, Money Interest rate, CPI (energy)) 8 responding(GNP Components C, I, G, (X-M) and Sup Comp.(W, Emp, CPI, hou	Estimating the Effects of the Oil-Price Shock on the U.S Economy.
MORRIS (1984)	Model for the U.S. labor market.	Quarterly (3)	Productivity, Man hours worked and Capital stock	Studying the returns to labor with a labor market VAR model.
PORTER AND OFFENBACHER (1983)	Model for U.S.	Quarterly (2, 3, 4)	GNP, GNP Def, Financial aggregates, Interest rate	Empirical comparisons of credit and monetary aggregates targetting for monetary policy.

TABLE 4.1. (Continued)

STUDY	MODEL(S)	DATA FREQUENCY (NUMBER OF VAR.)	VARIABLES	PURPOSES OF MODEL
SARACOGLU (1984)	Models for U.S West Germany, France, Japan, UK.	Monthly (6)	Money stock, Monetary base, Output, Price, Interest rate.	Studying the real interest rate determination using VAR modeling.
SCHLEGEL (1985)	Model for U.S.	Quarterly (4)	GNP, GNP Def, Interest rate, Unemployment rate	Forecasting the length and intensity of recessions and recoveries.
SIMS (1980a)	Models for U.S. and West Germ.	Quarterly (6)	GNP, Money, Price, Unemployment rate, Wages, Import price	Forecasting and Policy analysis using a six-variable unrestricted VAR model.
SIMS (1980b)	Models for U.S	Monthly (3 and 4)	Output, Money, Wholesale prices, Interest rate	Evaluating the monetarist interpretations on economic activity using VAR models.
SIMS (1981)	Model for U.S.	Quarterly (9)	Money, GNP, Price, Unemployment rate, Import prices, Wages, Investment, Gov. Spending, Interest rate	Forecasting and Policy analysis using a nine-variable VAR model.

TABLE 4.1. (Continued)

STUDY	MODEL(S)	DATA FREQUENCY (NUMBER OF VAR.)	VARIABLES	PURPOSES OF MODEL
SIMS (1982)	Model for U.S.	Quarterly (3 and 6)	GNP, GNP Def, Money Interest rate, Federal expenditure Federal revenues	Forecasting and Policy analysis using a three-variable and a six-variable VAR model.
TAKATOSHI (1984)	Exchange Rate Model for Yen / Dollar	Monthly (3)	Exchange rate, Interest rates (in U.S and Japan)	Testing uncovered interest parity in the foreign exchange market.
TAYLOR (1980)	Model for U.S.	Quarterly	GNP, GNP Def, Eff. exchange rate.	To compare the dynamic response patterns of prices and output using a VAR model
WELLS AND EVANS (1982, 1983)	Model for New Zealand	Quarterly (9)	Private sector Output, Employment, wages, price, money Gov. Spending, Import prices, Export prices, Exchange rate	Forecasting and Policy analysis using a nine-variable VAR model for the New Zealand economy, and comparing it with an SEM. Alternative approach to simulating VAR models. (1983)
WEBB (1984)	Model for U.S.	Quarterly (5)	GNP, Monetary base, Capacity Util. Rate GNP Def, Interest rate	Short-term forecasting with a five-variable VAR model, and comparisons with SEM on forecasting accuracy.

As Table 4.1, indicates the VAR technique was used to study such diverse issues as the relationship between inflation and government spending by Dwyer (1982) and the short-run fluctuations in fertility and mortality in preindustrial Sweden by Eckstein, Schultz and Wolan (1985). The majority of the studies concern the U.S economy but other industrialized countries like West Germany, France, United Kingdom, Canada and Japan as well as developing countries like Mexico and Columbia have also been studied.

Most of these studies used the VAR technique as a tool for unconditional and conditional forecasting of economic activity. The most ambitious VAR modeling effort to date has been the BVAR Model for the U.S economy developed at the Federal Reserve Bank of Minneapolis under the supervision of Robert Litterman.[1] At its current stage this model has 47 monthly variables that are distributed among eight economic sectors: Core, production, labor, financial markets, consumption, government, international trade, and price. Exhibit 4.1, shows the the main interactions among the sectors in the model. This model is used for forecasting as well as projecting the likely impact of both, unexpected shocks and the changes in Federal Reserve policies on the economy.

The estimation of the model was done using Bayesian

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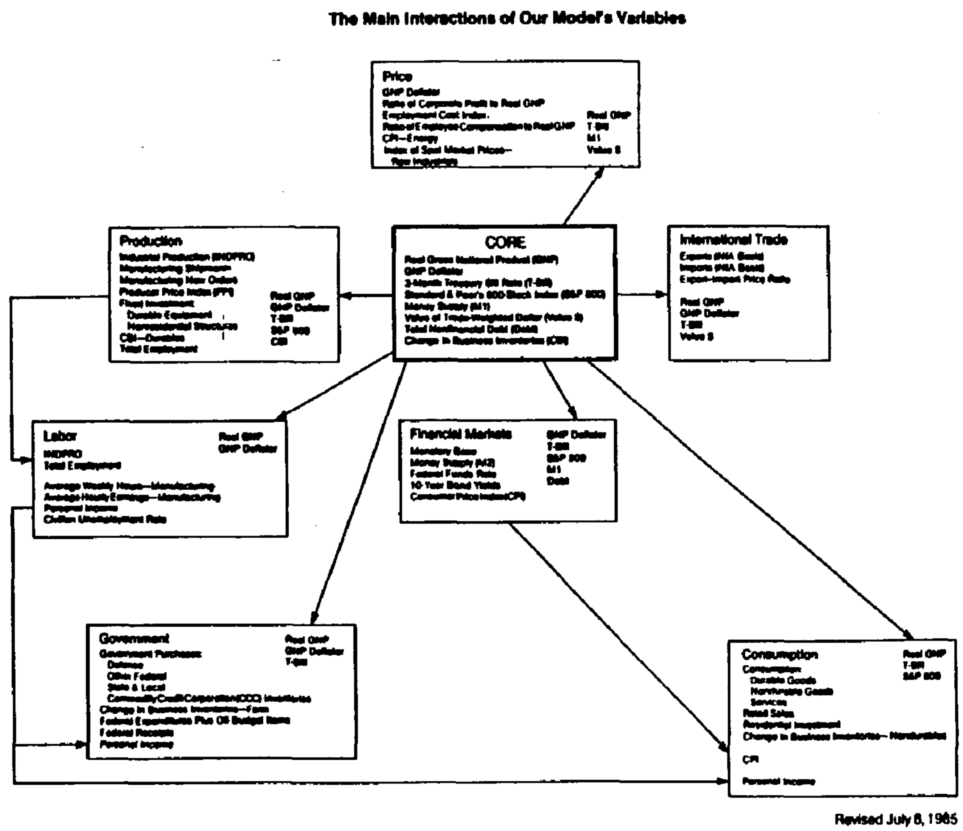
[1] A detailed exposition of the model is presented in Amirizadeh (1985).

EXHIBIT 4.1. THE BASIC STRUCTURE OF THE FEDERAL RESERVE BANK OF MINNEAPOLIS BAYESIAN VECTOR AUTOREGRESSION MODEL OF THE US ECONOMY



Source: Amirizadeh (1985), p.21.

restrictions, as discussed in the previous chapter, in order to deal with the overparameterization problem. The model has been successfully used to forecast economic activity often times better than the major SEMs. McNees (1986, p.16) has reported, "Experience to date suggests that BVAR-generated forecasts can present a strong challenge to conventional practice and serve as a powerful standard of comparison of other forecasts".

Less detailed VAR models have also claimed successful forecasting performances in other studies. Litterman (1979, 1981, 1982) has built several different size models for the U.S. economy and reported accurate forecast performances. Lupoletti and Webb (1984) showed that their small VAR model produced forecasts that are competitive with those issued by three well-known commercial forecasting services, Chase Econometrics, Data Resource Incorcopated (DRI) and Wharton Associates over the period 1970 through 1983. Webb (1984) has compared forecasts from a major consulting service, American Statistical Association-National Bureau of Economic Research (ASA-NBER), a survey of professional forecasters, and a VAR model for the U.S. economy. He has found that at a four-quarter horizon, the VAR model's predictions were more accurate than both the consulting service and the professional forecasters' forecasts for real GNP and more accurate than the consulting service for inflation and the interest rate. He also reported the interesting result that only the

VAR model predicted the 1982 recession.

The use of the VAR technique for policy analysis was shown in several studies by Sims (1980a, 1981, 1982), Litterman (1979, 1984a, 1984b, 1986) and Doan, Litterman and Sims (1983) with VAR models of different sizes. The impulse response analysis which is the method used in studying the impact of different policy measures was also used to study specific issues concerning different markets of the U.S. economy. Ashenfelter and Card (1982), and Morris (1984) studied the labor market. Friedman (1981), and, Porter and Offenbacher (1983) focused on the financial markets. Eckstein modeled the agricultural supply. Branson (1984, 1985), Kumcu (1983), and Saracoglu (1984) investigated the foreign exchange markets.

There has also been studies focusing on specific relationships between some major macroeconomic variables. Dwyer (1982) tested different hypotheses on the relationship between inflation and government deficits. Fisher (1981) studied the relationship between inflation and price variability in U.S. and Germany. Taylor (1980), and, Gordon and King (1982) looked at the dynamic response patterns of prices and output.

Regional Studies[a]

Studies have also been made in extending the challenge of VAR models in regional economics. An up to date survey of the major regional VAR studies are presented in Table 4.2, which is designed in a similar fashion as Table 4.1.

Anderson (1979) pioneered the VAR modeling effort in a regional context and demonstrated that VAR technique can be used exclusively for forecasting regional economic activity. The regional VAR models have typically been built with only a *few regional* or State variables. In all of these models the influence of the national economy on the regions are accounted for by entering several national variables on the right-hand-side of the model's equations. Thus, the national variables constitute driving variables, which influence the responding regional variables and these national variables are not influenced by the regional variables in return.

This chapter has presented a *brief* literature survey on the VAR modeling technique at the national and regional/ state levels. The next chapter will focus on the original research of this thesis, the proposed multi-country VAR

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[a] Although the section on regional studies has no bearing on the empirical work of this dissertation it is included to complete the literature survey on empirical studies with the VAR technique.

TABLE 4.2. A SURVEY OF DIFFERENT ASPECTS OF REGIONAL VECTOR AUTOREGRESSION STUDIES

STUDY	MODEL(S) (DATA FREQUENCY)	NUMBER OF VARIABLES region.	NUMBER OF VARIABLES nat.	VARIABLES Regional	VARIABLES National	PURPOSES OF MODEL
ANDERSON (1979)	Model for the Ninth Federal Reserve District. (Quarterly)	5	4	Employment labor for. Per. Income Retail Sales, Price.	Empl., labor for Price, GNP.	Short-term forecasting for the regional variables, and comparison of fore-casts with state SEMs.
AMIRIZADEH AND TODD (1984)	Five state models for the Ninth Federal Reserve District. (Quarterly)	4	4	Employment 2 Personal Income variables, Retail sales.	GNP, GNP Def, Money, Interest Rate.	Short-term forecasting for the regional variables.
HOEHN AND BALAZSY (1985a, 1985b)	Model for the State of Ohio (Quarterly)	10	14	4 Empl.var Labor forc Pers. Inc. Retail Sa. Hous. Sts. Hours, Prices.	GNP, GNP Def, Pri. Coin. In. Lead In., Interest rate, La. force, etc	Short-term forecasting for the regional variables.
HOEHN, GRUBEN AND FOMBY (1984a, 1984b)	Model for the State of Texas (Monthly)	7	15	Output, 2 Emp var. Price, Lab force, Per Income, Retail sales.	Coin. In. Lead. In. Output, Emp., Money, Interest rate, etc.	Short-term forecasting for the regional variables.
KINAL AND RATNER (1982, 1983)	Model for the State of New York (Monthly)	4	5	Retail Sa. Employment Price, Output.	Output, 2 Prices, Personal Income, Interest rate.	Short-term forecasting for the regional variables.

TABLE 4.2. (Continued)

STUDY	MODEL(S) (DATA FREQUENCY)	NUMBER OF VARIABLES region.	nat.	VARIABLES Regional	National	PURPOSES OF MODEL
KUPRIANOV AND LUPOLLETTI (1984)	Model for the Fifth Federal Reserve District. * (Quarterly)	2	3	Non-agri. employment Personal income.	Output, Money, Interest rate.	Short-term forecasting of regional variables.
LITTERMAN AND SUPEL (1983)	Model for the State of Minnesota	4	–	Individual tax, Corp. tax, Sales tax, Per. Income	——	Measuring the Uncertainty in Minnesota's Revenue Forecasts.

model, which integrates the linkage mechanisms suggested by multi-country structural macroeconometric models with the VAR technique.

CHAPTER V

A MULTI-COUNTRY LINK VECTOR AUTOREGRESSIVE MODEL

Introduction

In a world which is becoming progressively more interdependent, the main concern of model builders in recent years has been to capture the impact of the transmission of international economic fluctuations on individual economies. The pioneering Project LINK, and other studies that followed were designed for the purpose of linking individual country's structural econometric models through different linkage mechanisms. These models have been widely used for forecasting and policy analysis for individual countries in the context of the world economy.

On the other hand, as indicated in Chapter IV, in recent years the VAR approach to model building has challenged the construction of large-scale structural econometric models. This relatively new technique has been succesfully used in modeling and forecasting economic variables in a variety of different areas in economics as shown in Chapter IV. So far, the VAR technique has been used only in the context of country or domestic regional models and there has been no published study on building and estimating multi-country VAR models. The recognition of the increasing importance of international transmission of economic fluctuations, which brought about the development of the link econometric models, clearly indicates that, at this stage building a multi-country VAR model should be the next step in international modeling.

This dissertation is extending the scope of the challenge of the VAR technique to the international sphere with the construction of a multi-country link vector autoregressive (LINK-VAR) model. With the LINK-VAR model, this paper tets the the following important proposition: Can a multi-country VAR model outperform the individual country VAR models without linkages? That is, does the forecasting performance of economic variables improve when one moves from a closed-economy VAR specification to an open-economy VAR specification where the international influences are accounted for?

The first section of this Chapter outlines the basic features of the LINK-VAR model. In the second section the specific linkage mechanisms which connect the individual country models to one another are discussed.

The LINK-VAR Multi-Country Model

Using the VAR technique in a global context is very problematic. As indicated in the previous chapter, one of the limitations of the VAR technique is that, the number of parameters to be estimated increases substantially with the number of variables, which leads to an overparameterized model. In terms of a world system this limitation would make the estimation virtually impossible, since such a model would require the specification of each variable as a function of the past history of not only the domestic variables but also the past history of the variables in all other countries included in the model as well. With this approach it will not be feasible to build a model with even a few variables that represent each individual country. For instance, a ten country VAR model where each country is specified by four major variables, with six lags for each variable, will have 240 parameters to be estimated in each equation. Thus, a multi-country VAR model could be built only with an alternative model specification which would deal with the overparameterization problem.

In this dissertation the proposed method of building a multi-country VAR model reduces the overparameterization problem to a managable level. This Multi-Country Link VAR (LINK-VAR) model is built by integrating the linkage mechanisms suggested by multi-country structural models builders with the VAR national models. The proposed LINK-VAR is an eighteen country system and each national economy is specified by four major macroeconomic variables, i.e, output (Y), nominal money supply (M), prices (P), and interest rates (R) as well as by 'link variables'. Therefore, each equation in each country VAR system has the general form:

$$X_{it} = \underset{4\times1}{Z_t} + \sum_{j=1}^{m} \underset{4\times4}{A_i^h} \underset{4\times1}{X_{t-j}^h} + \sum_{k=1}^{p} \underset{4\times4}{B_i} \underset{4\times1}{L_{t-k}^h} + \underset{4\times1}{e_t} \qquad (5.1)$$

where,

X is the vector of the four domestic variables (Y, M, P, R)

L is the vector of international link variables

Z is the vector of constants and time trend (See Equation (3.1))

A is the matrix of coefficients for the past history of domestic variables

B is the matrix of coefficients for the past history of link variables

e is the vector of random disturbance terms

i is the equation number i=1,...,4

h is the country number h=1,....,18

j is the lag number for domestic variables j=1,.....,m

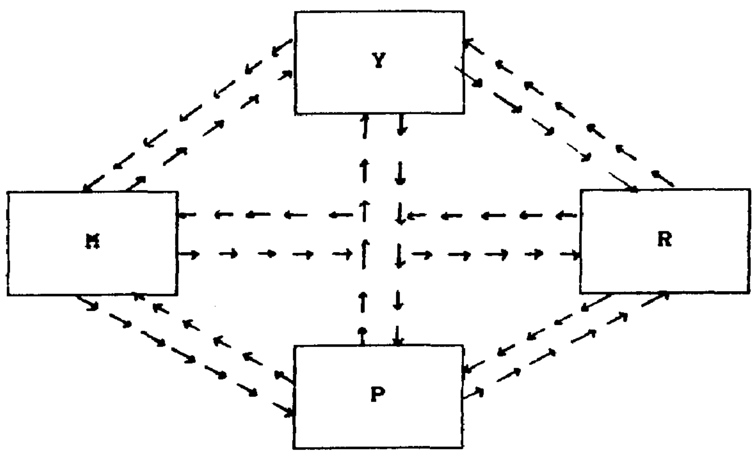
p is the lag number for link variables k=1,.......,p

It can be seen that the LINK-VAR Model is composed of eighteen four-equation country models linked through a set of international variables. The link variables provide the the connection between each individual country's domestic economy with the rest of the countries in the system, thereby accounting for the impact of the international economy on every aspect of the domestic economy. Notice that if the link variables are excluded from Equation (5.1) the LINK-VAR reduces into eighteen separate four-variable VAR individual country models. That is, without the link variables the typical country model becomes a closed-economy, pre-link model where the domestic economic activity is determined by the interaction of the national variables as illustrated in Exhibit 5.1.

The Linkage Mechanisms

Based on the review of the major international models in Chapter II, it is evident that the most common feature of all the international models has been the linkage mechanism through trade flows. The trade linkages are typically represented by a world trade model which determines exports from a central trade-share matrix that allocates each region's imports to the various exporting regions. This set up allows each country to be influenced by other countries through the channel of trade volume that exists between them. For instance, changes in import demands in one country will be transmitted to the trading partners as changes in their exports, which in turn affects the economic activity in their country. In the absence of a trade model, the exports in each country model will be considered exogenous and there would be no links through trade flows.

EXHIBIT 5.1. AN ILLUSTRATION OF THE CLOSED-ECONOMY (PRE-LINK) MODEL FOR THE TYPICAL COUNTRY IN LINK-VAR.



In the context of the LINK-VAR model, a mechanism that would serve as a trade model to link the individual countries together through their trade is needed. Such a mechanism can be designed by introducing a trade flows weighting scheme, which would measure the comparative importance of the typical country economy in relation to each of the other seventeen economies. This weighting scheme can then be used to construct variables, which would capture the international economy from the standpoint of the typical country. That is, for the typical country model represented in Exhibit 5.1, to become a part of the LINK-VAR Model, it has to be connected to the rest of the seventeen countries in the system with variables which account for the degree of openness of the typical country to the other countries. For this purpose, several link variables have been introduced to capture the effects of international influence upon domestic economic activity in each country. The standard practice in constructing weights has been to use commodity trade flows. In this study, an existing multilateral trade weighting scheme was selected rather than building either a bilateral or a global one. It is taken from the Multilateral Exchange Rate Model (MERM) of the International Monetary Fund (IMF).[1] The weights of MERM measure the effect on the home country's

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[1] The Multilateral Exchange Rate Model is discussed in Artus and Rhomberg (1973) and a revised version of the model is presented in Artus and McGuirk (1981). The MERM weights are taken from Artus and McGuirk (1981), pp.30-31.

trade balance measured in home currency of a change of one percent in the price of each foreign currency in terms of the home currency. That is, the weight of openness of country h relative to country i, w_{hi}, can be represented as,

$$w_{hi} = W_{hi} \;/\; \sum_{h \neq i} W_{hi} \tag{5.2}$$

where, W_{hi} is the effect of a change of one percent in the price of currency h in terms of currency i on the trade balance of country h measured in its own currency and deflated by the induced change in the average of its export and import prices in its own currency, calculated from the IMF's model. To calculate these weights, MERM uses information about the entire structure of trade, including both bilateral and third-market relations. MERM also includes the commodity composition of trade, associated price elasticities of demand and supply and the effects of exchange rate changes on wages. As Rhomberg (1976, p.102) has aptly pointed out the MERM weights derived from this model are much more comprehensive than weights based simply on trade flows between countries.

The selection of IMF's weighting scheme, therefore, overcomes the problem of measuring the degree that each country is exposed to other countries' economic fluctuations. The MERM weights are obviously not the perfect weighting scheme one can use for such purposes, as the impact of capital flows are completely left out from this measurement. As in the case of structural multi-country macroeconometric models, leaving out the financial linkages and focusing only on merchandise trade can constitute a challenging limitation. However, building a world-wide model, similar to MERM, which would incorporate capital flows in order to calculate financial weights, is out of the scope of this thesis. Therefore, the linkage mechanisms used in this study include only the trade weighted linkages. For the purposes of this study it is justified to assert that these weights provide some information as to the openness of each country to the rest of the other countries in the eighteen country system.

Four link variables have been derived by using the MERM weights.

<u>Output Link Variable</u>

$$V_{nt} = w_{n1} Y_{1t} + w_{n2} Y_{2t} + \ldots\ldots + w_{nz} Y_{zt}$$

<u>Money Link Variable</u>

$$S_{nt} = w_{n1} M_{1t} + w_{n2} M_{2t} + \ldots\ldots + w_{nz} M_{zt} \qquad (5.4)$$

<u>Price Link Variable</u>

$$Z_{nt} = w_{n1} P_{1t} + w_{n2} P_{2t} + \ldots\ldots + w_{nz} P_{zt} \qquad (5.5)$$

<u>Effective Exchange Rate Link Variable</u>

$$F_{nt} = w_{n1} E_{1t} + w_{n2} E_{2t} + \ldots. + w_{nz} E_{zt} \qquad (5.6)$$

where,

$Y_{1t}, Y_{2t}, \ldots, Y_{zt}$ = the output variable of each country.

$M_{1t}, M_{2t}, \ldots, M_{zt}$ = the money variable of each country.

$P_{1t}, P_{2t}, \ldots, P_{zt}$ = the price variable of each country.

$E_{1t}, E_{2t}, \ldots, E_{zt}$ = the bilateral exchange rate variable of each country.

$w_{n1}, w_{n2}, \ldots, w_{nz}$ = MERM weights and w_{nn} = 0.

The output link variable is assumed to capture the openness of the typical country model in terms of output fluctuations in the other countries. The money link captures the changes in monetary policies in the other countries. The fluctuations in the international prices are accounted for by the price link. The effective exchange rate link captures the movements in the domestic exchange rates in relation to the exchange rates of the other countries. Among the link variables the output link and the effective exchange rate link variables have a more straight foreward economic meaning.

The output link variable, in essence, represent the foreign demand on the home countries exports, which is what the trade model in structural international macroeconometric models determines. For instance, a change in the output of the typical country will influence its imports from the trading partners, which would then influence the exports of the trading partners and therefore would affect the output in the trading partner countries.

The interpretation of the effective exchange rate is also straightforward. The index of effective exchange rate measures the average change of the typical country's exchange rate against all other currencies.[a] It, therefore captures the effects of exchange rate movements on the trade balance of the typical country.

Money Link is a variable that has not been used before in world-wide models and constitutes one of the novelties introduced in this thesis. In a world characterized by interdependence and coordination/harmonization of policies, the influence of changes in monetary policy in one country on other countries can not be captured directly by focusing only on the trade flows. Similarly for the price link, the transmission of inflationary pressures would be more readily observed through the prices of tradable goods and not domestic prices. The aim here is to define some sort of a global money supply and a global inflation rate variables that each country faces. It is, therefore, desirable for the purposes of this study to capture the influence of both monetary pol-

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[a] See Rhomberg (1976), p.88.

icy and inflation in the rest of the countries upon the typical country. With their limitations regarding the weighting scheme, it can be argued however, that a great deal of the international influence of money and prices can be captured by the proposed money link and price link variables. [3]

With the output, money, price and effective exchange rate variables two different sets of possible linkages among the countries were considerd and were called (1) Linkage Mechanism A, (2) Linkage Mechanism B. In both specifications the link variables represent the influence of the other seventeen countries on the typical country economy and are exogenous, to the typical country model. The link variables are assumed to be the driving variables and influence the domestic variables which are the responding variables. The link variables in turn are not directly affected by these responding variables.

Linkage Mechanism A

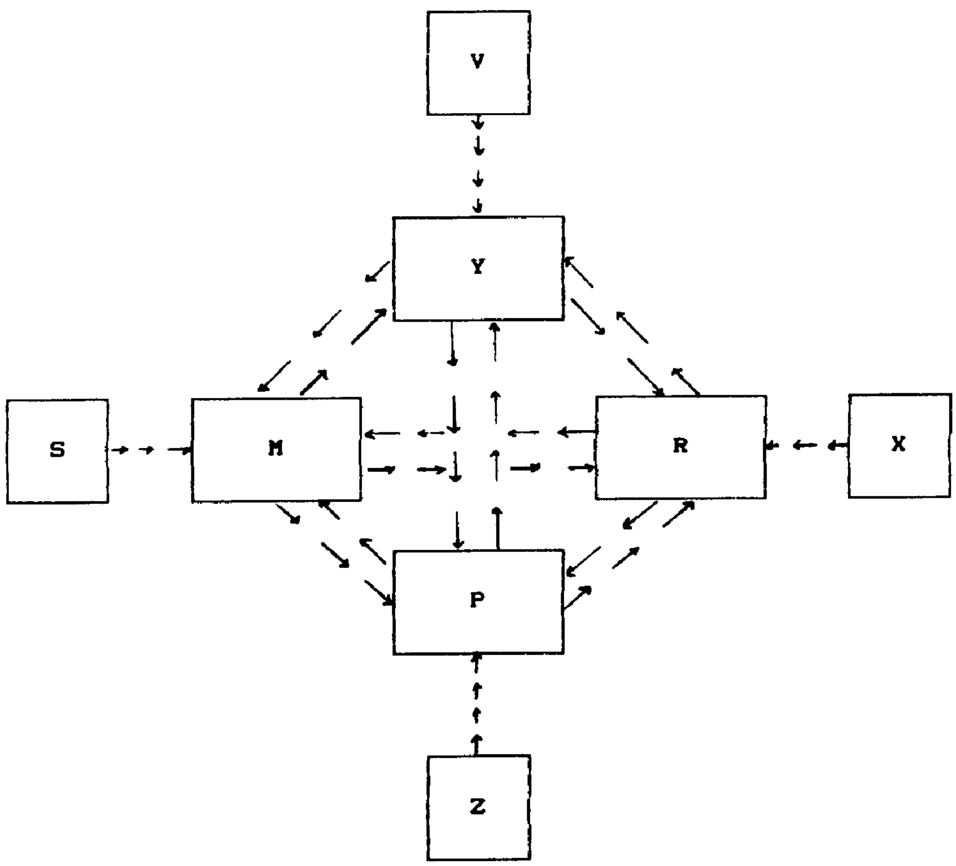
The first linkage mechanism that is considered here, links the typical country model to the rest of the countries

---

[3] Camara and Huß (1982) constructed similar price and money variables and called them 'effective relative price indices' and 'effective money supply indices' respectively. Their study focused on the causality among exchange rates, relative prices and money supplies in a multi-country context.

with a different link variable for each domestic variable. Each equation includes the past history of all domestic variables plus the past history of one link variable. The output link is entered only in the output equation, the money link is entered only in the money equation, the price link is entered only in the price equation and effective exchange rate link enters only in the interest rate equation as illustrated in Exhibit 5.2. The rational behind such a specification is the belief that each domestic variable is predominantly influenced by the corresponding international variable. Obviously, this does not mean that for example, the money link variable would not influence the domestic output, or that the effective exchange rate link variable would not influence the domestic prices. The model specification focuses particularly on the direct effects of each link upon the domestic variable. Notice that for every domestic variable, there is a directly corresponding international variable with the exception of interest rate. Interest rate is linked through the effective exchange rate link variable. The appropriate variable for linking the interest rate equation in the same line with the other equations should be an international interest rate variable, which is not readily available. The effective exchange rate link variable seems to be a resonable proxy for international short-term interest rate variations assuming that short term fluctuations in the exchange rates can predom-

EXHIBIT 5.2. AN ILLUSTRATION OF THE OPEN-ECONOMY (POST-LINK) MODEL FOR THE TYPICAL COUNTRY IN LINK-VAR. (LINKAGE MECHANISM A)



inantly be explained by biletaral interest rate differentials. The equations of a typical country model in LINK-VAR under the Linkage Mechanism A can be represented as follow:

The Output Equation for the Typical Country:

$$
\begin{aligned}
Y_t = a_i &+ b_{i1} Y_{t-1} + b_{i2} Y_{t-2} +\ldots\ldots+ b_{in} Y_{t-n} \\
&+ c_{i1} M_{t-1} + c_{i2} M_{t-2} +\ldots\ldots+ c_{in} M_{t-n} \\
&+ d_{i1} P_{t-1} + d_{i2} P_{t-2} +\ldots\ldots+ d_{in} P_{t-n} \\
&+ f_{i1} R_{t-1} + f_{i2} R_{t-2} +\ldots\ldots+ f_{in} R_{t-n} \\
&+ g_{i1} V_{t-1} + g_{i2} V_{t-2} +\ldots\ldots+ g_{ip} V_{t-p} \\
&+ r_i T + e_{it}
\end{aligned}
\qquad (5.7)
$$

where,

Y is output

M is money

P is price

R is interest rate

T is time.

V is the output link variable

e is the random disturbance term

The Money Equation for the Typical Country:

$$
\begin{aligned}
M_t = a_2 &+ b_{21} Y_{t-1} + b_{22} Y_{t-2} + \ldots\ldots + b_{2n} Y_{t-n} \qquad (5.8) \\
&+ c_{21} M_{t-1} + c_{22} M_{t-2} + \ldots\ldots + c_{2n} M_{t-n} \\
&+ d_{21} P_{t-1} + d_{22} P_{t-2} + \ldots\ldots + d_{2n} P_{t-n} \\
&+ f_{21} R_{t-1} + f_{22} R_{t-2} + \ldots\ldots + f_{2n} R_{t-n} \\
&+ g_{21} S_{t-1} + g_{22} S_{t-2} + \ldots\ldots + g_{2p} S_{t-p} \\
&+ r_2 T + e_{2t}
\end{aligned}
$$

where,

Y, M, P, R, and T are as defined above.

S is the money link variable

e is the random disturbance term

The Price Equation for the Typical Country :

$$
\begin{aligned}
P_t = a_3 &+ b_{31} Y_{t-1} + b_{32} Y_{t-2} + \ldots\ldots + b_{3n} Y_{t-m} \qquad (5.9) \\
&+ c_{31} M_{t-1} + c_{32} M_{t-2} + \ldots\ldots + c_{3n} M_{t-n} \\
&+ d_{31} P_{t-1} + d_{32} P_{t-2} + \ldots\ldots + d_{3n} P_{t-n} \\
&+ f_{31} R_{t-1} + f_{32} R_{t-2} + \ldots\ldots + f_{3n} R_{t-n} \\
&+ g_{31} Z_{t-1} + g_{32} Z_{t-2} + \ldots\ldots + g_{3n} Z_{t-n} \\
&+ r_3 T + e_{3t}
\end{aligned}
$$

where,

Y, M, P, R, and T are as defined above.

Z is the price link variable

e is the random disturbance term.

The Interest Rate Equation for the Typical Country:

$$
\begin{aligned}
R_t = a_4 &+ b_{41} Y_{t-1} + b_{42} Y_{t-2} + \ldots\ldots + b_{4n} Y_{t-n} \qquad (5.10) \\
&+ c_{41} M_{t-1} + c_{42} M_{t-2} + \ldots\ldots + c_{4n} M_{t-n} \\
&+ d_{41} P_{t-1} + d_{42} P_{t-2} + \ldots\ldots + d_{4n} P_{t-n} \\
&+ f_{41} R_{t-1} + f_{42} R_{t-2} + \ldots\ldots + f_{4n} R_{t-n} \\
&+ g_{41} F_{t-1} + g_{42} F_{t-2} + \ldots\ldots + g_{4n} F_{t-n} \\
&+ r_4 T + e_{4t}
\end{aligned}
$$

where,

Y, M, P, R, and T are as defined above.

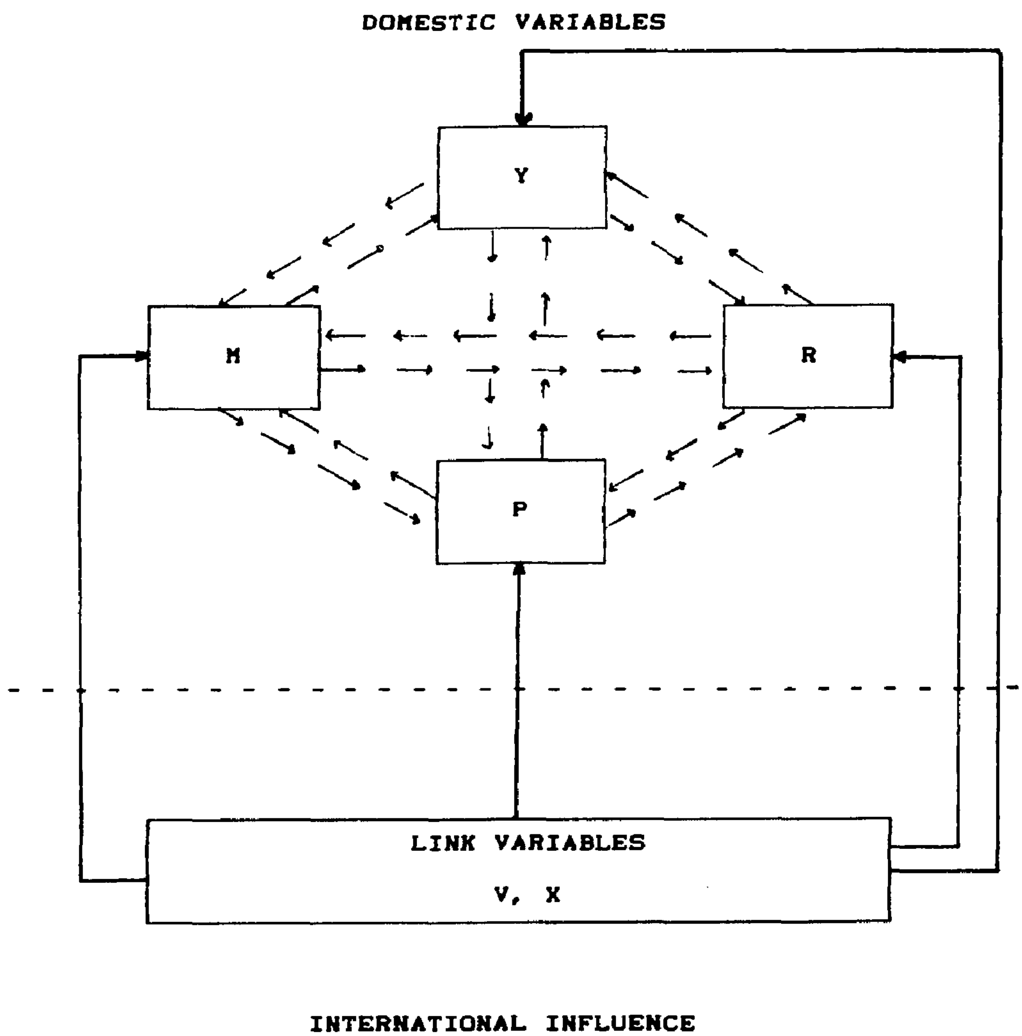
F is the effective exchange rate link variable.

e is the random disturbance term.

Linkage Mechanism B

The second linkage mechanism that is considered includes linkages through only two link variables, the output link and the effective exchange rate link. Unlike Linkage Mechanism A, Linkage Mechanism B is more general and, it allows for the two link variables enter in every equation of the typical country model as shown in Exhibit 5.3. The output link variable represents the output fluctuations in the other economies of the system and the effective exchange rate link variable represents movements in financial and price variables. Thus, there is an international output variable and an international price variable in every equation of the typical country model. In essence, this type of a linkage mechanism is very similar to the way regional models are linked to national models as illustrated in Table 4.2. One could think of individual countries as a specific region of the international economy where the international variables, which are exogenous to the single country model, will enter on the right-hand-side of every equation. The equations of th typical country model in LINK-VAR under the Linkage Mechanism B are represented below;

EXHIBIT 5.3. AN ILLUSTRATION OF THE OPEN-ECONOMY (POST-LINK) MODEL FOR THE TYPICAL COUNTRY IN LINK-VAR. (LINKAGE MECHANISM B)



The Output Equation for the Typical Country:

$$
\begin{aligned}
Y_t = a_i &+ b_{i1} Y_{t-1} + b_{i2} Y_{t-2} + \ldots\ldots + b_{in} Y_{t-n} \\
&+ c_{i1} M_{t-1} + c_{i2} M_{t-2} + \ldots\ldots + c_{in} M_{t-n} \\
&+ d_{i1} P_{t-1} + d_{i2} P_{t-2} + \ldots\ldots + d_{in} P_{t-n} \\
&+ f_{i1} R_{t-1} + f_{i2} R_{t-2} + \ldots\ldots + f_{in} R_{t-n} \\
&+ g_{i1} V_{t-1} + g_{i2} V_{t-2} + \ldots\ldots + g_{ip} V_{t-p} \\
&+ s_{i1} F_{t-1} + s_{i2} F_{t-2} + \ldots\ldots + s_{ip} F_{t-p} \\
&+ r_i T + e_{it}
\end{aligned}
\qquad (5.11)
$$

where,

Y is output

M is money

P is price

R is interest rate

T is time.

V is the output link variable.

F is the effective exchange rate link variable.

e is the random disturbance term.

The Money Equation for the Typical Country:

$$
\begin{aligned}
M_t = a_2 &+ b_{21} Y_{t-1} + b_{22} Y_{t-2} + \ldots\ldots + b_{2n} Y_{t-n} \qquad (5.12) \\
&+ c_{21} M_{t-1} + c_{22} M_{t-2} + \ldots\ldots + c_{2m} M_{t-m} \\
&+ d_{21} P_{t-1} + d_{22} P_{t-2} + \ldots\ldots + d_{2m} P_{t-m} \\
&+ f_{21} R_{t-1} + f_{22} R_{t-2} + \ldots\ldots + f_{2m} R_{t-m} \\
&+ g_{21} V_{t-1} + g_{22} V_{t-2} + \ldots\ldots + g_{2p} V_{t-p} \\
&+ s_{21} F_{t-1} + s_{22} F_{t-2} + \ldots\ldots + s_{2p} F_{t-p} \\
&+ r_2 T + e_{2t}
\end{aligned}
$$

where,

Y, M, P, R, and T are as defined above.

V is the output link variable.

F is the effective exchange rate link variable.

e is the random disturbance term.

The Price Equation for the Typical Country:

$$
\begin{aligned}
P_t = a_3 &+ b_{31} Y_{t-1} + b_{32} Y_{t-2} + \ldots\ldots + b_{3m} Y_{t-m} \\
&+ c_{31} M_{t-1} + c_{32} M_{t-2} + \ldots\ldots + c_{3m} M_{t-m} \\
&+ d_{31} P_{t-1} + d_{32} P_{t-2} + \ldots\ldots + d_{3m} P_{t-m} \\
&+ f_{31} R_{t-1} + f_{32} R_{t-2} + \ldots\ldots + f_{3m} R_{t-m} \\
&+ g_{31} V_{t-1} + g_{32} V_{t-2} + \ldots\ldots + g_{3m} V_{t-m} \\
&+ s_{31} F_{t-1} + s_{32} F_{t-2} + \ldots\ldots + s_{3p} F_{t-p} \\
&+ r_3 T + e_{3t}
\end{aligned}
\qquad (5.13)
$$

where,

Y, M, P, R, and T are as defined above.

V is the output link variable.

F is the effective exchange rate link.

e is the random disturbance term.

The Interest Rate Equation for the Typical Country:

$$
\begin{aligned}
R_t = a_4 &+ b_{41} Y_{t-1} + b_{42} Y_{t-2} + \ldots\ldots + b_{4m} Y_{t-m} \qquad (5.14) \\
&+ c_{41} M_{t-1} + c_{42} M_{t-2} + \ldots\ldots + c_{4m} M_{t-m} \\
&+ d_{41} P_{t-1} + d_{42} P_{t-2} + \ldots\ldots + d_{4m} P_{t-m} \\
&+ f_{41} R_{t-1} + f_{42} R_{t-2} + \ldots\ldots + f_{4m} R_{t-m} \\
&+ g_{41} V_{t-1} + g_{42} V_{t-2} + \ldots\ldots + g_{4p} V_{t-p} \\
&+ s_{41} F_{t-1} + s_{42} F_{t-2} + \ldots\ldots + s_{4m} F_{t-m} \\
&+ r_4 T + e_{4t}
\end{aligned}
$$

where,

Y, M, P, R, and T are as defined above.

V is the output link variable.

F is the effective exchange rate link variable.

e is the random disturbance term.

In concluding this chapter, the basic features of the LINK-VAR model can be summarized as: (1) The LINK-VAR model is an eighteen country system where each country model is specified with four major macroeconmic variables (output, money, price and interest rate); (2) The country models in the LINK-VAR are linked through two different linkage mechanisms; (3) Linkage Mechanism A considers four link variables linking the corresponding four domestic variables; and, (4) Linkage Mechanism B is more general and considers only two link variables in every equation of the typical country model.

In the next chapter the data, the estimation, and the model selections of LINK-VAR will be discussed in detail.

CHAPTER VI

DATA, ESTIMATION AND MODEL SELECTIONS

Introduction

The LINK-VAR is a monthly model covering eighteen major OECD countries (Australia, Austria, Canada, Denmark, Finland, France, Germany (West), Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and the United States). Each country model in LINK-VAR is specified by four major macroeconomic variables (output, money, price, and interest rate) except for Spain and Finland which are represented by the first three since compatible interest rate series for both countries are not available.

This section is organized in the following way: The first section gives the description of the data used in the study. The estimation procedure of the LINK-VAR model is discussed in the second section. The third section presents the model selections for the individual country specifications in the LINK-VAR. The summary of the results from the model selections constitute the last section of this chapter.

Data Description

It is evident from the survey of VAR models in Chapter IV that the most common variable used to represent output is Real GNP. It should be noted that the majority of the national studies used quarterly data. Quarterly series for GNP are available for the some of the western industrialized countries. Since GNP series are not compiled on a monthly basis, a proxy is needed to represent output. In this study the standard practice was followed and the seasonally adjusted Index of Industrial Production, which is the most common proxy for the economic activity in monthly studies, was used.

Monthly series for the narrow definition of money (M1) is readily available for the majority of industrialized countries. The M1 series was selected as the money variable, except for Sweden and Switzerland where a more consistent series M2 exists.

For the price variable in the LINK-VAR, the Consumer Price Index for all items (1980=100) was used. It is taken as a proxy for the broader price variable, the GNP Deflator.

The interest rate variable is the least homogenous measure across the countries since there are a variety of different rates one could consider. According to major international studies, a comparable short term rate for each country can be found as long as consistent data are available.[1]

With few exceptions the source of the data is OECD's Main Economic Indicators: Historical Statistics 1964-1983 and the various issues of monthly Main Economic Indicators. The data for the Effective Exchange Rate Link variable were taken directly from IMF's International Financial Statistics Data tape (Series AMX). A detailed description of the data and their sources are discussed in Appendix B.

The standard practice in VAR studies is to use some transformation on the data in order to work with stationary series. This could be done by either using growth rates or differencing the data. Another standard practice, which is the one adopted in this study, is to estimate the equations in logs except for variables that represent percentage rates, such as the unemployment rate and the interest rate, and include a trend variable in every equation. Therefore, in this study all of the variables except interest rate were used in log form.

Estimation of LINK-VAR

The country models in the LINK-VAR were estimated by using the ordinary least squares technique. In a reduced-

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[1] IMF and OECD, in their monthly publications have selected those representative short-term rates for international comparisons. See Appendix B, for the exact description of the interest rate data.

form equations model, such as the system of equations in a VAR model, the model can be estimated with techniques that account for cross-equation correlation of disturbance terms in order to gain efficiency in the coefficient estimates.[2] However, if all equations have the same explanatory variables, the ordinary least squares will provide equally efficient estimates of the coefficients.[3]

The sample period used for the estimation was 1972:01-1984:06 for the majority of the countries where the historical data were available. Due to data limitations for some of the series the estimation period for Austria, Denmark and Norway was started in 1973:01 and for Sweden in 1975:01.

Ex-post forecasts were generated for 1984:07-1985:06. As actual data were available until 1985:06, the intention was to have a twelve month forecast horizon covering the last twelve observations of the available data. The estimations were done in two stages; (1) Pre-Link Estimations and (2) Post-Link Estimations. After each estimation, twelve-month forecasts were generated and used to determine the best model specifications.

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[2] See Kmenta (1971), pp. 517-520.

[3] See Ibid., p. 521.

Pre-Link (closed-economy) Estimations

In the first stage, the eighteen individual country models of LINK-VAR were estimated as closed-economy systems to establish an appropriate pre-link model for each country, before studying the impact of international fluctuations. As indicated in Chapter III, the key task in building a VAR model is the choice of the lag structure which is selected based on some statistical criteria.

One way of determining the lag length is to use a test which would evaluate alternative lag structures based on goodness of fit in the sample period. Sims (1980a) suggested an asymptotic X^2 test where shorter lag structures are tested as restrictions on longer lags. Hakkio and Morris (1984) showed how to use such a test with a simple three equation model.

A second way to choose the lag structure is to use some statistical criteria measuring the predictive accuracy of the model with alternative lag lengths. It is quite often the case that goodness of fit does not guarantee predictive accuracy, especially in multi-equation models.[4] Since the purpose of this study is to build a forecasting model, the latter kind of lag selection, seems to be more appropriate.

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[4] See, for instance Pindyck and Rubinfeld (1981), p.361.

One criterion that is widely used for evaluating forecasting accuracy is the root-mean-square error (RMSE) which is given by,

$$RMSE = \quad 1/T \sum_{t=1}^{T} (Y^f_t - Y^a_t)^2 \qquad (6.1)$$

where, Y^f is the forecasted value of Y, Y^a is the actual value of Y and T is the number of forecast periods.

The lag structure which provides the least RMSE for each variable is selected as the optimum lag length for the model. Obviously, RMSE is a good measure to make single equation lag selections. However when a system of equations is considered, RMSE criterion could easily lead to inconclusive results. When, for example, six competing models are being evaluated regarding lag structures, equation by equation comparisons could easily lead to very mixed results. It is possible to find that the lag structure in model one has the best output forecast, model two has the best money forecast, model three has the best price forecast and model four has the best interest rate forecast. From such a set of results it would be very difficult to select the optimum model specification. Since our purpose is to select the lag structure for the whole system using post-sample prediction performance, a criterion which would provide a comparison of different specifications not only by single equation but also in a system of equations is needed. To this end, a criterion was developed in this study, the 'mean standard total error' (MSTE) of prediction. MSTE is simply a standardized measure of the average prediction error of different equation-systems and can be represented as:

$$MSTE_i = \left(\frac{1}{n} \sum_{j=1}^{n} \left(\frac{RMSE_{ij}}{(1/n) \sum_{j=1}^{n} RMSE_{ij}} \right) \right) \qquad (6.2)$$

where $RMSE_{ij}$ is the root-mean-square-error from equation i in model specification j, and i= 1,..., m is the number of variables, and j=1,..., n is the number of alternative lag structures.

From Equation (6.2) one can see that MSTE is the mean of the sum of the standardized error of each equation where the standardized error is calculated as the ratio of each RMSE to the average RMSE. The specification which produced the least MSTE was usually selected as the optimum lag structure. It is recognized that MSTE could be biased in case of an explosive forecast in one or more variables, nevertheless, when this is not the case, it can be a very useful criterion in determining the lag structure. The MSTE measure was not the only criterion used in making the lag structure selections in this study, at times subjective judgement was used where ever it was felt to be necessary.

In the Pre-Link estimation stage, each country model was estimated using six alternative lag structures in quarterly intervals, i.e., three, six, nine, twelve, fifteen, and eighteen months. For each lag structure twelve-period-ahead forecasts were generated. These results are reported in Table 6.1 for each country. Twenty four lags were also tried, but due to the fact that it produced explosive forecasts in some countries, these results were not included in the tables. The forecasts generated by all the selections were strictly unconditional forecasts, where only the information up to the period 1984:06 was used. The first stage of estimations was completed by selecting the best closed-economy specification for each of the eighteen countries in LINK-VAR.

Post-Link (Open Economy) Estimations

In the second stage of estimations, each country model was estimated as open-economy (post-link) systems by introducing the link variables into the best closed-economy specifications that were selected in the first stage. Post-Link Estimations were done for the two different linkage mechanisms that were introduced in Chapter V. As in the closed-economy case, it can be argued that each country model would have a different lag structure in terms of the link variables. That is, it is reasonable to believe that the transmission of international fluctuations would take longer for some countries than for others. For this reason alternative lag structures with equal size for the link variables were considered. One could argue that the influence of the international economy on each variable may differ in terms of lag lengths. For instance, one could expect a faster international impact on interest rate than on output which would mean that the post-link specification should consider disproportianate lag structures for each equation in the typical country model. Only symmetric lag structures were considered and disproportionate lag structures were not tried for the purposes of the study. There is reason to believe that the results could have been improved if the latter strategy were followed. The possible combinations of disproportianate lag structures are so numerous that the gain in such an exercise might be undermined by the amount of computations necessary.

Twelve-period-ahead forecasts were generated from each post-link specification and the optimum post-link lag structure was selected based on the forecast performance. In the case of post-link forecasting the forecasts were conditional on the given values of the link variables. In ex-post forecasting experiments, the common practice is to use the actual values of the exogenous variables over the forecast horizon. This practice was followed in the case of the LINK-VAR estimation. It is important to note that unconditional forecasts can still be generated if the exogenous variables, i.e., the link variables in individual country models, are forecasted by using their own past history up to the end of the estimation period. This process assumes that each country is a 'small open economy'. The link variables have an influence upon each country but they are not affected by each country's model. One therefore, can generate ex-ante forecasts by using this approach.

<u>Model Selections for Each Country Model in LINK-VAR</u>

Initially a pre-link (closed economy) specification was made for each of the eighteen countries. Then, the linkage mechanisms were introduced into the selected pre-link specification and the best post-link (open-economy) specification was determined. The MSTE criterion was generally followed in these selections and in some country specific cases other special considerations where taken into account. In the pre-link model the lag structure which yielded the lowest MSTE and relatively lower RMSEs in at least two equations, compared to other specifications, was selected. Where the MSTE measures for several specifications were very close, the lag structure of the lowest order (i.e., smaller number of lags) was chosen in order to gain some degrees of freedom.

In the post-link model the lag structure which firstly yielded the lowest MSTE and secondly the larger number of equations with relatively lower RMSEs, compared to the best pre-link specification, was selected. More emphasis was given to equation by equation comparisons since the purpose was to find the post-link specification which improves more equations than the pre-link specification. In most cases the lag structure with the lowest MSTE had also the most number of improved equations over pre-link. The selected specifications are reported in country Tables 6.1 for the pre-link, 6.2A for post-link A, and 6.2B for post-link B. A brief discussion of how the selection was made for each country is provided below.

Australia

The six lags specification was chosen as the optimum for Australia, Table 6.1.1. This lag structure has the lowest MSTE measure and it has at least three equations with lower RMSEs compared to the rest of the specifications. Six lags has also the best output and interest rate forecast, second best money forecast, and third best price forecast. Table 6.1.1 also indicates that output and price predictions are better at short (three, six) and long (eighteen) lags. On the other hand, interest rate predictions deteriorate as more lags are introduced, while money predictions are better between six to fifteen lags.

The best post-link selection under the linkage mechanism A for Australia was the fifteen lag specification, Table

6.2A.1. Although it has the second lowest MSTE it compares well with the eighteen lag specification with the lowest MSTE. Fifteen lags has better output and money forecasts and eighteen lags has better price and interest forecasts. Among other reasons fifteen lags was selected over other specifications because it compares better with the pre-link specification. Output and money forecasts of fifteen lags are almost the same as the pre-link, price forecast is significantly improved and interest forecast is slightly worse. Table 6.2A.1 also indicates that price forecasts are improved as more lags are introduced and they are better than the pre-link prediction for price for every specification. Money predictions can not be improved over the pre-link prediction at all. Interest rate forecast is better than the pre-link forecast only at twenty one lags. Finally, the output forecast is slightly improved only at fifteen lags.

Twelve lags was selected for the post-link specification for Australia under the linkage mechanism B, Table 6.2B.1. This lag structure has the lowest MSTE and has at least three better equations than all the other possible alternatives. Table 6.2B.1 indicates that price predictions can be improved over the pre-link in all cases. Interest rate prediction can not be improved. Output forecasts improve up to eighteen lags, while money improves only at eighteen lags.

AUSTRALIA

TABLE 6.1.1

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.01692	.02549	.01026	1.73300	.93677
1 TO 6 *	.01346	.01548	.01862	1.45100	.83936
1 TO 9	.01693	.01464	.02138	1.53600	.92680
1 TO 12	.02246	.01840	.02073	2.01500	1.10582
1 TO 15	.02266	.01778	.02353	2.07300	1.14746
1 TO 18	.01482	.02347	.01203	2.79900	1.04379

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

AUSTRALIA

TABLE 6.2A.1

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.01346	.01548	.01862	1.45100	
1 TO 3	.01452	.01968	.01225	1.74800	1.05713
1 TO 6	.01452	.02296	.01138	1.88000	1.08590
1 TO 9	.01445	.02439	.00960	1.99100	1.06532
1 TO 12	.01381	.02939	.01239	1.84500	1.16414
1 TO 15 *	.01300	.01555	.00763	1.76600	.85971
1 TO 18	.01575	.02149	.00388	1.46300	.81700
1 to 21	.01685	.03205	.00857	1.28200	1.05202
1 TO 24	.01459	.02709	.00467	1.60500	.89202

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

AUSTRALIA

TABLE 6.2B.1

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.01346	.01548	.01862	1.45100	
1 TO 3	.01216	.01644	.00926	1.77500	.86268
1 TO 6	.01271	.02354	.00690	2.07700	.89410
1 TO 9	.01574	.03007	.00231	2.09600	.85492
1 TO 12 *	.01115	.01559	.00800	1.78900	.80062
1 TO 15	.01135	.01575	.00819	1.94700	.83166
1 TO 18	.01332	.01399	.01004	1.75000	.87827
1 TO 21	.02739	.04397	.00449	2.18500	1.23467
1 TO 24	.03797	.05125	.01145	1.84100	1.63809

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

<u>Austria</u>

The pre-link selection for Austria was three lags, Table 6.1.2. It provides the least MSTE and also has at least two better equations than the two alternative specifications, nine lags and twelve lags, with second and third lowest MSTE values. An equation by equation comparison indicates that three lags has the best price forecast, second best output, third best interest and fourth best money forecast, yielding a reasonably balanced forecast performance. An overall assessment of the pre-link specifications indicate that output and price forecasts deteriorate as more lags are introduced. Further more, money predictions are better at longer lags and the interest rate forecasts are the best within six to nine months.

Three lags was selected for the post-link specification under linkage mechanism A, Table 6.2A.2. Three lags has the lowest MSTE and has at least two better predictions than all the other alternatives. Lags six is also a relatively good specification. The overall results for this case indicate that, price and output are improved at every possible lag structure, money can not be improved by the post-link specification at all.

The selection for the post-link specification under linkage mechanism B was nine lags, Table 6.2B.2. This selec-

AUSTRIA

TABLE 6.1.2

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.02984	.07031	.01361	.26410	.74253
1 TO 6	.02688	.08510	.01632	.32010	.84572
1 TO 9	.03615	.07619	.02162	.13980	.78436
1 TO 12	.03853	.06867	.02312	.15530	.79221
1 TO 15	.05197	.02635	.05197	.74900	1.47095
1 TO 18	.08314	.05865	.04633	.53870	1.47095

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

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TABLE 6.2A.2

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.02984	.07031	.01361	.26410	
1 TO 3 *	.02256	.03618	.00970	.30950	.87615
1 TO 6	.02266	.05371	.00767	.45080	.93895
1 TO 9	.02185	.06615	.00719	.63030	1.03996
1 TO 12	.02046	.07379	.00548	.75830	1.05084
1 TO 15	.02001	.07425	.00750	.77200	1.12205
1 TO 18	.02069	.07011	.00665	.64220	1.02868
1 TO 21	.02048	.06116	.00912	.52620	1.02463
1 TO 24	.01958	.06702	.00540	.54520	.91874

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

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TABLE 6.2B.2

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected ' Pre-Link	.02984	.07031	.01361	.26410	
1 TO 3	.03028	.05802	.01679	.18640	1.06132
1 TO 6	.02723	.03095	.01386	.35470	.91555
1 TO 9 *	.02879	.02596	.00964	.60630	.92726
1 TO 12	.03275	.02928	.00365	.88990	.96977
1 TO 15	.03826	.03301	.00513	.75800	.99698
1 TO 18	.03640	.05307	.00680	.43060	.95140
1 TO 21	.03401	.07242	.01113	.24640	1.04583
1 TO 24	.04186	.09146	.00910	.21790	1.16426

' Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

tion has the second lowest MSTE and was preferred over lag six with the lowest MSTE. Nine has two better, one almost the same and one worse forecast compared to six. Further more, nine lags has three better predictions, output, money and price, than the pre-link specification and no other lag structures has this advantage. Table 6.2B.2 also indicates that there is an uneven distribution of international influence on individual variables under the linkage mechanism B. Output is slightly improved only at six and nine lags. Money is improved within first eighteen lags. Price is improved between nine and twenty four lags, while the interest rate is improved within the first three and between twenty one and twenty four lags.

Belgium

Six lags was selected as the best pre-link selection for Belgium, Table 6.1.3. Six lags yields the lowest MSTE value and at least two better predictions than nine lags, which has the second lowest MSTE. This specification also provides a balanced forecast performance with the best price and interest rate forecasts and third best output and money forecasts. From the overall picture it can be observed that, the best output and interest rate predictions are within the first nine lags. At the same time, the best money forecast is provided at eighteen lags, while the best price forecasts are at six and nine lags.

The linkage mechanism A post-link selection was six lags, Table 6.2A.3. Note that, six lags was chosen as the best specification although it has the sixth lowest MSTE value. Table 6.2A.3 indicates that three and six lags specifications improve three equations (output, money and interest rate) over the pre-link selection but at the same time generate very bad predictions for price. As a result the MSTE values for three and six lags are biased due to the huge forecast errors in price. Six lags was selected as the best selection acknowledging the failure in the price forecast. Table 6.2A.3 also shows that, price forecast can not be improved over pre-link although longer lags reduces the forecast error. Money predictions are better except for the twenty four lags. Interest rate forecasts deteriorate after twelve lags, while output forecasts are relatively better at three and six lags.

Under linkage mechanism B, the post-link selection was fifteen lags, which has the fourth lowest MSTE, Table 6.2B.3. The problem encountered in linkage mechanism A seems to appear again, where the forecasts of output, money and interest rate can be improved with a deteriorating price forecast. Fifteen lags is the only specification where a better forecast for output, money and interest rate can be obtained simultaneously. Output forecasts are better except for twenty four lags. Money forecasts are better at all

BELGIUM

TABLE 6.1.3

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.02963	.02526	.00699	1.72100	1.10731
1 TO 6 *	.03261	.01992	.00354	1.20000	.82530
1 TO 9	.03206	.01929	.00372	1.28500	.83541
1 TO 12	.03937	.02276	.00630	1.89600	1.14555
1 TO 15	.03564	.02271	.00574	1.20600	.98281
1 TO 18	.03485	.01835	.00608	2.23400	1.10362

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

BELGIUM

TABLE 6.2A.3

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03261	.01992	.00354	1.20000	
1 TO 3	.02227	.01610	.03708	.61600	1.09770
1 TO 6 *	.02410	.01490	.03271	.58000	1.02125
1 TO 9	.03755	.01560	.02114	.54400	.95602
1 TO 12	.03710	.01500	.01457	1.20700	.98749
1 TO 15	.03393	.01687	.01200	1.25400	.96202
1 TO 18	.03240	.01800	.00744	1.52300	.95625
1 to 21	.03220	.01894	.00413	1.78700	.97567
1 TO 24	.03660	.01999	.00478	1.82600	1.04360

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

BELGIUM

TABLE 6.2B.3

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03261	.01992	.00354	1.20000	
1 TO 3	.02136	.01478	.00419	2.08100	.82420
1 TO 6	.02014	.01339	.01096	2.15500	.89452
1 TO 9	.02600	.01385	.01695	2.51000	1.09536
1 TO 12	.02683	.01592	.01985	1.31000	.99839
1 TO 15 *	.02475	.01798	.02194	1.15800	1.01921
1 TO 18	.02453	.01670	.02500	1.30500	1.06029
1 TO 21	.02898	.01339	.02267	1.37000	1.02494
1 TO 24	.03507	.01324	.02206	1.44000	1.08309

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

lags. Price predictions can not be improved at all, while interest rate predictions are bad except for the selected fifteen lags.

Canada

The pre-link selection for Canada was very straight forward. The best specification was three lags, which has the lowest MSTE and at the same time has lower RMSEs for every variable, Table 6.1.4. A systematic pattern can be seen in all equations where longer lags deteriorate the forecast performance, except for price which shows some fluctuations in RMSEs.

The post-link selection under linkage mechanism A was three lags which indicated a relatively rapid international influence over the domestic economy, Table 6.2A.4. Three lags has the lowest MSTE measure and has at least three better forecasts than nine lags, which has the second best MSTE. As in the case of the pre-link selections, the output and money forecasts get worse as more lags are introduced. Price forecasts are better up to twelve lags, while interest rate prediction errors fluctuate at longer lags.

Linkage mechanism B yield the same selection, three lags, Table 6.2B.4. At three lags, MSTE measure is the lowest and at least three equations have the lowest RMSEs. Table 6.2B.4 also indicates that output prediction errors

CANADA

Table 6.1.4

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.02913	.02213	.02071	1.05600	.52235
1 TO 6	.04039	.04562	.03147	2.66200	.93227
1 TO 9	.04284	.04449	.03356	2.60400	.95137
1 TO 12	.04949	.07318	.03181	2.23600	1.05907
1 TO 15	.06402	.07449	.03203	2.98200	1.21423
1 TO 18	.07221	.08268	.02949	3.49000	1.32071

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

CANADA

Table 6.2A.4

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.02913	.02213	.02071	1.05600	
1 TO 3 *	.01716	.01432	.00728	1.77300	.61969
1 TO 6	.02015	.03716	.00776	1.54800	.74002
1 TO 9	.02206	.02701	.00497	1.80400	.67642
1 TO 12	.02949	.04359	.00519	2.76000	.95733
1 TO 15	.04643	.04297	.01443	1.56200	1.13595
1 TO 18	.03727	.06676	.02084	1.36500	1.29916
1 TO 21	.03565	.08305	.01481	1.82200	1.29572
1 TO 24	.03685	.07896	.01364	1.94800	1.27571

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

CANADA

TABLE 6.2B.4

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.02913	.02213	.02071	1.05600	
1 TO 3 *	.01188	.03471	.02731	.76070	.71904
1 TO 6	.01502	.04200	.02560	.79930	.79100
1 TO 9	.01368	.05298	.03005	.92360	.87807
1 TO 12	.01910	.08957	.02774	1.55100	1.22544
1 TO 15	.01732	.06775	.03124	1.26400	1.07793
1 TO 18	.01650	.07345	.03138	1.16000	1.06599
1 TO 21	.01661	.07394	.03260	1.26600	1.10314
1 TO 24	.01786	.07206	.03208	1.39600	1.13939

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

are lower, money and price prediction errors are higher than pre-link errors at all lags. Interest rate forecasts are better within the first nine lags.

Denmark

The pre-link selection for Denmark was three lags, Table 6.1.5. Although three lags has the third lowest MSTE, it has at least two lower RMSEs compared to six lags and eighteen lags. Since relatively accurate forecasts can be generated with fewer lags, three lags seemed to be the best choice. The RMSEs for individual equations indicate that the forecast performance is better at first six lags and at fifteen and eighteen lags.

The post-link, linkage A selection for Denmark was six lags, which has the lowest MSTE, Table 6.2A.5. Twelve lags which has a very close MSTE measure is not preferred, since three lags have lower forecast errors for at least two variables. The forecasting performance can be improved over pre-link selection for all four variables at all lags except for three lags, indicating that international variables are crucial for better forecasts.

Table 6.2B.5 shows that the significant improvement by the linkage mechanism A can not be maintained by the linkage mechanism B. The selection is nine lags, which has the lowest MSTE but can generate better forecasts for only output,

DENMARK

TABLE 6.1.5

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION:
Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.04996	.05350	.01615	4.30800	.84765
1 TO 6	.05532	.05996	.00314	6.01200	.79579
1 TO 9	.04967	.08317	.01877	7.86700	1.14522
1 TO 12	.04636	.08921	.03187	7.17000	1.27599
1 TO 15	.04693	.05800	.03610	6.31200	1.20494
1 TO 18	.05758	.06460	.00513	3.21100	.73047

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

DENMARK

TABLE 6.2A.5

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04996	.05350	.01615	4.30800	
1 TO 3	.05018	.01939	.00719	1.66200	.90291
1 TO 6 *	.04549	.01717	.00581	1.08000	.73474
1 TO 9	.04547	.03137	.01216	2.09600	1.20013
1 TO 12	.04347	.02593	.00370	1.30400	.74826
1 TO 15	.04405	.02775	.01035	1.90900	1.07626
1 TO 18	.04285	.03460	.00550	1.98500	.96478
1 TO 21	.04255	.04756	.00747	2.39100	1.18663
1 TO 24	.04096	.05077	.00538	2.81800	1.18629

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

DENMARK

TABLE 6.2B.5

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04996	.05350	.01615	4.30800	
1 TO 3	.04590	.06869	.02257	4.38800	.98270
1 TO 6	.04696	.07870	.02436	5.10200	1.09349
1 TO 9 *	.04534	.07137	.02646	2.04600	.86274
1 TO 12	.05379	.06071	.03822	1.80200	.91933
1 TO 15	.05409	.05562	.03990	2.52600	.95739
1 TO 18	.05859	.04757	.03622	4.19700	1.02844
1 TO 21	.05145	.02552	.04981	4.87700	1.03225
1 TO 24	.05967	.02961	.05310	5.03500	1.12366

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

and interest rate, compared to the pre-link selection. The international influence represented by the link variables seems to be asymmetrical. Output forecasts are better within nine lags, while money forecasts are better between eighteen and twenty four lags. Price prediction errors get larger with longer lags and interest rate prediction errors are smaller between nine and eighteen lags. As a result none of the individual specifications yield better forecasts for all four variables over the pre-link selection.

Finland

Finland has one of the two three equation country models in LINK-VAR. The three lags specification which has the second lowest MSTE was selected as the best pre-link specification, Table 6.1.6. Although Lags fifteen and eighteen have equally low MSTE values, three lags was preferred in order to gain degrees of freedom. Table 6.1.6 also indicates that the prediction errors for money increase with longer lags, while output and interest rate prediction errors shows some fluctuations.

Twenty four lags, which has the lowest MSTE was chosen as the best linkage A specification, Table 6.2A.6. The money and price forecasts are better, while the output forecast is worse compared to the pre-link specification. In fact, the output prediction errors are higher than pre-link for every

FINLAND

TABLE 6.1.6

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.03884	.03721	.01128	—	.87923
1 TO 6	.04261	.04261	.01591	—	1.07851
1 TO 9	.04601	.06699	.01224	—	1.13157
1 TO 12	.03742	.07775	.01355	—	1.15146
1 TO 15	.02682	.07553	.00810	—	.88415
1 TO 18	.03258	.07200	.00669	—	.87508

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

FINLAND

TABLE 6.2A.6

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected ¹ Pre-Link	.03884	.03721	.01128	——	
1 TO 3	.05584	.03545	.02187	——	1.08777
1 TO 6	.06106	.04044	.02265	——	1.17649
1 TO 9	.06159	.05183	.02265	——	1.27117
1 TO 12	.05848	.03438	.01773	——	1.00907
1 TO 15	.05303	.04879	.01040	——	.93775
1 TO 18	.04945	.04188	.01048	——	.86176
1 TO 21	.04867	.04730	.01210	——	.93426
1 TO 24 *	.04173	.03227	.00976	——	.72172

¹ Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table (6.1).

FINLAND

TABLE 6.2B.6

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03884	.03721	.01128	——	
1 TO 3 *	.05071	.04428	.00488	——	.88469
1 TO 6	.05277	.04751	.00521	——	.93792
1 TO 9	.05505	.05583	.00551	——	1.02275
1 TO 12	.05490	.05538	.00544	——	1.01464
1 TO 15	.05599	.05520	.00565	——	1.03308
1 TO 18	.05859	.05954	.00534	——	1.05649
1 TO 21	.06463	.05717	.00439	——	1.01776
1 TO 24	.05888	.04680	.00622	——	1.03268

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

lag structure. Price forecasts improve after twelve lags and money forecasts get better at three, twelve and twenty four lags.

The three lag specification which has the lowest MSTE was selected as the best post-link model under linkage mechanism B, Table 6.2B.6. Three lags has also the lowest RMSEs for every variable compared to the other alternative specifications. When compared to pre-link selection there is improvement only in the price forecasts at every lag, while both output and money have larger RMSEs at all lags.

France

The pre-link selection for France was three lags. It is a relatively straight forward choice since three lags has the lowest MSTE accompanied with lower prediction errors for at least three variables, Table 6.1.7. The forecast errors get bigger between six and twelve lags, drop slightly for fifteen lags and reach to the largest values at eighteen lags.

The post-link, linkage A, selection for France was six lags, which has the lowest MSTE, Table 6.2A.7. In fact the MSTE values for lags three, six, nine, twelve and fifteen are very close. All four equations improve over the pre-link selection, except interest rate in lags 12. The improvement over pre-link is at all lags for output, price and money.

FRANCE

TABLE 6.1.7

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.03796	.04616	.02956	1.76100	.78247
1 TO 6	.04483	.05140	.03523	2.09600	.87218
1 TO 9	.05127	.05227	.03523	3.10700	1.02932
1 TO 12	.05692	.04907	.03504	4.06200	1.11100
1 TO 15	.05502	.04614	.02995	3.15500	.97500
1 TO 18	.07090	.04764	.03312	5.03500	1.23007

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

FRANCE

TABLE 6.2A.7

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03796	.04616	.02956	1.761	
1 TO 3	.03051	.01980	.01851	1.74200	.94705
1 TO 6 *	.02940	.01962	.01789	1.44000	.88983
1 TO 9	.02849	.01969	.02003	1.49800	.91551
1 TO 12	.02812	.01908	.02061	1.78400	.94771
1 TO 15	.02686	.01964	.02049	1.74000	.93688
1 TO 18	.02985	.02209	.02363	2.05600	1.07005
1 TO 21	.02986	.02052	.02369	2.59200	1.11897
1 TO 24	.02988	.02030	.02428	2.99300	1.17400

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

FRANCE

TABLE 6.2B.7

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03796	.04616	.02956	1.76100	
1 TO 3	.04248	.02994	.02180	2.29600	1.25230
1 TO 6	.04113	.02912	.02005	1.93800	1.15751
1 TO 9	.03928	.02697	.01987	1.86500	1.10810
1 TO 12	.03714	.02455	.01741	1.66100	1.00361
1 TO 15	.03570	.02134	.01465	.95470	.81693
1 TO 18	.03781	.02036	.01618	1.23500	.88279
1 TO 21 *	.03266	.01544	.01560	1.22600	.78455
1 TO 24	.02549	.01526	.02265	2.34600	.96441

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

The results reported in Table 6.2A.7 show that international linkages are crucial in improving the forecast performance.

The post-link, linkage B, selection was twenty one lags which again has the lowest MSTE, Table 6.2B.7. The MSTE values for fifteen, eighteen and twenty one lags are very close. Further more, the RMSEs for all of the variables are smaller than the pre-link selection. Overall money and price forecasts are better for all the lags. Output forecasts are better between twelve and twenty four lags, while interest rate forecasts are better between twelve and twenty one lags indicating a balanced improvement over the pre-link selection.

Germany (West)

Six lags which has the lowest MSTE was the pre-link selection for Germany, Table 6.1.8. Six lags has also a fairly balanced forecast performance with the best interest forecast, second best money and price forecasts, and the fourth best output forecast. The RMSEs for the money variable increases consistently over longer lags. The same is true for price and interest rate after nine lags. Output RMSEs seems to fluctuate as more lags are introduced.

The post-link, linkage A selection was three lags which has the second lowest MSTE, Table 6.2A.8. Nine lags can also be selected since the forecast performance is slightly worse for output and money and slightly better for price and interest rate. Table 6.2A.8 indicates that, in comparison with the pre-link selection, output and money RMSEs are lower for short lags (three and six for output and three, six and nine for money), price RMSEs are lower and interest rate RMSEs are higher at all lags.

Six lags which has the lowest MSTE was the selected post-link specification under the linkage mechanism B, Table 6.2B.8. It is the only specification which has the lower RMSEs in all four cases compared to the pre-link selection. It has also the best forecast for money, price and interest rate and second best forecast for output. Table 6.2B.8 also shows that, compared to the pre-link specification output forecasts can be improved with up to fifteen lags and the only lag specification that improves money, price and interest rate is the six lags.

Ireland

Nine lags was chosen as our pre-link specification which has the second lowest MSTE, Table 6.1.9. Fifteen lags has the lowest MSTE however as indicated before a comparable lower order lag structure seemed more appropriate. Nine lags has the best interest rate forecast, the second best output forecast, third best money forecast and the worst price forecast. This specification does not have a well balanced

GERMANY (WEST)

TABLE 6.1.8

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.03559	.00993	.00632	.91200	.72838
1 TO 6 *	.04108	.01193	.00472	.28500	.60010
1 TO 9	.04164	.02623	.00417	.85600	.80375
1 TO 12	.05002	.03405	.00565	1.81700	1.15502
1 TO 15	.03543	.03944	.00587	1.47000	1.05752
1 TO 18	.03972	.05632	.00949	3.02700	1.65522

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

GERMANY (WEST)

TABLE 6.2A.8

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04108	.01193	.00472	.28500	
1 TO 3 *	.02098	.01040	.00432	1.09400	.84719
1 TO 6	.03901	.01079	.00430	.54000	.76692
1 TO 9	.04137	.01090	.00405	.34600	.70215
1 TO 12	.04126	.01895	.00425	.59800	.89455
1 TO 15	.04341	.02271	.00673	.74560	1.12204
1 TO 18	.04440	.02804	.00680	.71300	1.18219
1 TO 21	.04367	.03553	.00511	.80190	1.21652
1 TO 24	.04438	.03404	.00662	.78300	1.26846

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

GERMANY (WEST)

TABLE 6.2B.8

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04108	.01193	.00472	.28500	
1 TO 3	.01755	.01853	.00502	1.13700	.73599
1 TO 6 *	.03143	.00907	.00419	.26160	.52612
1 TO 9	.03708	.01822	.00561	1.97500	.98571
1 TO 12	.03399	.01622	.00579	3.00200	1.07761
1 TO 15	.03782	.01147	.00615	2.71700	1.00111
1 TO 18	.05746	.01641	.01543	.89270	1.29385
1 TO 21	.05458	.01503	.00637	1.08300	.95314
1 TO 24	.05018	.02088	.00701	3.97800	1.40842

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

forecast performance as a whole, which is also true for all the other alternative specifications as well. When each variable is studied separately, one can see that there are no significant patterns in forecast performance when more lags are introduced into each equation.

Three lags was selected as the best post-link, linkage A specification, Table 6.2A.9. Three lags has prediction errors lower than other alternative specifications for at least two variables Table 6.2A.9 also indicates that compared to pre-link selection output and price forecasts can be improved and money forecasts can not be improved at all alternative lags. Interest forecasts on the other hand are either slightly better or slightly worse at each lag structure.

Six lags which has the lowest MSTE was the post-link, linkage B selection for Ireland, Table 6.2B.9. It also has at least three better forecasts compared to the alternative specifications. Similar to linkage A, the output and price forecasts are better, while money forecasts are worse than the pre-link selection at all lags. Interest rate forecasts are better at every lag structure except for nine and twelve.

Italy

The pre-link selection for Italy was six lags which has

IRELAND

TABLE 6.1.9

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.05355	.04617	.02400	2.39300	1.08279
1 TO 6	.05045	.04374	.02267	2.86700	1.09137
1 TO 9 *	.04090	.04184	.02790	1.50300	.93137
1 TO 12	.04017	.04839	.02281	1.99600	.96722
1 TO 15	.05076	.03530	.01978	1.96000	.91001
1 TO 18	.04686	.03989	.02298	2.55000	1.01723

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

IRELAND

TABLE 6.2A.9

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04090	.04184	.02790	1.50300	
1 TO 3 *	.03411	.05780	.01458	1.45200	.90735
1 TO 6	.03377	.06493	.01834	1.42400	.97682
1 TO 9	.03490	.06279	.02208	1.50200	1.03447
1 TO 12	.03700	.05300	.02049	1.51900	.99059
1 TO 15	.03810	.05408	.01878	1.55400	.98780
1 TO 18	.03790	.05506	.02274	1.18100	.97628
1 TO 21	.03701	.06083	.02167	1.45100	1.02714
1 TO 24	.03501	.05923	.02460	1.79100	1.09956

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

IRELAND

TABLE 6.2B.9

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04090	.04184	.02790	1.50300	
1 TO 3	.03174	.05622	.01450	1.46400	.98133
1 TO 6 *	.03059	.06306	.00799	1.44800	.85839
1 TO 9	.03201	.05370	.00873	1.62600	.88519
1 TO 12	.03323	.05277	.01274	1.74100	.99459
1 TO 15	.03583	.06015	.01489	1.35200	1.01173
1 TO 18	.03625	.07215	.01443	.99930	.98111
1 TO 21	.03934	.12420	.01460	1.17700	1.21189
1 TO 24	.03706	.12070	.00900	1.21900	1.07577

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

the second lowest MSTE, Table 6.1.10. Six lags was preferred over eighteen lags since six lags which forecasts equally well has fourty-eight more degrees of freedom. The overall performance of the pre-link specifications for Italy indicates that forecasts of shorter (three, six, nine) and longer (eighteen) lags are relatively better for all variables in the country system.

The post-link, linkage A selection for Italy was six lags which has the lowest MSTE, Table 6.2A.10. Six lags has at least two better forecasts than fifteen lags, and has four better forecasts than nine lags. Table 6.2A.10 indicates that, all four variables can be forecasted better with the link variables at all alternative lags. This result shows the significance of international influence over the domestic economy in the case of Italy..

The post-link, linkage B selection for Italy was fifteen lags which has the lowest MSTE, Table 6.2B.10. Fifteen lags has at least three better predictions than any of the alternative specifications. Further more similar to linkage A, the forecast errors are reduced for all the variables at all lags when the link variables are introduced into the domestic model. The improvement in forecasting performance under linkage B is even more significant than the linkage A performance.

ITALY

TABLE 6.1.10

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION:
Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.07174	.07217	.04532	5.54600	.85141
1 TO 6 *	.07937	.06610	.04038	5.66500	.83387
1 TO 9	.07725	.05663	.06327	8.84300	.98317
1 TO 12	.14610	.08401	.07549	11.79000	1.43565
1 TO 15	.08946	.06547	.07653	8.76900	1.10636
1 TO 18	.03924	.04265	.06190	8.17700	.78953

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

ITALY

TABLE 6.2A.10

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.07937	.06610	.04039	5.66500	
1 TO 3	.06133	.02583	.02325	4.79500	1.10777
1 TO 6 *	.03129	.01825	.02319	3.62100	.79254
1 TO 9	.04051	.02930	.02893	3.73800	.99401
1 TO 12	.04152	.03854	.02997	3.60100	1.07158
1 TO 15	.04314	.03672	.02268	3.36400	.97214
1 TO 18	.04739	.03798	.02827	3.53700	1.05619
1 TO 21	.03601	.03337	.02575	3.25800	1.00235
1 TO 24	.03586	.03935	.02906	3.11300	1.00342

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

ITALY

TABLE 6.2B.10

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.07937	.06610	.04038	5.66500	
1 TO 3	.06755	.05939	.03151	3.95200	2.27221
1 TO 6	.02775	.02570	.01112	1.05600	.79976
1 TO 9	.03603	.02801	.00523	.61200	.67801
1 TO 12	.03303	.02849	.00675	.81640	.72940
1 TO 15 *	.02978	.02368	.00815	.39790	.61494
1 TO 18	.03724	.02992	.00677	.42180	.69298
1 TO 21	.03486	.03057	.01813	1.28700	1.06113
1 TO 24	.03008	.03014	.01969	1.78800	1.15156

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

Japan

The pre-link selection for Japan was six lags which has the lowest MSTE, Table 6.1.11. Six lags has lower RMSEs for at least three variables than the alternative specifications. This specification also has the best output and money forecast, second best interest rate forecast and fifth best price forecast, yielding a forecast performance which is fairly balanced with the exception of price. One can also observe that price forecasts improve significantly and money and interest rate forecasts deteriorate as more lags are introduced. Output forecasts do not show any observable pattern.

The results for the post-link, linkage A selections indicate that the link variables do not add any significant information on to the pre-link selection except for the price variable, Table 6.2A.11. Output predictions are slightly worse, money prediction errors are almost doubled, while interest forecasts are explosive. As a result, making a selection under these circumstances seems to be quite arbitrary. In this case, eighteen lags was selected which has the second lowest MSTE and has a relatively better balanced forecast performance.

The results for the post-link, linkage B selections were similar to the linkage A selections were the link var-

JAPAN

TABLE 6.1.11

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.01175	.01898	.01253	.22900	.92798
1 TO 6 *	.01073	.01773	.01046	.21900	.82912
1 TO 9	.01367	.01830	.00957	.23260	.86512
1 TO 12	.01472	.03064	.00632	.43740	1.06038
1 TO 15	.02749	.02057	.00538	.21500	.96989
1 TO 18	.01526	.04320	.00541	.67830	1.34751

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

JAPAN

TABLE 6.2A.11

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.01073	.01773	.01046	.21900	
1 TO 3	.01167	.02338	.00915	.87200	.85816
1 TO 6	.01614	.02566	.01184	.99790	1.05891
1 TO 9	.01727	.02581	.00914	1.07700	1.02798
1 TO 12	.01674	.02414	.00945	1.13500	1.02485
1 TO 15	.01337	.03072	.00543	1.16100	.92240
1 TO 18 *	.01116	.02775	.00709	1.12500	.89119
1 TO 21	.01181	.03061	.01245	1.14900	1.07444
1 TO 24	.01178	.03733	.01170	1.27300	1.14207

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

JAPAN

TABLE 6.2B.11

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected ' Pre-Link	.01073	.01773	.01046	.2190	
1 TO 3	.01830	.02361	.00601	1.19800	.90581
1 TO 6 *	.03017	.01397	.00627	1.43200	.97448
1 TO 9	.03197	.01539	.00916	1.47200	1.12093
1 TO 12	.03326	.01430	.00691	1.44000	1.03468
1 TO 15	.03137	.01898	.00711	1.22900	1.03399
1 TO 18	.02176	.02227	.00634	1.33900	.96580
1 TO 21	.01481	.03361	.00667	.96300	.96055
1 TO 24	.01226	.03500	.00709	1.16100	1.00376

' Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

iables do not make a significant improvement over the forecasting performance of the pre-link selection, Table 6.2B.11. Only price predictions are better at all possible lags, while money forecasts are improved at six, nine and twelve lags. Six lags was chosen since it has two lower prediction errors over the pre-link selection.

Netherlands

The pre-link selection for Netherlands was three lags, which has the second lowest MSTE and generates at least two better forecasts than the alternative specifications, Table 6.1.12. The lag structures for individual variables seems to substantially differ, yielding an asymmetrical lag structure as a model. Output forecasts improve with longer lags while money and price forecasts gets worse as more lags are introduced. Further more, interest rate forecasts do not have an observable pattern.

The post-link, linkage A results indicate an interesting pattern, Table 6.2A.12. Money, price and interest rate forecasts gets better and better as more post-link lags are introduced. On the other hand, output forecasts do not have a significant pattern while their forecast errors are lower at all lags compared to the pre-link selection. The lowest MSTE values can be observed at lags twenty four, twenty one and eighteen. Twenty four lags, which has the lowest MSTE and also has at least three better forecasts than the alternative lag structures seems to be the appropriate selection. Given how insignificant the shorter link lags are, an experiment was conducted with a lag structure of lags twelve to twenty four. The results indicate that money and interest rate forecasts can be improved further without a substantial deterioration in the forecasts of output and price. In fact, the twelve to twenty four lags provided better forecasts for all four variables when compared to pre-link selection.

Very similar results were encountered for linkage B, Table 6.2B.12. The same trend an be detected in money, price and interest rate forecasts where, longer lags provide better predictions. On the other hand, output predictions unlike the linkage A can only be improved at shorter lags. Twenty four lags which has the lowest MSTE and also has at least three better forecasts than the alternative lag structures was the selection under linkage mechanism B. The same experiment was repeated with lags twelve to twenty four and this time money and price predictions improved without a substantial loss in output and interest rate forecasts. Notice that twelve to twenty four lag specification has three improved forecasts over the pre-link selection, one more than the alternative lag structures that were tried.

NETHERLANDS

TABLE 6.1.12

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.04755	.08404	.01310	3.78800	.95166
1 TO 6	.05725	.09885	.00987	4.46500	1.02593
1 TO 9	.03909	.11110	.01147	6.03300	1.04361
1 TO 12	.03226	.10810	.01126	4.94700	.93179
1 TO 15	.02693	.11420	.01641	5.65100	1.04215
1 TO 18	.02222	.11700	.01876	4.54900	1.00485

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

NETHERLANDS

TABLE 6.2A.12

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04755	.08404	.01310	3.78800	
1 TO 3	.04185	.11090	.01876	6.10100	1.20312
1 TO 6	.04282	.10090	.01819	5.62100	1.14824
1 TO 9	.04440	.10430	.01833	5.33600	1.15529
1 TO 12	.04287	.10340	.01420	5.44800	1.06380
1 TO 15	.04414	.09803	.01313	5.19900	1.02314
1 TO 18	.04412	.09122	.00609	4.89600	.84482
1 TO 21	.04784	.08622	.00406	4.67800	.80056
1 TO 24 *	.04377	.08371	.00349	4.71800	.76104
12 TO 24	.04481	.07539	.00875	3.33000	

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

NETHERLANDS

TABLE 6.2B.12

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.04755	.08404	.01310	3.78800	
1 TO 3	.04046	.11650	.02141	5.75500	1.18439
1 TO 6	.04483	.12320	.01732	5.74200	1.14147
1 TO 9	.04452	.12480	.01756	5.49800	1.34620
1 TO 12	.05032	.12330	.01530	5.21700	1.10151
1 TO 15	.05100	.12260	.01502	5.34900	1.10526
1 TO 18	.04802	.11440	.01096	4.43800	.94433
1 TO 21	.05738	.09879	.00257	2.62500	.69628
1 TO 24 *	.06249	.09506	.00381	1.79700	.69216
12 TO 24	.06457	.07938	.00187	1.84000	

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

Norway

The pre-link selection for Norway was three lags, which has the lowest MSTE and also has at least two better forecasts than the closest alternative six lags, Table 6.1.13. The results from all the alternative specifications do not seem to indicate any observable pattern as to the lag structures. The forecast errors for each variable fluctuate with a different frequency.

Three lags which has the lowest MSTE was the post-link, linkage A selection for Norway, Table 6.2A.13. Three lags specification has also the best forecasts for all the variables. The forecasts for money and interest rates deteriorate with longer lags. On the other hand, output and price forecasts are better at shorter (three, six) lags and at longer (twenty one and twenty four) lags.

Three lags was the selection for post-link, linkage mechanism B, Table 6.2B.13. Three lags specification has the lowest MSTE and also has at least three better predictions than all the competing alternatives. The same observation can be made for money and interest rate, where their forecast performance deteriorate at longer langs. The output and price forecast errors fluctuate in an asymmetrical fashion. Table 6.2B.13 also indicates that, link variables do not improve the output and money forecast over the pre-link selection.

NORWAY

<u>TABLE 6.1.13</u>

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION:
Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.03323	.06534	.02639	1.58000	.87023
1 TO 6	.02979	.05856	.03171	1.82000	.87288
1 TO 9	.02220	.05934	.04495	3.05800	1.02481
1 TO 12	.02798	.05399	.04542	2.77900	1.02357
1 TO 15	.03432	.05484	.03943	3.40500	1.09830
1 TO 18	.04257	.05946	.03767	2.77600	1.11021

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

NORWAY

TABLE 6.2A.13

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected ' Pre-Link	.03323	.06534	.02639	1.58000	
1 TO 3 *	.05373	.05692	.00596	.82400	.66605
1 TO 6	.05766	.05832	.00852	.98830	.76612
1 TO 9	.06938	.07541	.01738	.98130	1.04769
1 TO 12	.06873	.07292	.01718	.98370	1.03320
1 TO 15	.06669	.08407	.01431	1.15200	1.03239
1 TO 18	.06127	.08489	.01178	1.59600	1.03733
1 TO 21	.05776	.08558	.01275	2.29600	1.16358
1 TO 24	.05752	.08718	.01127	2.97800	1.25364

' Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

NORWAY

TABLE 6.2B.13

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03323	.06534	.02639	1.58000	
1 TO 3 *	.04641	.09679	.01565	1.02500	.80402
1 TO 6	.04105	.10700	.01590	2.13400	.90353
1 TO 9	.04518	.11190	.01361	2.21400	.91250
1 TO 12	.04249	.11210	.01385	2.21800	.90138
1 TO 15	.04137	.11220	.01334	2.38600	.90354
1 TO 18	.03633	.11310	.01955	3.21900	1.04445
1 TO 21	.03603	.11720	.02124	3.94300	1.14409
1 TO 24	.06021	.12641	.02519	4.22300	1.38650

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

Spain

Three lags was selected as the pre-link selection for the three equation model of Spain, Table 6.1.14. Three lags selection has the lowest MSTE and also has at least two better forecasts than alternative specifications. Money pre-link forecasts gets worse at longer lags. Price forecasts deteriorate after twelve lags. Output forecasts do not show a significant pattern.

The results for post-link, linkage A, indicate that the output and money forecasts can not be improved with the link variables and only the price forecasts can be bettered, Table 6.2A.14. Therefore, the selection was the one with the minimum MSTE. Three lags yields the lowest MSTE and has at least two better forecasts than the other alternatives.

The post-link, linkage B, selection for Spain was three lags which has the lowest MSTE, Table 6.2B.14. This selection has also at least two better predictions than the alternative specifications. Table 6.2B.14 also indicates that output prediction errors fluctuate in an unpredictible way and money prediction errors get bigger while the price prediction errors get smaller at longer lags.

SPAIN

TABLE 6.1.14

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.02144	.06422	.01657	—	.83522
1 TO 6	.02624	.06323	.01353	—	.84737
1 TO 9	.02613	.07088	.01285	—	.85901
1 TO 12	.02050	.11980	.01979	—	1.06673
1 TO 15	.01861	.12880	.02278	—	1.12360
1 TO 18	.02233	.14870	.02402	—	1.26807

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

SPAIN

TABLE 6.2A.14

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.02144	.06422	.01657	——	
1 TO 3 *	.03129	.09159	.00859	——	.78659
1 TO 6	.04294	.09236	.00901	——	.87645
1 TO 9	.05052	.09887	.00883	——	.94411
1 TO 12	.05207	.09936	.00565	——	.86457
1 TO 15	.05627	.08194	.02090	——	1.26512
1 TO 18	.06473	.09637	.01509	——	1.20605
1 TO 21	.05561	.07859	.01475	——	1.07188
1 TO 24	.06110	.08219	.01004	——	.98525

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

SPAIN

TABLE 6.2B.14

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.02144	.06422	.01657	——	
1 TO 3 *	.02685	.03061	.01098	——	.67458
1 TO 6	.03436	.03835	.01117	——	.77995
1 TO 9	.03970	.05543	.00613	——	.75666
1 TO 12	.04125	.10390	.01253	——	1.13988
1 TO 15	.03434	.11820	.01731	——	1.26504
1 TO 18	.04088	.11990	.01861	——	1.36847
1 TO 21	.02791	.11860	.01238	——	1.07001
1 TO 24	.04248	.09179	.00684	——	.94542

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

Sweden

The pre-link selection for Sweden was three lags which has the lowest MSTE, Table 6.1.15. The three lag specification also has the second best output, money and interest rate forecast and third best price forecasts. The results also indicate that there is no observable pattern in RMSEs of individual variables at alternative specifications.

The post-link, linkage A selection for Sweden was three lags which has the lowest MSTE, Table 6.2A.15. Six, nine, twelve and fifteen have close MSTE values, however three lags has at least two better forecasts than all of them. The money and price predictions cannot be improved and the interest rate predictions can be improved over the pre-link selection at all lags. Output forecasts are relatively better at shorter lags.

The post-link, linkage B selection for Sweden was twelve lags which has the lowest MSTE with at least three better forecasts than the close alternatives, Table 6.2B.15. The output and price forecasts do not get better with the addition of the link variables, but the interest rate forecasts do. The money forecast is improved only at twelve lags.

SWEDEN

TABLE 6.1.15

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.03017	.02242	.01236	2.63400	.74807
1 TO 6	.03382	.01376	.02304	1.81700	.84900
1 TO 9	.04475	.03655	.01124	2.65000	.91822
1 TO 12	.02881	.05766	.00927	3.37600	.99477
1 TO 15	.07341	.04593	.01588	4.41100	1.35837
1 TO 18	.04749	.02494	.00879	7.58700	1.13156

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

SWEDEN

TABLE 6.2A.15

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03017	.02242	.01236	2.63400	
1 TO 3 *	.02797	.02377	.01493	1.83500	.94639
1 TO 6	.02708	.02544	.01628	1.75700	.95828
1 TO 9	.02860	.02918	.01446	1.81200	.98424
1 TO 12	.03264	.03182	.01660	1.36300	.99217
1 TO 15	.03010	.03276	.01805	1.34600	.99651
1 TO 18	.03027	.03563	.02029	1.25500	1.03714
1 TO 21	.03391	.03627	.01619	1.27800	1.01784
1 TO 24	.03268	.03510	.02389	1.04200	1.06764

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

SWEDEN

TABLE 6.2B.15

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.03017	.02242	.01236	2.63400	
1 TO 3	.03549	.02329	.01793	1.60200	.90211
1 TO 6	.03643	.02253	.02277	1.42500	.91258
1 TO 9	.03498	.02101	.02373	1.43200	.89684
1 TO 12 *	.03195	.02047	.02741	1.35300	.88703
1 TO 15	.03543	.03544	.03286	1.50800	1.12576
1 TO 18	.03517	.03208	.03235	1.44900	1.07790
1 TO 21	.03018	.02501	.04317	1.60300	1.09154
1 TO 24	.03249	.03230	.03782	1.44900	1.10624

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

Switzerland

Three lags which has the lowest MSTE was selected as the best pre-link specification, Table 6.1.16. Three lags has the best money prediction, second best price and interest rate prediction and the third best output prediction. The twelve lags specification which has the second lowest MSTE and three better forecasts than the three lags specification was not selected. It seemed more appropriate to have a model with much fewer lags which can almost do as good as a model with longer lags. Table 6.1.16 also indicates that there are no significant patterns in RMSEs at different lag structures.

The post-link results under linkage mechanism A are reported in Table 6.2A.16. The results indicate that none of the forecasts of Switzerlands can be improved with the link variables. The prediction errors of all variables at all lag structures are bigger than the prediction errors of the pre-link selection. When this is the case, the choice of a lag structure becomes almost arbitrary. The twelve lag specification was selected since it has the lowest MSTE. Experiments were conducted with different lag structures and only the results from the selection with lags six through twelve reported. This particular specification reduced the prediction errors of all four variables and also output and interest rate forecasts got better than the corresponding pre-link forecasts.

A similar picture can be observed for the forecasts under the linkage mechanism B, Table 6.2B.16. All four variables are again forecasted better without the link variables. The post-link specification which has the lowest MSTE was chosen following the selection criteria of this study. Experiments with different lags yielded interesting results. For example, the lags twelve to twenty four specification reduces the RMSEs drastically in every variable and in fact output and interest rate forecasts are once again, better than the corresponding pre-link forecasts.

United Kingdom

Nine lags was selected as the pre-link selection for United Kingdom, Table 6.1.17. The nine lags specification has the second lowest MSTE and is slightly inferior to the fifteen lags specification. Similar to the case of Switzerland an exception was made for United Kingdom and a selection with fewer parameters to estimate was selected. Table 6.1.17 also indicates that output forecasts gets better at nine and fifteen lags, the best money forecasts is at eighteen lags, the price forecasts improve after fifteen lags, while interest rate forecasts are almost the same for all specifications.

SWITZERLAND

TABLE 6.1.16

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3 *	.01264	.00843	.00507	.40540	.82638
1 TO 6	.01254	.01999	.00533	.40640	1.00585
1 TO 9	.01254	.01704	.00527	.42960	.97402
1 TO 12	.00959	.01844	.00488	.38190	.89417
1 TO 15	.01551	.01784	.00543	.42510	1.04511
1 TO 18	.01853	.02076	.00622	.55120	1.25302

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

SWITZERLAND

TABLE 6.2A.16

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.01264	.00843	.00507	.40550	
1 TO 3	.02917	.03248	.01152	.59500	.90172
1 TO 6	.03025	.03124	.01094	.59730	.89043
1 TO 9	.02614	.03136	.01157	.59030	.87060
1 TO 12 *	.02295	.02901	.01008	.53350	.77966
1 TO 15	.03062	.03356	.01455	.62660	.98998
1 TO 18	.03512	.03549	.01660	.65100	1.07867
1 TO 21	.04461	.03612	.01520	.73480	1.16531
1 TO 24	.05615	.04550	.01512	.75360	1.32362
6 to 12	.00848	.02076	.00850	.15030	

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

SWITZERLAND

TABLE 6.2B.16

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.01264	.00843	.00507	.40550	
1 TO 3 *	.03714	.07236	.01435	.57440	.72235
1 TO 6	.05010	.07646	.01690	.77950	.87848
1 TO 9	.05343	.08335	.01963	.82790	.95812
1 TO 12	.06193	.07496	.02577	1.00800	1.07944
1 TO 15	.06146	.07224	.02588	1.01500	1.07095
1 TO 18	.06241	.07079	.02721	1.02500	1.08634
1 TO 21	.05139	.06658	.03526	.95890	1.08269
1 TO 24	.05538	.06438	.03616	1.02800	1.12164
12 TO 24	.00859	.02209	.01938	.10900	

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

The linkage mechanism A forecasts indicate that introducing longer lags improve the predictions of all four variables Table 6.2A.17. The twenty four lags specification which has the lowest MSTE has also the best price and interest rate forecast, second best money forecast and third best output forecast. The relatively poor forecasting performance in shorter lag structures, led to experimenting with different specifications which emphasize the longer lags. One such specification is the twelve to twenty four lags model where only the output and interest rate predictions show significant improvement.

The post-link, linkage B selection was the twenty one lags specification which has the lowest MSTE, Table 6.2A.17. A similar pattern can be observed as in linkage A, where longer lags improve forecast performance except for output. The results from an alternative lag structure (twelve - twenty four) is also reported where output prediction error is reduced but the other three prediction errors get larger.

United States

The pre-link selection for United States was the nine lags specification which has the lowest MSTE, Table 6.1.18. This lag structure also yields the best output and interest rate, the second best price and the third best money forecasts. Table (6.1.18) also indicates that the forecast

UNITED KINGDOM

TABLE 6.1.17

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.01583	.04597	.02018	1.20200	1.14289
1 TO 6	.02124	.04997	.00799	1.26700	1.00685
1 TO 9 *	.01481	.04472	.01256	1.21900	.96866
1 TO 12	.01665	.04742	.01332	1.18500	1.01858
1 TO 15	.01389	.04742	.00933	1.16600	.89282
1 TO 18	.02094	.04004	.00982	1.19100	.97019

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

UNITED KINGDOM

TABLE 6.2A.17

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.01481	.04472	.01256	1.21900	
1 TO 3	.04640	.05378	.03810	1.83600	1.34722
1 TO 6	.04032	.04982	.03873	1.82900	1.29479
1 TO 9	.04638	.04275	.02081	1.51500	1.01990
1 TO 12	.04767	.04259	.01501	1.40000	.93679
1 TO 15	.03720	.04353	.01899	1.55200	.95224
1 TO 18	.03550	.04388	.01296	1.78400	.90624
1 TO 21	.03943	.03736	.00960	1.34000	.78101
1 TO 24 *	.03829	.03990	.00752	1.33400	.76181
12 to 24	.01362	.04343	.02047	1.17600	

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

UNITED KINGDOM

TABLE 6.2B.17

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected ' Pre-Link	.01481	.04472	.01256	1.21900	
1 TO 3	.06124	.04635	.00452	1.35400	.80149
1 TO 6	.06325	.04698	.00873	1.81110	.97252
1 TO 9	.06973	.04547	.00980	1.81500	1.00788
1 TO 12	.06985	.04599	.01020	1.88600	1.03092
1 TO 15	.07317	.02986	.01671	1.85500	1.07622
1 TO 18	.09166	.02491	.02496	1.85500	1.28852
1 TO 21 *	.09024	.03761	.00436	1.68200	.87918
1 TO 24	.10570	.02201	.00933	1.72900	.94328
12 TO 24	.05930	.02258	.02307	3.83200	

' Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

errors get larger and larger after nine lags and practically becomes explosive at eighteen lags.

The nine lags post-link, linkage A specification which has the lowest MSTE was selected for United States, Table 6.2A.18. This lag structure provides at least two better forecasts than the other close alternatives, six and twelve lags. The output prediction error is at its minimum at nine lags and it increases with longer lags. The money and price forecast errors fluctuate at alternative lags without showing a significant pattern. The interest rate forecasts are better at shorter lags than longer lags.

The nine lags post-link specification was selected again under the linkage mechanism B, Table 6.2B.18. The nine lags specification has the lowest MSTE and has at least two better forecasts than close alternatives. The output forecast can only be improved over the pre-link selection at nine lags. The money forecasts cannot be bettered over the pre-link at all lags. On the other hand, price and Interest rate prediction errors can be reduced drastically at all alternative lag structures.

The Summary of Model Selection Results

A summary of the model selection results for all the eighteen countries that are included in LINK-VAR are

UNITED STATES

TABLE 6.1.18

SELECTING THE BEST PRE-LINK(CLOSED-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures.

(1) Number of Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
1 TO 3	.03287	.01168	.02785	2.78100	.66970
1 TO 6	.03877	.01708	.02565	2.80500	.72723
1 TO 9 *	.02363	.01755	.01934	2.46700	.59575
1 TO 12	.03887	.02901	.01441	2.74500	.73880
1 TO 15	.13520	.03725	.03353	6.32100	1.57335
1 TO 18	.13331	.03449	.03683	8.46300	1.69516

* Selected pre-link(closed-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error, where the standardized error in each equation is calculated as the ratio of each root-mean-square error to the average root-mean-square error. (See equation (6.2)).

UNITED STATES

TABLE 6.2A.18

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: *Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links.* (Linkage Mechanism A)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected ' Pre-Link	.02363	.01755	.01934	2.46700	
1 TO 3	.02497	.02837	.01469	1.67000	1.00878
1 TO 6	.02127	.02734	.01293	1.40900	.89124
1 TO 9 *	.01702	.02967	.01178	1.43000	.85068
1 TO 12	.02193	.03222	.01091	1.43000	.90639
1 TO 15	.02575	.03198	.01463	1.55100	1.02756
1 TO 18	.02418	.02908	.01756	1.65900	1.05585
1 TO 21	.02924	.02830	.01679	1.86100	1.11807
1 TO 24	.03325	.03120	.01370	1.94600	1.14143

' Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

UNITED STATES

TABLE 6.2B.18

SELECTING THE BEST POST-LINK(OPEN-ECONOMY) SPECIFICATION: Twelve Months Ahead Forecast Errors of VAR Specification with Alternative Lag Structures for the International Links. (Linkage Mechanism B)

(1) Number of Link Lags	(2) Output	(3) Money	(4) Price	(5) Interest	(6) MSTE
Selected [1] Pre-Link	.02363	.01755	.01934	2.46700	
1 TO 3	.03688	.01825	.00551	.81180	.92062
1 TO 6	.02912	.01806	.00575	.81280	.88321
1 TO 9 *	.02039	.02339	.00520	.85680	.87571
1 TO 12	.02830	.02735	.00556	.85930	.98820
1 TO 15	.04511	.01796	.00409	.95110	.93353
1 TO 18	.04607	.01716	.00374	1.08500	.94777
1 TO 21	.06159	.02463	.00534	1.06300	1.20225
1 TO 24	.06021	.02641	.00519	1.22300	1.24871

[1] Selected pre-link(closed-economy) specification from Table 6.1

* Selected post-link(open-economy) specification.

Column (1) represents the number of lags of each variable in each equation.

Columns (2)-(5) are root-mean-square errors from post-sample forecasts, measured in the same units as the variables.

Column (6) represents the mean standardized total error as explained in Table 6.1.

reported in Table 6.3. From alternative pre-link specifications, the three lags was selected for ten countries, the six lags specification for five countries and the nine lag specification for three countries. This result indicates that relatively few lags are needed to specify national country models using the VAR technique.

It is less straight forward to interpret the post-link lag structures. Given the location and the degree of openness of each country in LINK-VAR, one would expect to observe the international influence at different lag structures. In some countries, the international economic fluctuations improves the forecasting performance at very short lags as in for instance Canada while in some others the link variables help forecasting at much longer lags as in for example, Netherlands. The post-link model selections are entirely based on forecasting performance therefore inferences about the exact timing of the transmission mechanism of international fluctuations can not be made easily. LINK-VAR is built exclusively as a forecasting model and it has to be evaluated in terms of its forecasting performance. The post-link results are also based on the specific lag structures that were imposed on each country model. The timing of the international influence on specific macroeconomic variables may vary considerably. Thus, experimenting with disproportianate lag structures or lag structures emphasizing the longer lags could provide the researcher with improved forecasts.

TABLE 6.3

SUMMARY OF THE MODEL SELECTION RESULTS

(1) Country	(2) Pre-Link Selection	(3) Post-Link A Selection	(4) Post-Link B Selection
1. Australia	1 to 6	1 to 15	1 to 12
2. Austria	1 to 3	1 to 3	1 to 9
3. Belgium	1 to 6	1 to 6	1 to 15
4. Canada	1 to 3	1 to 3	1 to 3
5. Denmark	1 to 3	1 to 6	1 to 9
6. Finland	1 to 3	1 to 24	1 to 3
7. France	1 to 3	1 to 6	1 to 21
8. Germany (West)	1 to 6	1 to 3	1 to 6
9. Ireland	1 to 9	1 to 3	1 to 6
10. Italy	1 to 6	1 to 6	1 to 15
11. Japan	1 to 6	1 to 18	1 to 6
12. Netherlands	1 to 3	1 to 24	1 to 24
13. Norway	1 to 3	1 to 3	1 to 3
14. Spain	1 to 3	1 to 3	1 to 3
15. Sweden	1 to 3	1 to 3	1 to 12
16. Switzerland	1 to 3	1 to 12	1 to 3
17. United Kingdom	1 to 9	1 to 24	1 to 21
18. United States	1 to 9	1 to 9	1 to 9

In this chapter the estimation results from the pre-link and post-link modes of the model LINK-VAR was presented. In the next chapter, the focus will be on the statistical and the visual comparison of the forecasts from closed-economy specification with the open-economy specifications.

CHAPTER VII

INTERPRETATION OF RESULTS

Introduction

In the previous chapter, the methodology of model selection was presented and individual country model selections were reported for both pre-link and post-link specifications of the LINK-VAR model. In this chapter a detailed evaluation of the forecast performance of these selected specifications will be offered. The forecast comparison of the pre-link and two post-link specifications will be made by considering each country separately. An overall evaluation of the proposed LINK-VAR model will be presented in the next chapter.

The standard practice for VAR studies is, to present only results of forecasting experiments or impulse responses and variance decompositions, depending on the purpose of the study. The coefficient estimates of individual equations are usually not reported. There is a very valid reason for this exclusion. As Sims (1980a, p.20) suggested, unlike structural econometric models, "autoregressive systems .... are difficult to describe succinctly [and] it is especially difficult to make sense of them by examining the coefficients in the regression equations themselves". His point is based on the fact that the equations in the VAR system do not represent a structure, thus the individual coefficient estimates do not have any economic meaning. Following this standard practice, only the forecast evaluations are reported below, without presenting coefficient estimates, and their related statistics.

This chapter is organized in two sections: The first section discusses the forecast evaluation criteria utilized in this study. The second and the last section presents the forecast performance of the LINK-VAR model.

The Criteria for Forecast Evaluation[1]

The model selections of CHAPTER VI were generally based on the Root-Mean-Square-Error (RMSE) and the Mean Standard Total Error (MSTE) criterion. In comparing the forecasts from the pre-link selection versus the forecasts from the two post-link selections some additional criteria were used. The forecasting performance was evaluated based on the following criteria; (1) Mean Error; (2) Mean Absolute Error; (3) Root-Mean-Square-Error; (4) Theil's Inequality Coefficient; (5) The decomposition of Theil's Inequality coeffi-

---

[1] Undoubtedly there is a multitude of forecast evaluation criteria one can consider. The criteria used here are outlined in Pindyck and Rubinfeld (1981), p.360-367.

cient in terms of bias, variation, and co-variation; and (6) A visual comparison emphasizing how well the turning points can be forecasted. These criteria and their implications for forecast evaluation are presented below.

The Mean Error (ME) can be represented by:

$$ME = 1 / T \left(\sum_{t=1}^{T} (Y^f_t - Y^a_t) \right) \qquad (7.1)$$

ME is simply the average of the total deviations of forecasted values from the actual values. The problem in interpreting ME is that at times it may be close to zero although the forecast errors are large (if large positive errors cancel out large negative errors). To avoid this problem the common practice is to look at the next criterion, the Mean Absolute Error (MAE). MAE can be represented as:

$$MAE = 1 / T \sum_{t=1}^{T} | Y^f_t - Y^a_t | \qquad (7.2)$$

MAE is the mean of the absolute value of the forecast errors. It is therefore, useful to report both ME and MAE and check whether they are equal in magnitude. If they are, this would indicate a systematic under or over shooting of the forecasted values.

The next criterion, RMSE is a more popular forecast evaluation statistic than MAE since it penalizes large individual errors more heavily than the MAE. The formula for RMSE is:

$$RMSE = 1 / T \sum_{t=1}^{T} (Y^f_t - Y^a_t)^2 \qquad (7.3)$$

Another useful statistic which is related to the RMSE is the Theil's Inequality coefficient or simply Theil's U coefficient which can be defined as:

$$U = \frac{\sqrt{\left[1 / T \sum_{t=1}^{T} (Y^f_t - Y^a_t)^2 \right]}}{\sqrt{\left[1 / T \sum_{t=1}^{T} (Y^f_t)^2 \right]} + \sqrt{\left[1 / T \sum_{t=1}^{T} (Y^a_t)^2 \right]}} \qquad (7.4)$$

where the numerator is simply the RMSE. The Theil-U coefficient always falls between 0 and 1 due to the scaling of the denominator. If the forecasts are perfectly accurate ($Y^f_t = Y^a_t$), U will equal to 0. If the forecasts are always 0 when the actual values are non-zero (or vice versa), U will equal to one. U will be one also if, the forecasted values are positive (negative) when actual values are negative (positive).

Finally, the Theil-U coefficient can be decomposed into three parts representing the proportions of inequality as bias proportion, variance proportion, and co-variance proportion.[a] This decomposition is very useful in breaking the forecast error into its characteristic sources as the three components sum up to 1. The bias proportion measures the systematic error, the variance proportion measures the forecasts ability to duplicate the variability in the actual values, and the co-variance proportion measures the unsystematic error. In terms of forecast performance, the relatively more worrisome components are bias and variance and for any value of U > 0, the most desirable distribution of the error proportions is the bias and the variance components to be zero and the covariance component to be one.

Small forecast errors are only one desirable measure of forecast accuracy. Another important criterion is how well a forecasting model can predict the 'turning points' in the forecast period. A forecast with a relatively high, for instance, RMSE compared with a competing forecast with a relatively low RMSE could be more desirable if the former could predict the downturns or upswings better than the latter. Therefore, the ability to reproduce turning points or

---

[a] See Pindyck and Rubinfeld (1981), p.365 for a mathematical exposition of how Theil-U coefficient can be decomposed into three parts.

fast changes in the actual data is a very significant criterion for forecast evaluation. This criterion requires a visual comparison of the forecasts from competing models.

The Forecast Performance of LINK-VAR

Using this multitude of forecast evaluation criteria the forecast performance of pre-link and post-link specifications were evaluated for the forecast period 1984:07-1985:06. The evaluation at times was difficult, when mixed results were obtained from the prediction assesment criteria. At these instances a certain amount of judgement was necessary to decide on which forecast to choose. The summary statistics for the ex-post forecast evaluation are reported in individual country Tables 7.1 and 7.2. A visual comparison of forecasts from pre-link and two post-link specifications against the actuals are provided in individual country Exhibits 7.1, 7.2, 7.3 and 7.4.

Australia

The comparison of pre-link and post-link forecast performance for Australia are reported in Tables 7.1.1, 7.1.2 and Exhibits 7.1.1, 7.2.1, 7.3.1, and 7.4.1.

Forecasts for the output variable are generally good from all three specifications. Both post-link selections

AUSTRALIA

TABLE 7.1.1

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0012	.0033	-.0002	.0049	.0014	.0044
Mean Absolute Error	.0106	.0097	.0100	.0134	.0135	.0122
Root-Mean-Sq. Error	.0135	.0130	.0112	.0155	.0156	.0156
Theil's Ineq. Coeff.	.0015	.0014	.0012	.0008	.0008	.0008
Fraction of Error due to a)Bias	.0083	.0625	.0004	.1001	.0079	.0791
b)Diff. Var.	.0724	.0162	.2123	.0121	.0058	.1638
c)Diff. Co-var	.9193	.9213	.7874	.8878	.9863	.7570

AUSTRALIA

TABLE 7.2.1

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0154	-.0062	-.0063	.3616	-.8087	-.3308
Mean Absolute Error	.0154	.0063	.0067	1.2840	1.3910	1.5880
Root-Mean-Sq. Error	.0186	.0076	.0080	1.4510	1.7660	1.7890
Theil's Ineq. Coeff.	.0019	.0008	.0008	.0543	.0633	.0653
Fraction of Error due to a)Bias	.6843	.6689	.6259	.0622	.2057	.0342
b)Diff. Var.	.3133	.3037	.3572	.8149	.4898	.7208
c)Diff. Co-var	.0023	.0274	.0169	.1229	.3005	.2450

EXHIBIT (7.1.1) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (AUSTRALIA)

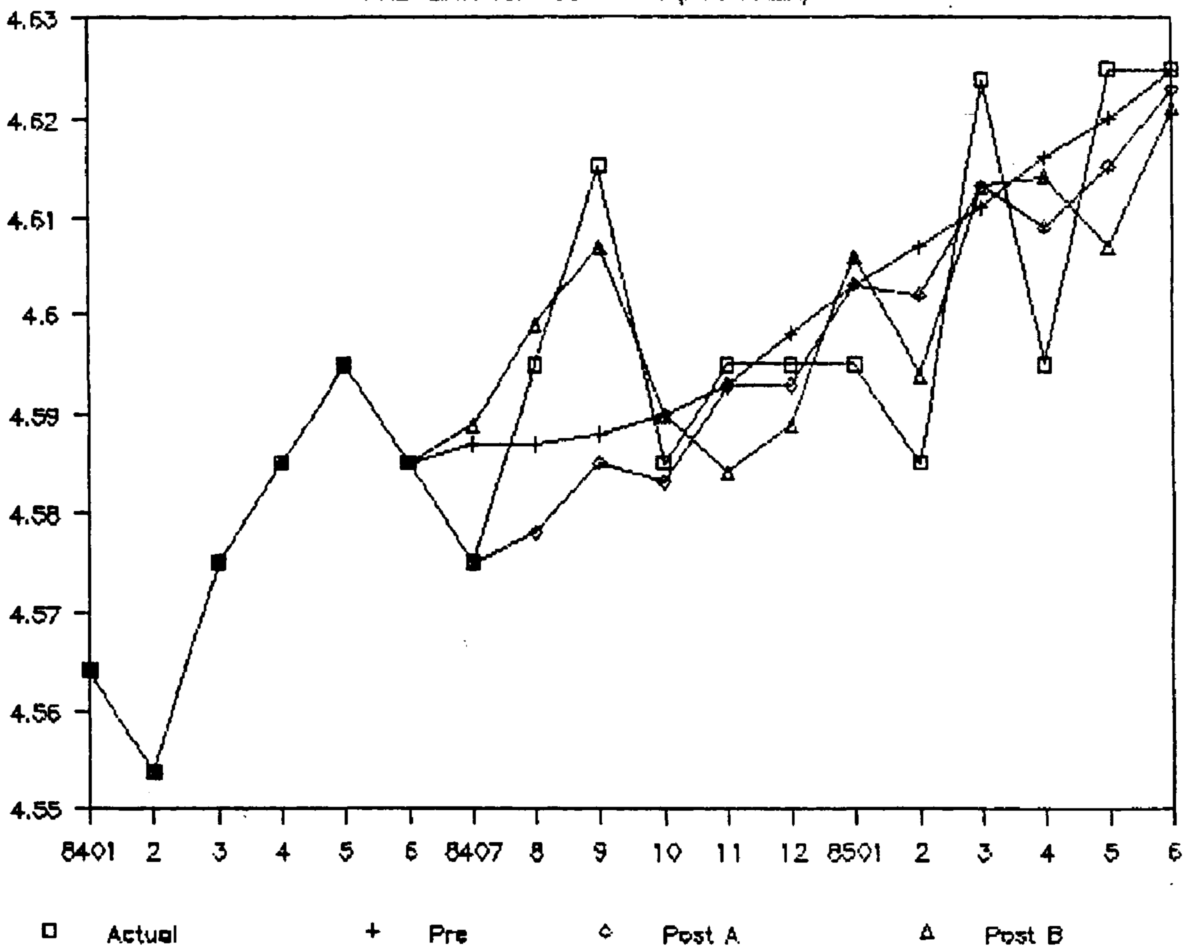
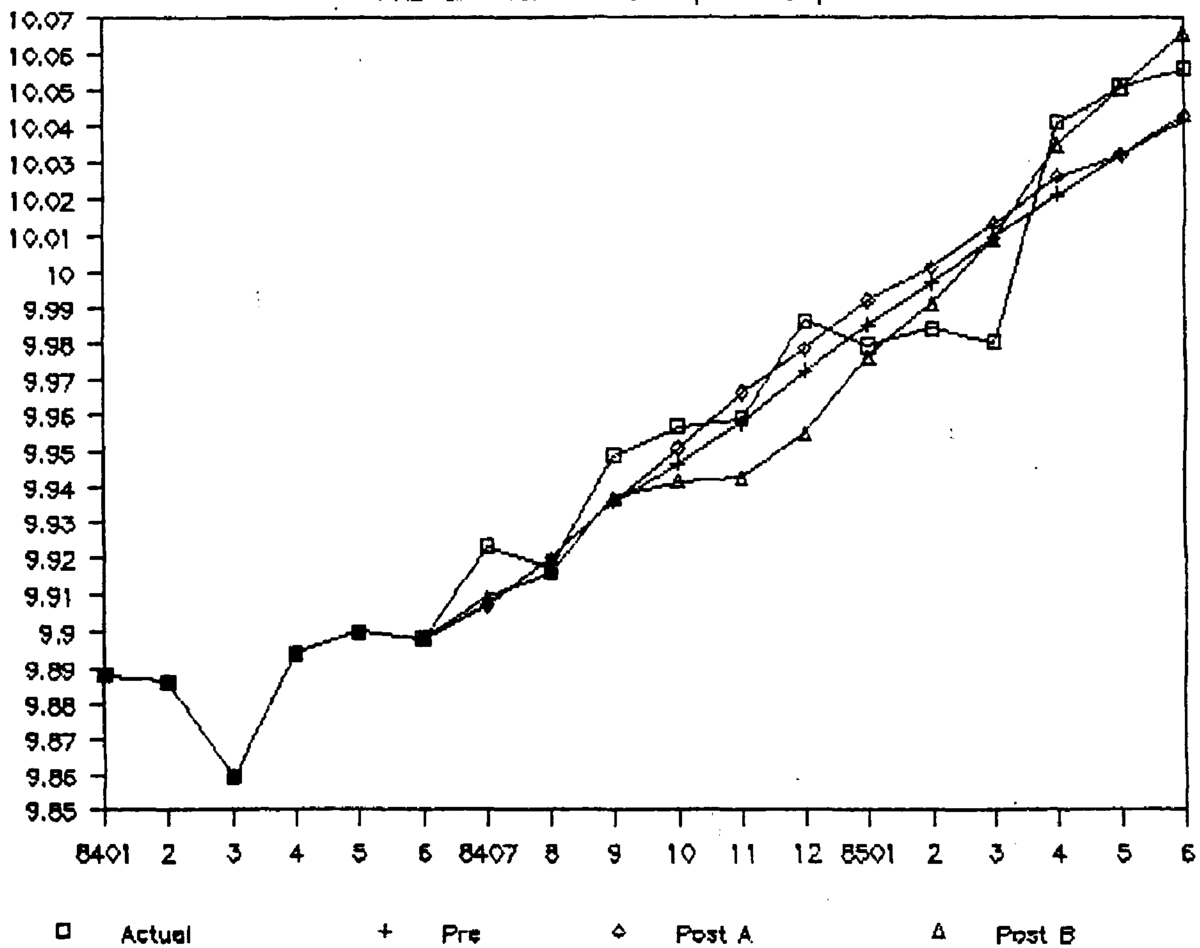


EXHIBIT (7.2.1) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (AUSTRALIA)



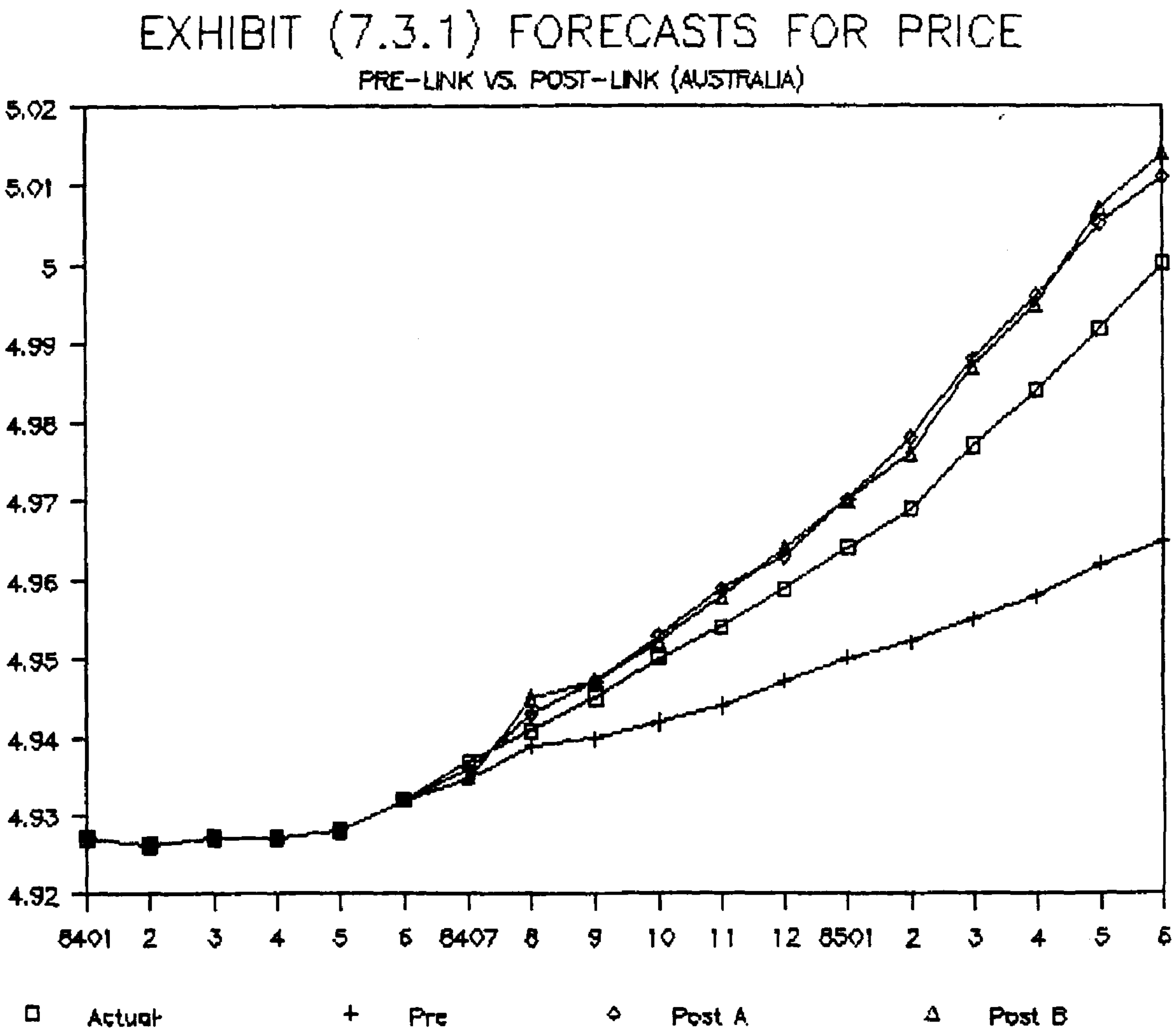
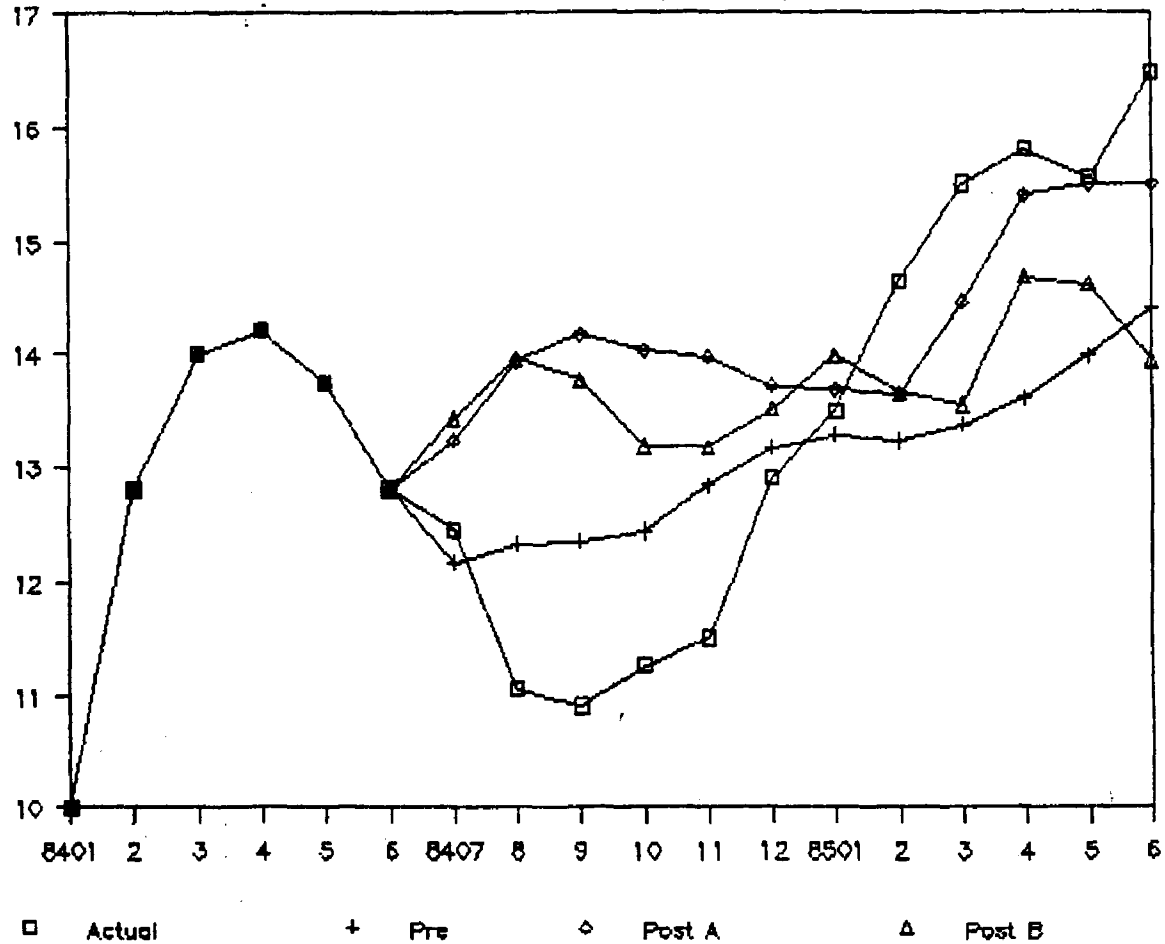


EXHIBIT (7.3.1) FORECASTS FOR PRICE
PRE-LINK VS. POST-LINK (AUSTRALIA)
5.02
5.01
5
4.99
4.98
4.97
4.96
4.95
4.94
4.93
4.92
8401
2
3
4
5
6
8407
8
9
10
11
12
8501
2
3
4
5
6
Actual
Pre
Post A
Post B

EXHIBIT (7.4.1) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (AUSTRALIA)



show some improvement over the pre-link selection. The improvement is more significant under the linkage mechanism B. The post-link forecasts can generate the variation in the actual data better than the pre-link forecast.

Money is also forecasted very well by all three specifications. The summary statistics indicate very close forecast errors. By including the link variables, the forecasts are neither improved nor made worse.

The post-link specifications generate relatively better forecasts of price than the pre-link specification. The pre-link forecasts systematically underpredict and both post-link forecasts systematically overpredict the actual price data. The magnitude of the errors of pre-link forecast is however, more than twice the errors of the post-link forecasts. A comparison between the post-link A forecast and post-link B forecast indicate that they are almost the same.

The interest rate predictions indicate that pre-link forecast have relatively lower forecast errors than both post-link forecasts. On the other hand the decomposition of the Theil-U coefficient as well as, the visual comparison indicate that pre-link forecast is not superior to both post-link forecasts. Both post-link A and post-link B predictions overshoot the actual values in the first six months but after that they do reasonably well. The pre-link forecast although more accurate within the first six months, can not pick up the variation in the actual interest rate values as well as both post-link forecasts (specifically in the last six months). Therefore, all three forecasts could be considered equally accurate.

Out of the four variables that constitutes the model for Australia output and price forecasts can be improved without losing anything from the forecasts of money and interest rate. This outcome indicates that the forecast performance from the Australian model can be improved when the international influence is accounted for.

Austria

The comparison of pre-link versus post-link forecast performance for Austria are reported in Tables 7.1.2, 7.2.2 and Exhibits 7.1.2, 7.2.2, 7.3.2, and 7.4.2.

The best output forecast for Austria is the one generated by the post-link A, specification. Post-link A prediction has the lowest forecast errors and also reproduces the movements in the actual data better than the pre-link forecast. Post-link B, is the second best forecast showing a marginal improvement over the pre-link forecast.

The money variable is forecasted better by both post-link specifications than the pre-link specification. In fact the pre-link forecast misses the mark for the entire period. The best forecast is provided by the post-link B specification which has almost one third of the forecast errors of

AUSTRIA

TABLE 7.1.2

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0159	-.0047	.0210	-.0682	-.0291	-.0142
Mean Absolute Error	.0254	.0202	.0231	.0682	.0292	.0222
Root-Mean-Sq. Error	.0298	.0226	.0288	.0703	.0362	.0260
Theil's Ineq. Coeff.	.0032	.0024	.0031	.0066	.0034	.0024
Fraction of Error due to a)Bias	.2852	.0425	.5302	.9415	.6451	.2970
b)Diff. Var.	.0134	.5296	.3944	.0032	.1455	.2040
c)Diff. Co-var	.7013	.4279	.0753	.0553	.2095	.4990

AUSTRIA

TABLE 7.2.2

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0123	.0064	.0085	.2478	.2759	.5489
Mean Absolute Error	.0123	.0074	.0087	.2478	.2759	.5489
Root-Mean-Sq. Error	.0136	.0097	.0096	.2641	.3095	.6063
Theil's Ineq. Coeff.	.0014	.0010	.0010	.0170	.0199	.0397
Fraction of Error due to a)Bias	.8188	.4406	.7844	.8799	.7947	.8196
b)Diff. Var.	.1167	.5162	.1026	.0152	.0790	.1108
c)Diff. Co-var	.0646	.0432	.1130	.1049	.1263	.0697

EXHIBIT (7.1.2) FORECASTS FOR OUTPUT

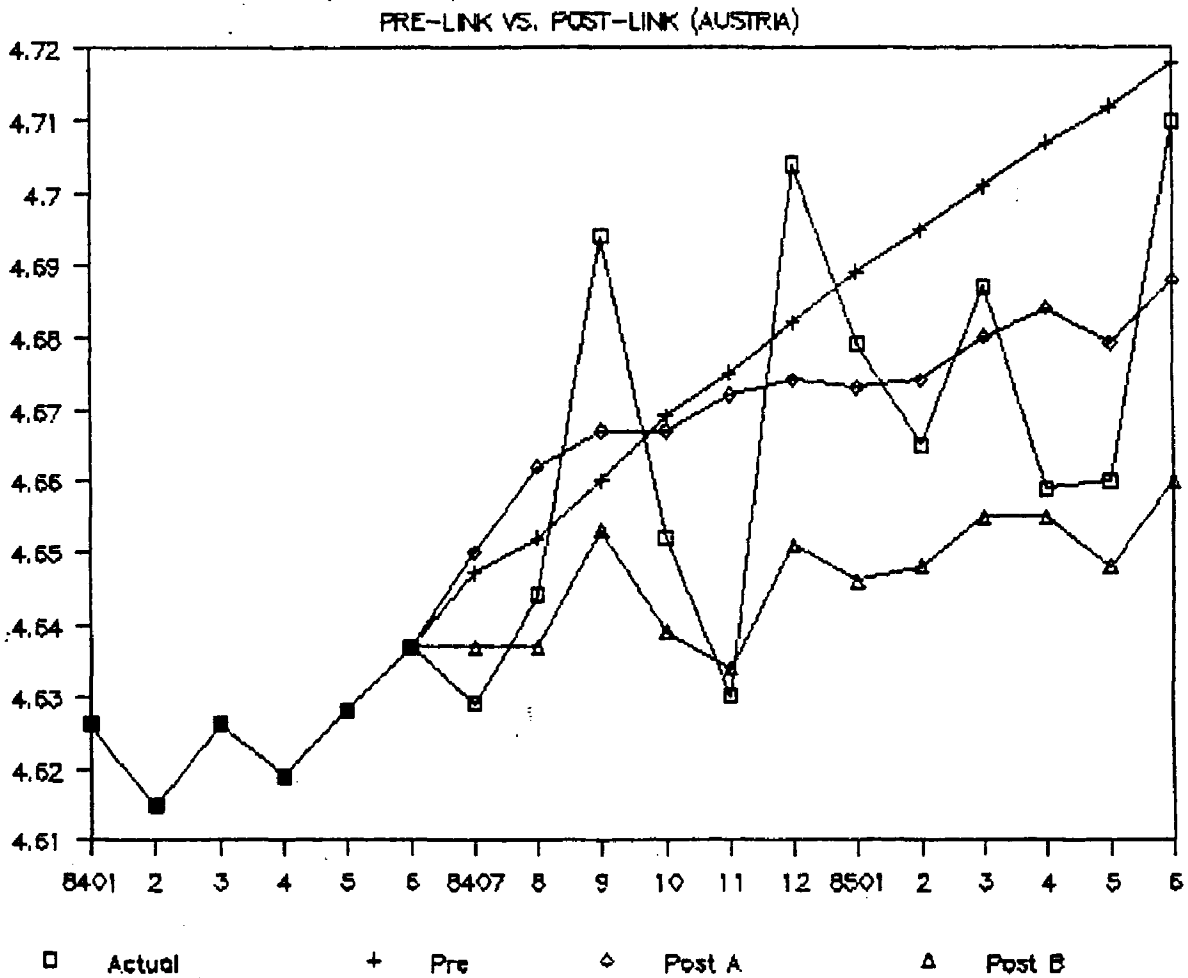


EXHIBIT (7.2.2) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (AUSTRIA)

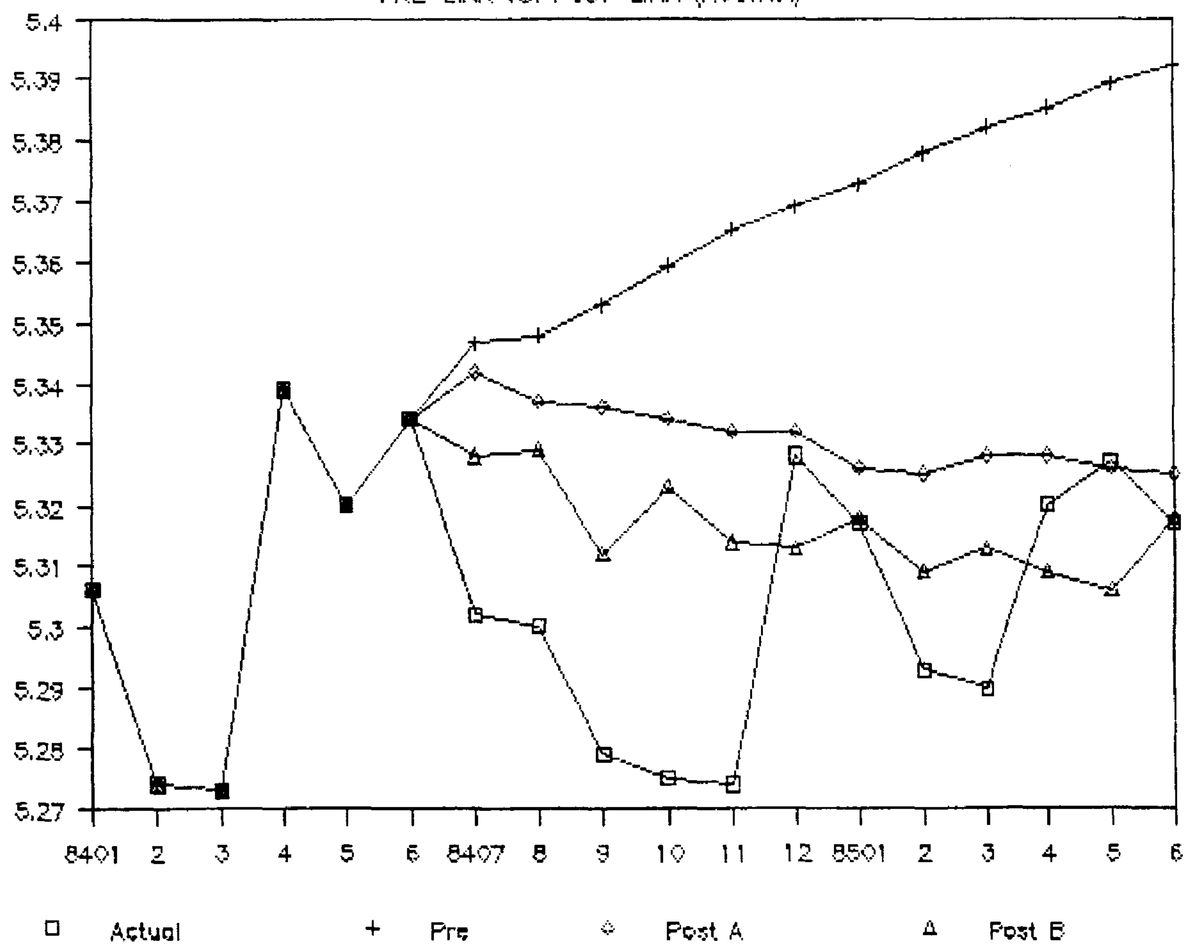


EXHIBIT (7.3.2) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (AUSTRIA)

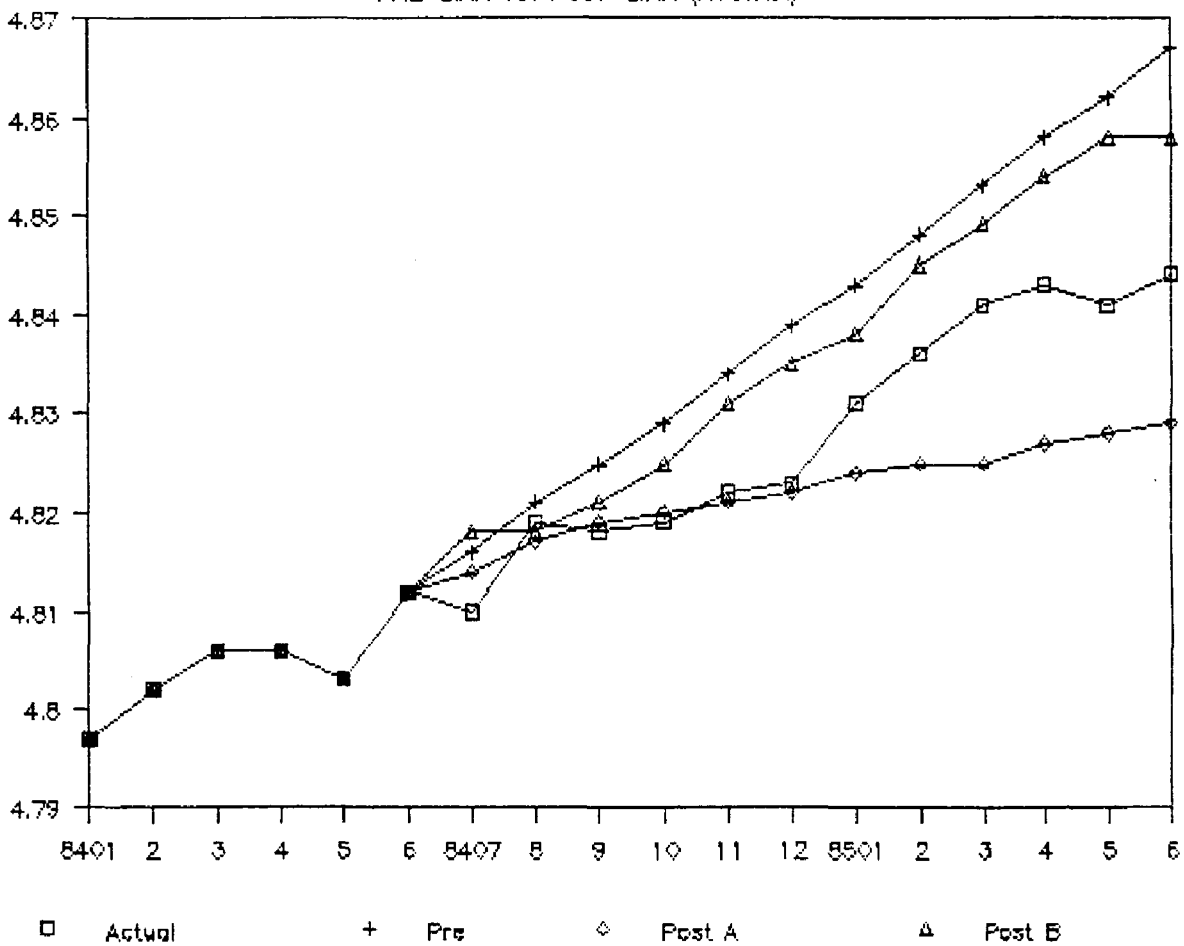
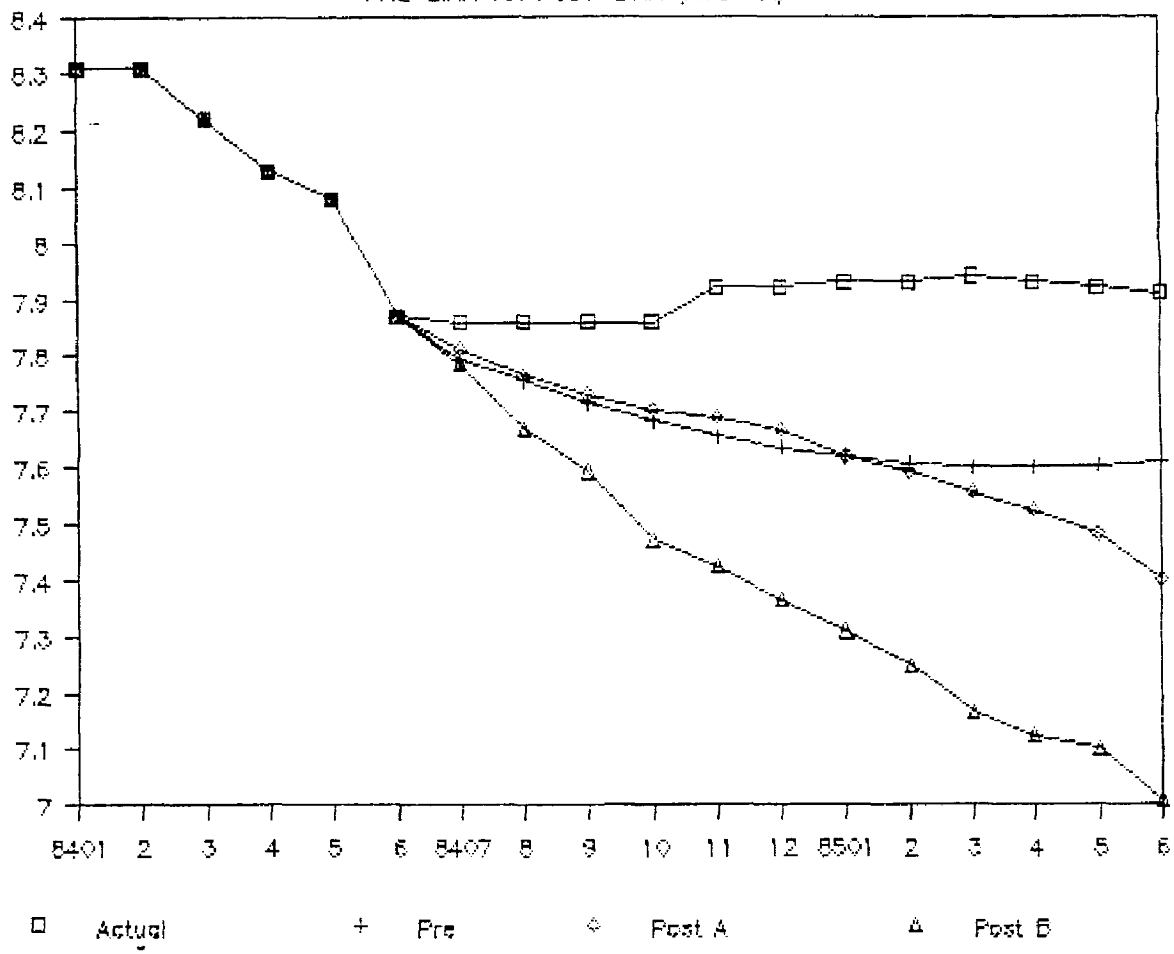


EXHIBIT (7.4.2) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (AUSTRIA)



the pre-link selection. The improvement over the pre-link forecasts in both post-link cases is considerable.

The price variable is again forecasted better with the post-link specifications. The pre-link forecasts overshoot the actual values for the entire period. This is true for the last ten months for the post-link B forecasts as well. However, the magnitude of the forecast errors for the post-link B, specification is lower for the entire forecast period. The post-link A forecasts are right on the mark for the first six months and the last six months are underpredicted. The post-link B prediction has a slight edge over the post-link A prediction.

The pre-link forecast of the interest rate is marginally better than post-link A forecast and much better than the post-link B forecast. The interest rate values for the entire period remained fairly constant and all three forecasts underpredicted the interest rate for the entire period. The forecasts of post-link A is slightly closer to the actual than the pre-link forecasts for the first eight months. The summary statistics indicate that the magnitude of the errors were fairly small for all the forecasts. This is also seen from the comparison of the actual magnitudes and forecasted magnitudes. For instance, the actual value for the interest rate at 1985:06 (where the distance between the actual and the forecasted values is the maximum) is 7.91, the pre-link forecast is 7.61 and the post-link A forecast is 7.40, indicating how accurate the forecasts really are.

The results for Austria indicate that output, money and price forecasts can be improved significantly by both post-link specifications. Only the interest rate forecast is not improved over the pre-link selection. As a result, by taking the international influence into account one can substantially improve the forecast accuracy of the pre-link (closed-economy) model.

Belgium

The forecast comparison of the pre-link and post-link specifications for Belgium are presented in Tables 7.1.3, 7.2.3 and Exhibits 7.1.3, 7.2.3, 7.3.3 and 7.4.3.

All three specifications forecast the output fairly well. The post-link forecasts show some improvement over the pre-link forecast. In terms of the summary statistics post-link A has the lowest errors, however post-link B, has the least bias and can reproduce the movements in the actual output better than the others.

Post-link A forecast of money is again the best forecast. Excluding the erratic increase in the last three months in the actual money, both pre and post link forecasts overpredict. However, the forecast errors are smaller in both post-link forecasts than the pre-link forecast.

BELGIUM

TABLE 7.1.3

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0227	.0128	.0214	-.0160	-.0019	-.0115
Mean Absolute Error	.0246	.0198	.0214	.0177	.0117	.0138
Root-Mean-Sq. Error	.0326	.0241	.0248	.0199	.0149	.0180
Theil's Ineq. Coeff.	.0035	.0026	.0027	.0014	.0011	.0013
Fraction of Error due to a)Bias	.4826	.2821	.1304	.6480	.0165	.4116
b)Diff. Var.	.4062	.4732	.3049	.0585	.6662	.0162
c)Diff. Co-var	.1112	.2446	.5647	.2935	.3173	.5722

BELGIUM

TABLE 7.2.3

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0004	.0274	-.0194	-.9407	.0297	-.6028
Mean Absolute Error	.0029	.0274	.0194	.9407	.5017	.9660
Root-Mean-Sq. Error	.0035	.0327	.0219	1.2000	.5802	1.1580
Theil's Ineq. Coeff.	.0004	.0033	.0022	.0545	.0275	.0534
Fraction of Error due to a)Bias	.7026	.6150	.7840	.6150	.0026	.2708
b)Diff. Var.	.1768	.1150	.1981	.1150	.4279	.0112
c)Diff. Co-var	.1206	.2700	.0179	.2700	.5695	.7180

EXHIBIT (7.1.3) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (BELGIUM)

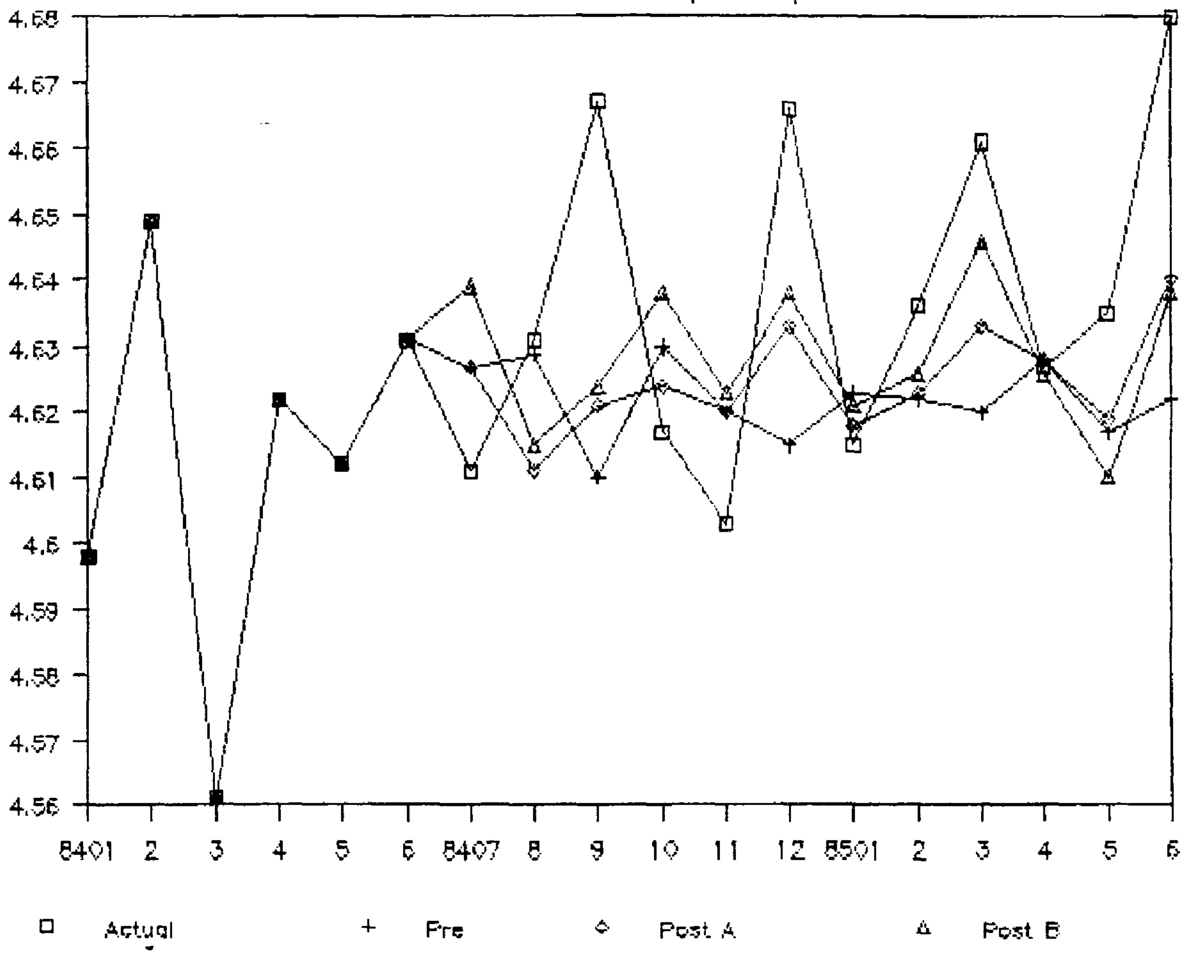


EXHIBIT (7.2.3) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (BELGIUM)

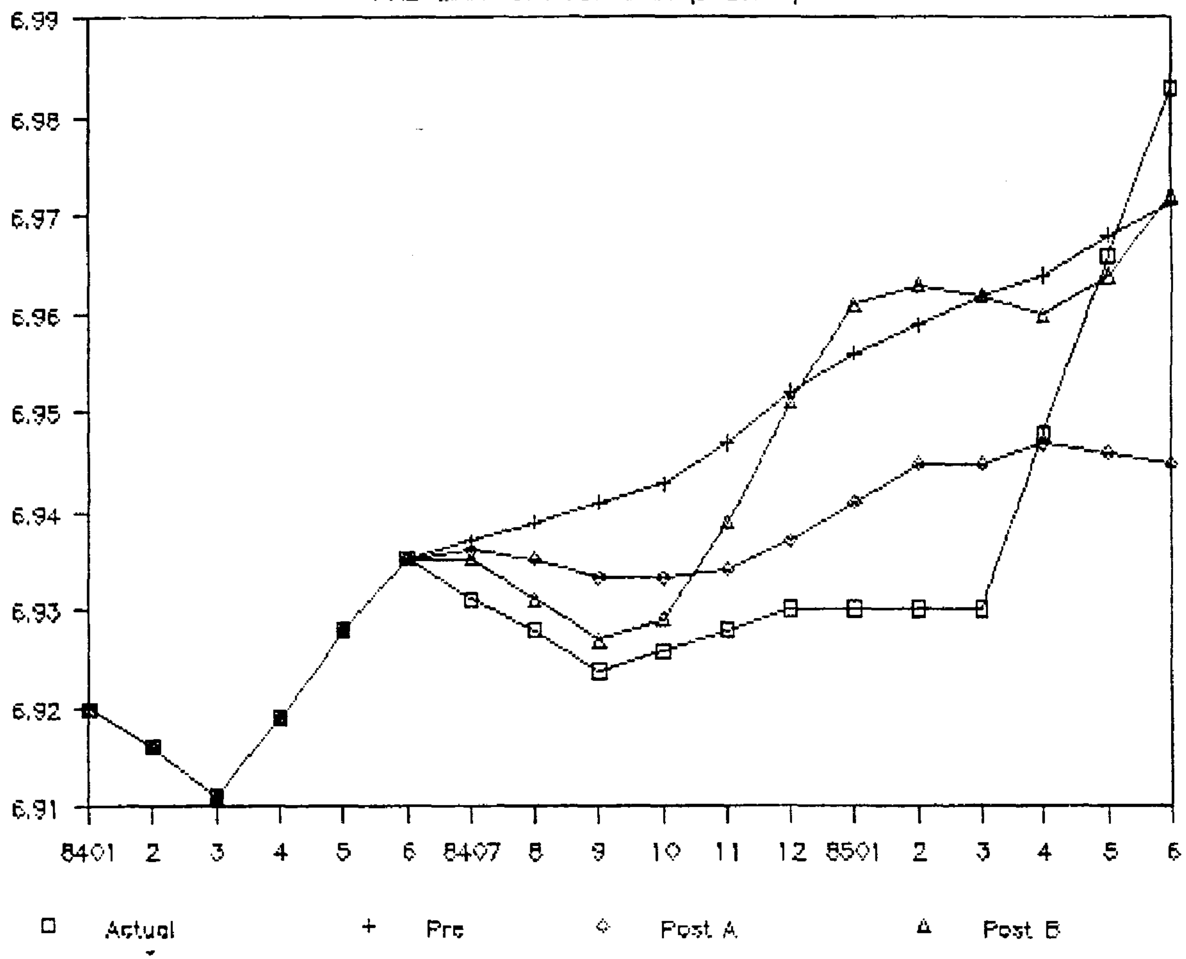


EXHIBIT (7.3.3) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (BELGIUM)

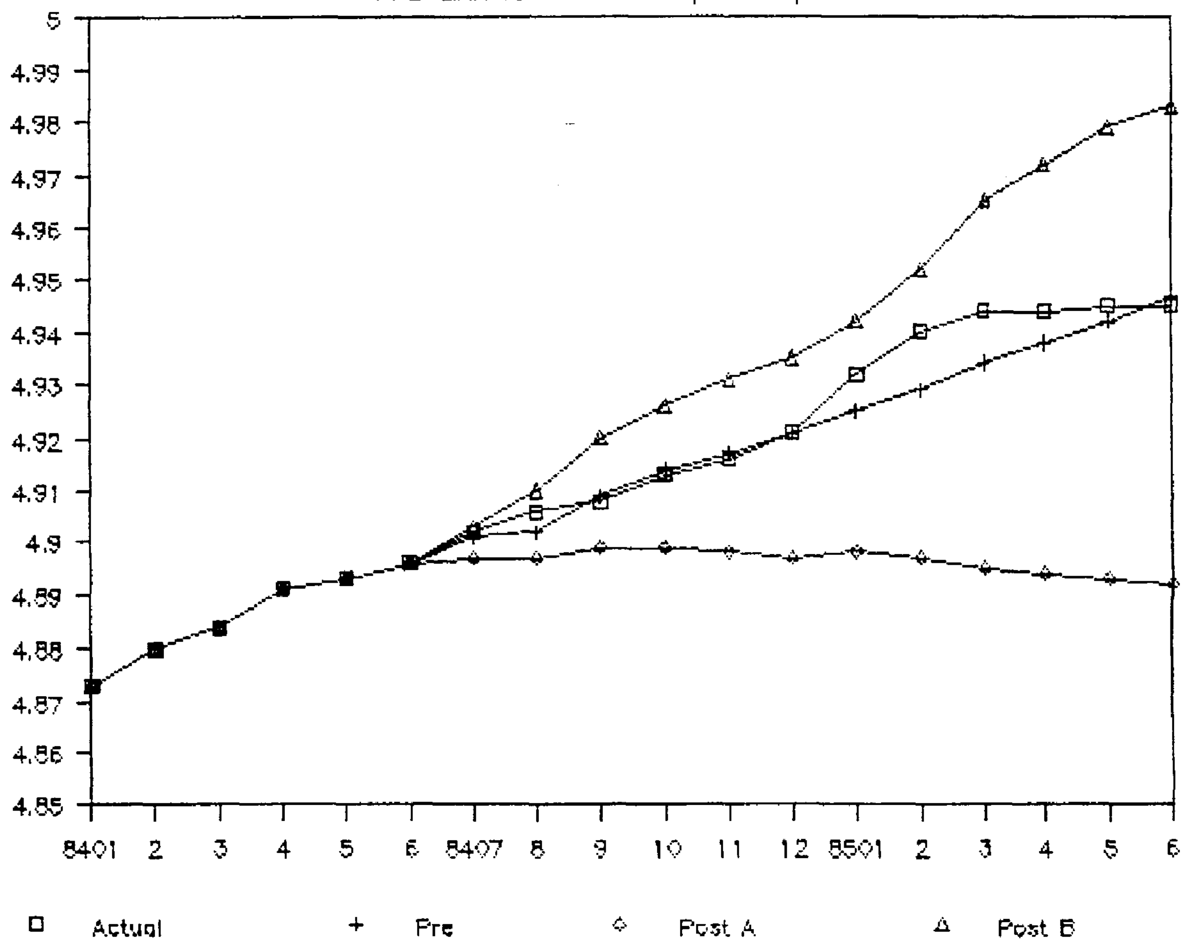
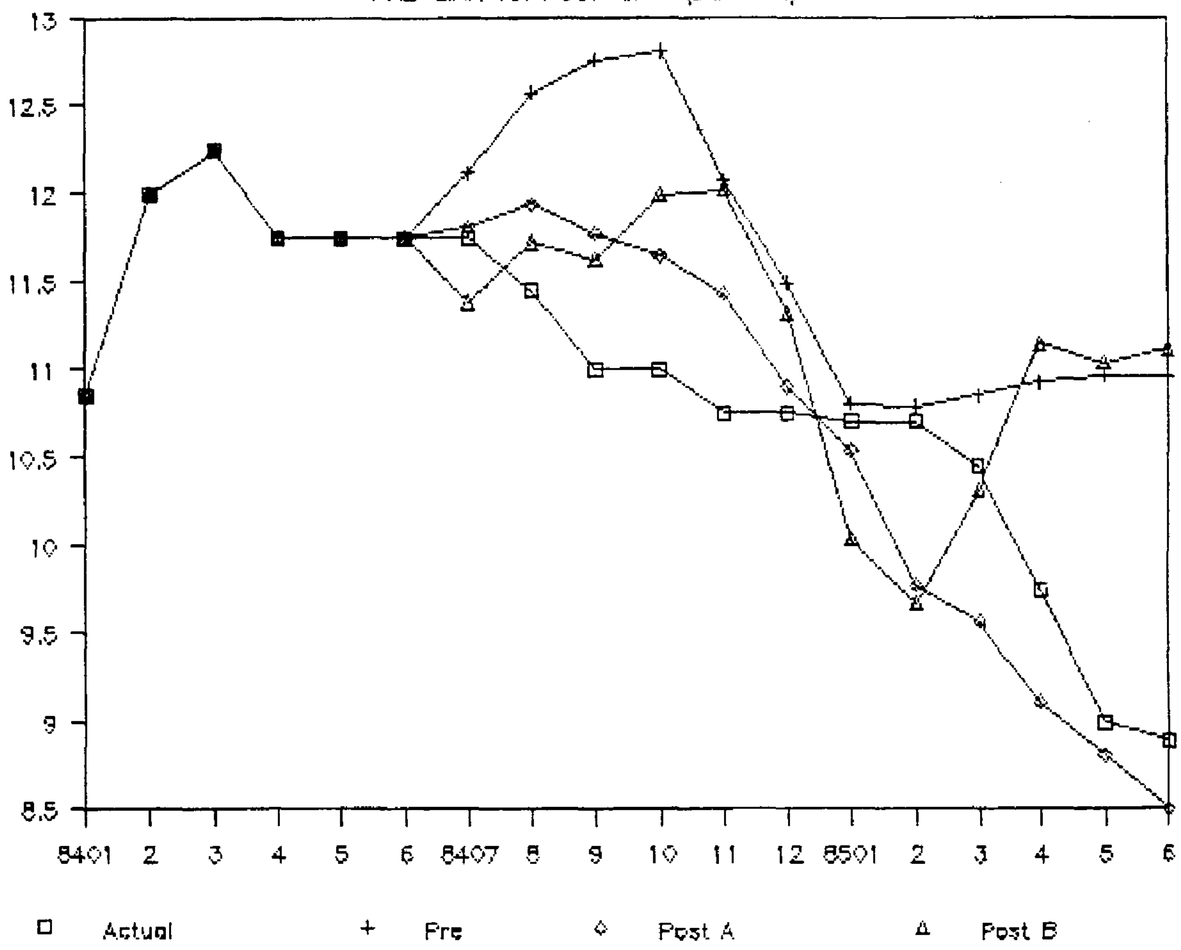


EXHIBIT (7.4.3) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (BELGIUM)



The price variable is forecasted very well by the pre-link selection and the addition of the link variables does not help at all. Post-link A forecast explodes in the downward direction and the post-link B forecast explodes in the upward direction.

Post-link A forecasts for the interest rate is far superior over both post-link B and pre-link specifications. This result can be seen both statistically (where post-link A, has the lowest errors) and graphically (where post-link A replicates the actual movement in the interest rates over the twelve month horizon.

Under both link mechanism forecasts of three variables are improved, output, money, and interest rate, indicating the significance of international fluctuations on the forecast performance.

<u>Canada</u>

The comparison of pre-link versus post-link forecast performance for Canada are reported in Tables 7.1.4, 7.2.4. and Exhibits 7.1.4, 7.2.4, 7.3.4 and 7.4.4.

Both post-link forecasts for output are better than the pre-link forecast for the entire twelve months period. The post-link B, specification generates the most accurate prediction. Both post-link forecasts are much less biased and the forecast errors can be attributed almost entirely to the

CANADA

TABLE 7.1.4.

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0220	-.0061	.0031	-.0193	-.0108	-.0308
Mean Absolute Error	.0267	.0153	.0096	.0193	.0115	.0308
Root-Mean-Sq. Error	.0291	.0172	.0119	.0221	.0143	.0347
Theil's Ineq. Coeff.	.0031	.0018	.0013	.0033	.0021	.0051
Fraction of Error due to a)Bias	.5703	.1265	.0666	.7631	.5664	.7892
b)Diff. Var.	.1371	.1822	.0001	.0339	.0385	.0982
c)Diff. Co-var	.2926	.6913	.9333	.2030	.3951	.1126

CANADA

TABLE 7.2.4

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0187	-.0066	-.0248	-.4800	1.6130	-.0593
Mean Absolute Error	.0187	.0068	.0248	.9050	1.6130	.6801
Root-Mean-Sq. Error	.0207	.0073	.0273	1.0560	1.7730	.7607
Theil's Ineq. Coeff.	.0021	.0007	.0028	.0481	.0888	.0353
Fraction of Error due to a)Bias	.8139	.8265	.8259	.2068	.8280	.0061
b)Diff. Var.	.1704	.0293	.1622	.5154	.0475	.6033
c)Diff. Co-var	.0157	.1442	.0120	.2779	.1245	.3906

EXHIBIT (7.1.4) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (CANADA)

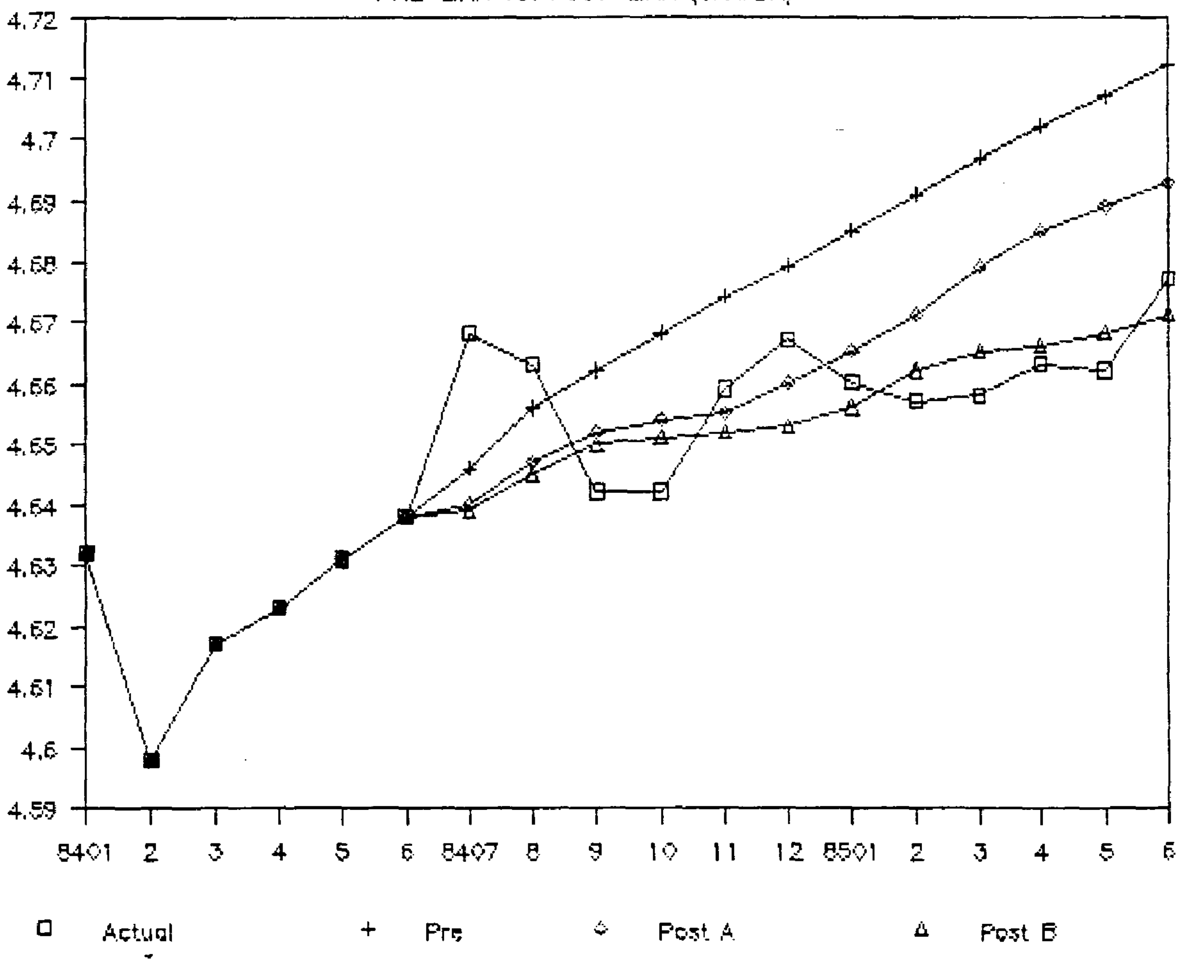


EXHIBIT (7.2.4) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (CANADA)

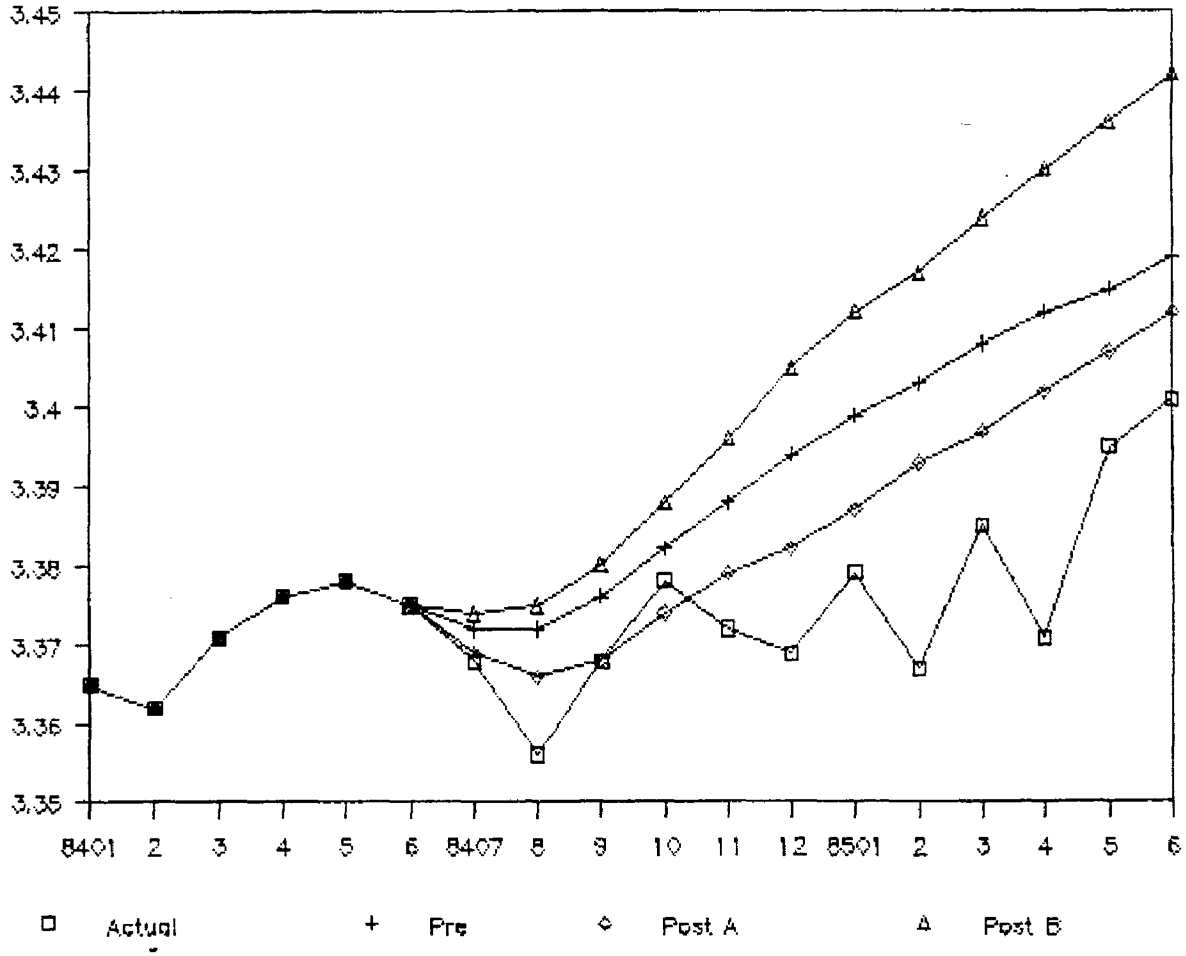


EXHIBIT (7.3.4) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (CANADA)

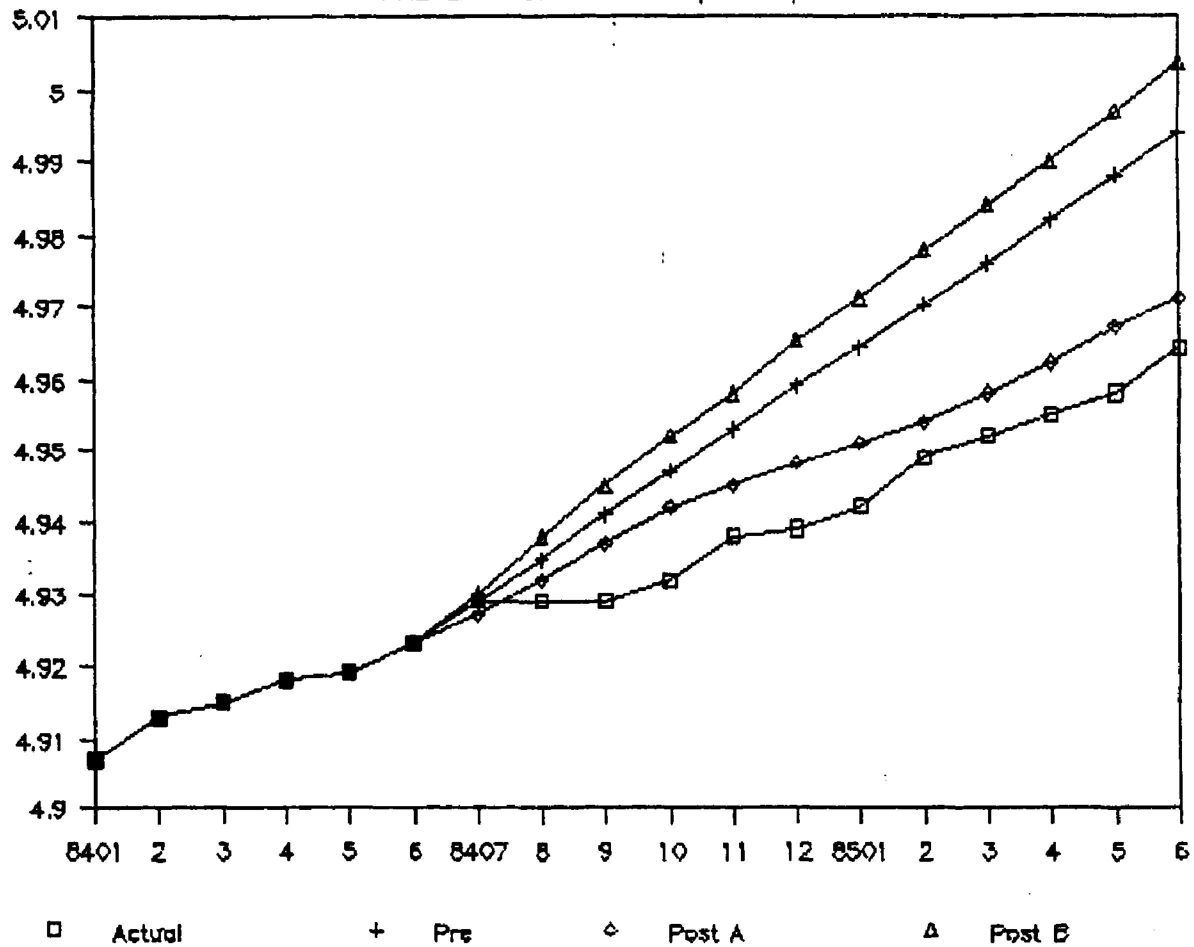
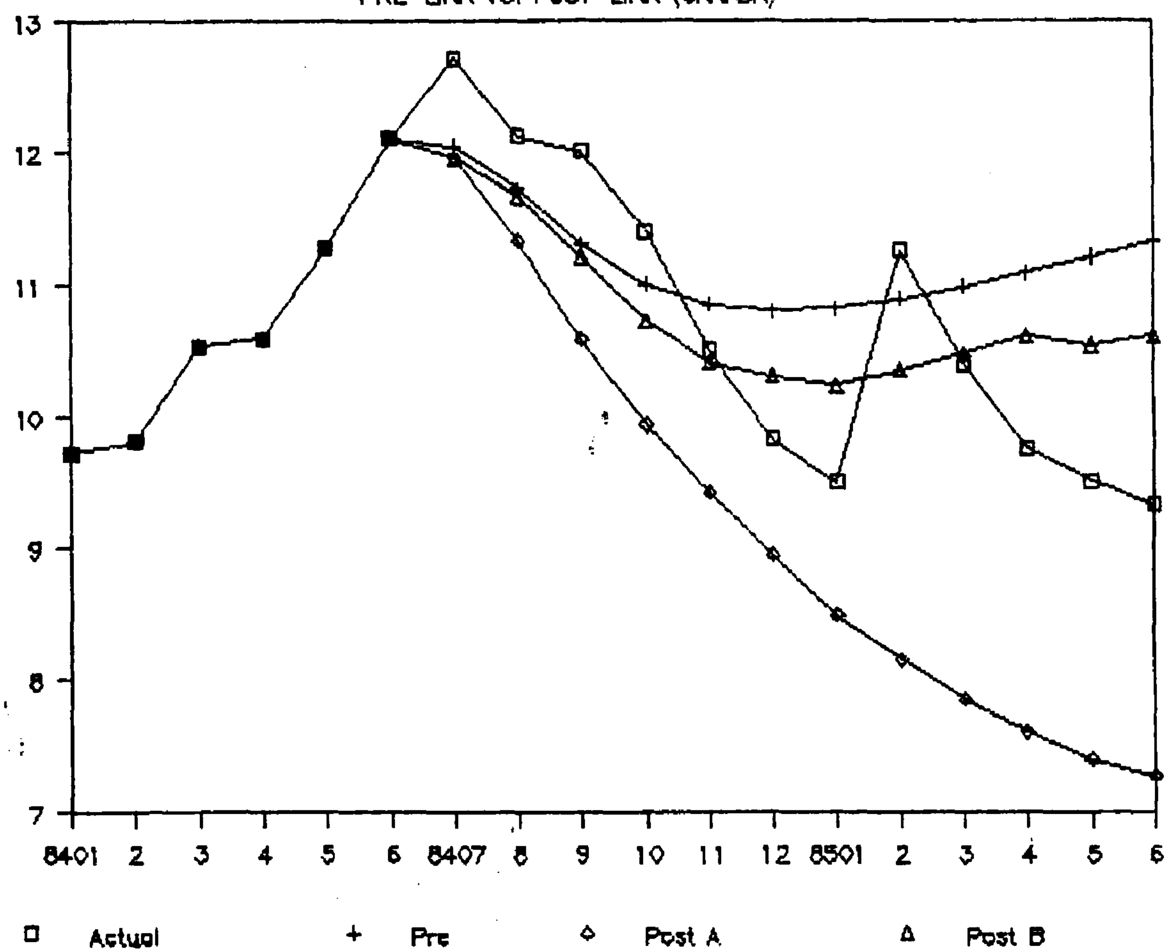


EXHIBIT (7.4.4) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (CANADA)



co-variance proportion of inequality.

All three forecasts of money overpredicted the actual values for the entire forecast period. The forecast with the lowest errors is the post-link A forecast, which also has the lowest bias among the three. The monthly fluctuations in the actual money variable are completely missed by all three predictions. The post-link B forecast is the worst among the three.

The price forecasts present a similar picture, where once again all three forecasts overpredicted the actual values, while post-link A forecast has the lowest prediction errors. The bias component in all three forecasts are almost the same, while the post-link A forecast has the lowest variance proportion. The post-link B, forecast is again the worse of the three.

The interest rate in Canada is forecasted fairly well except for the eighth month. Although the post-link A forecast has the highest forecast errors with the highest bias proportion, it seems to be the only forecast that picked up the movement in the actual values better than the competing alternatives, except for the blip in the eighth month. Both the pre-link and post-link B forecasts missed the mark after the eighth month and predicted an upswing, when the actual values were decreasing. Among the two inferior forecasts, post-link B has an edge over the pre-link, in terms of the magnitude of forecast errors.

The results for Canada indicate that post-link A, can improve the forecasts of all four variables over the pre-link selection showing the significance of the international links. On the other hand post-link B generates mixed results, improving two, output and interest rate, and making the other two worse.

Denmark

The forecast comparison of the pre-link and post-link selections for Denmark are presented in Tables 7.1.5, 7.2.5 and Exhibits 7.1.5, 7.2.5, 7.3.5, and 7.4.5.

The output variable is forecasted the best by the pre-link selection for the first six months of the forecast horizon. The second six months are forecasted relatively better by the two post-link specifications. The post-link B, forecast has a slight edge over both pre-link and post-link A forecasts especially in the latter six months period. The downturn in the seventh and ninth months couldn't be fore-seen by all three predictions.

The best money forecast is provided by the post-link A selection. The pre-link and post-link B forecasts can only compete for the first five months of the horizon. After the fifth month the post-link A forecast almost duplicates the movement in the actual money variable. Post-link B, produces the worst forecast among the three.

DENMARK

TABLE 7.1.5

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0173	.0117	.0129	.0392	.0004	.0589
Mean Absolute Error	.0315	.0396	.0383	.0460	.0142	.0627
Root-Mean-Sq. Error	.0500	.0455	.0453	.0535	.0172	.0714
Theil's Ineq. Coeff.	.0052	.0048	.0048	.0054	.0017	.0072
Fraction of Error due to a)Bias	.1204	.0662	.0810	.5362	.0005	.6810
b)Diff. Var.	.2686	.3579	.4083	.4156	.0165	.2607
c)Diff. Co-var	.6110	.5759	.5107	.0482	.9831	.0583

DENMARK

TABLE 7.2.5

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0148	-.0055	-.0245	-3.6250	.1066	-1.1930
Mean Absolute Error	.0148	.0055	.0245	3.6820	.8705	1.7300
Root-Mean-Sq. Error	.0162	.0058	.0265	4.3080	1.0800	2.0460
Theil's Ineq. Coeff.	.0016	.0006	.0027	.1681	.0495	.0884
Fraction of Error due to a)Bias	.8426	.8883	.8600	.7081	.0097	.3404
b)Diff. Var.	.1309	.0472	.1265	.0412	.0133	.0242
c)Diff. Co-var	.0265	.0645	.0135	.2508	.9769	.6354

EXHIBIT (7.1.5) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (DENMARK)

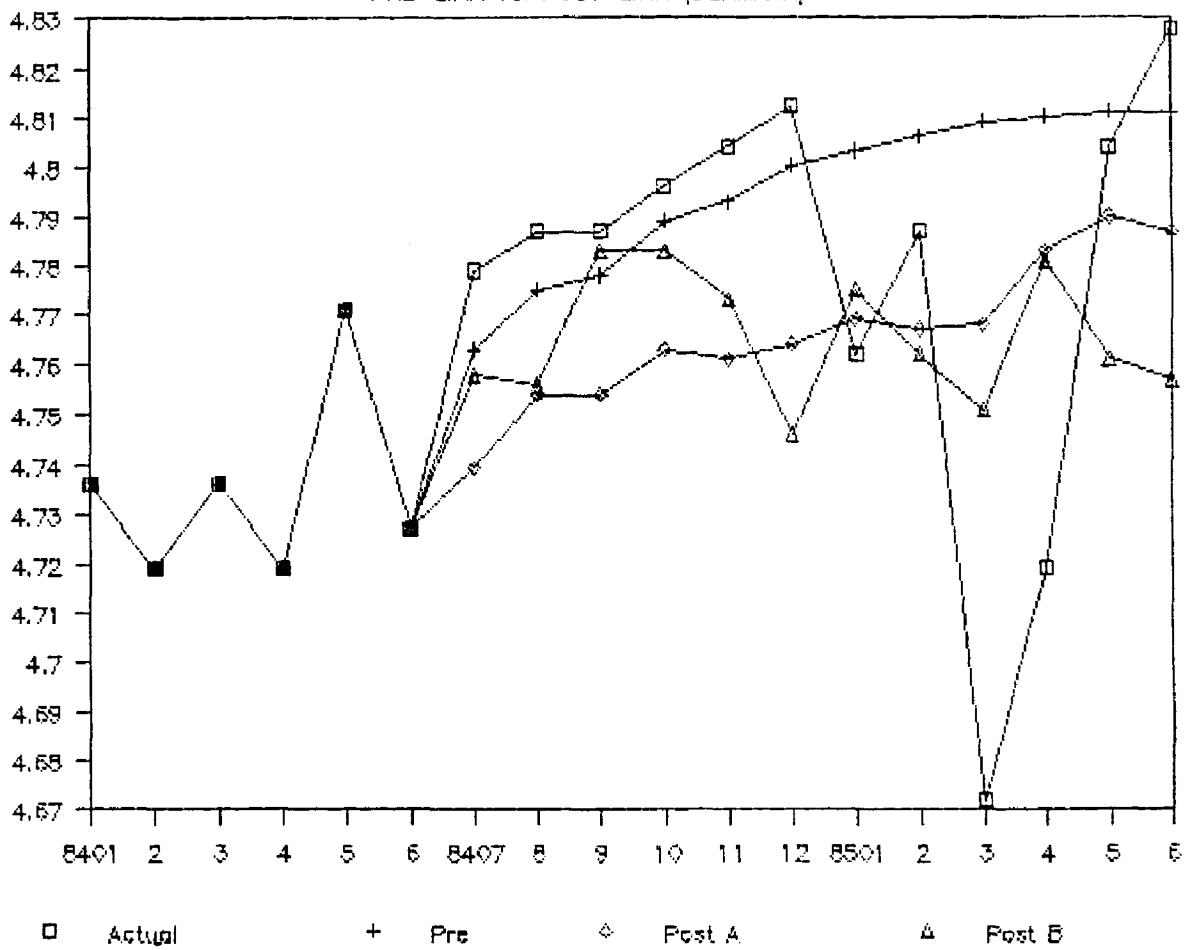


EXHIBIT (7.2.5) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (DENMARK)

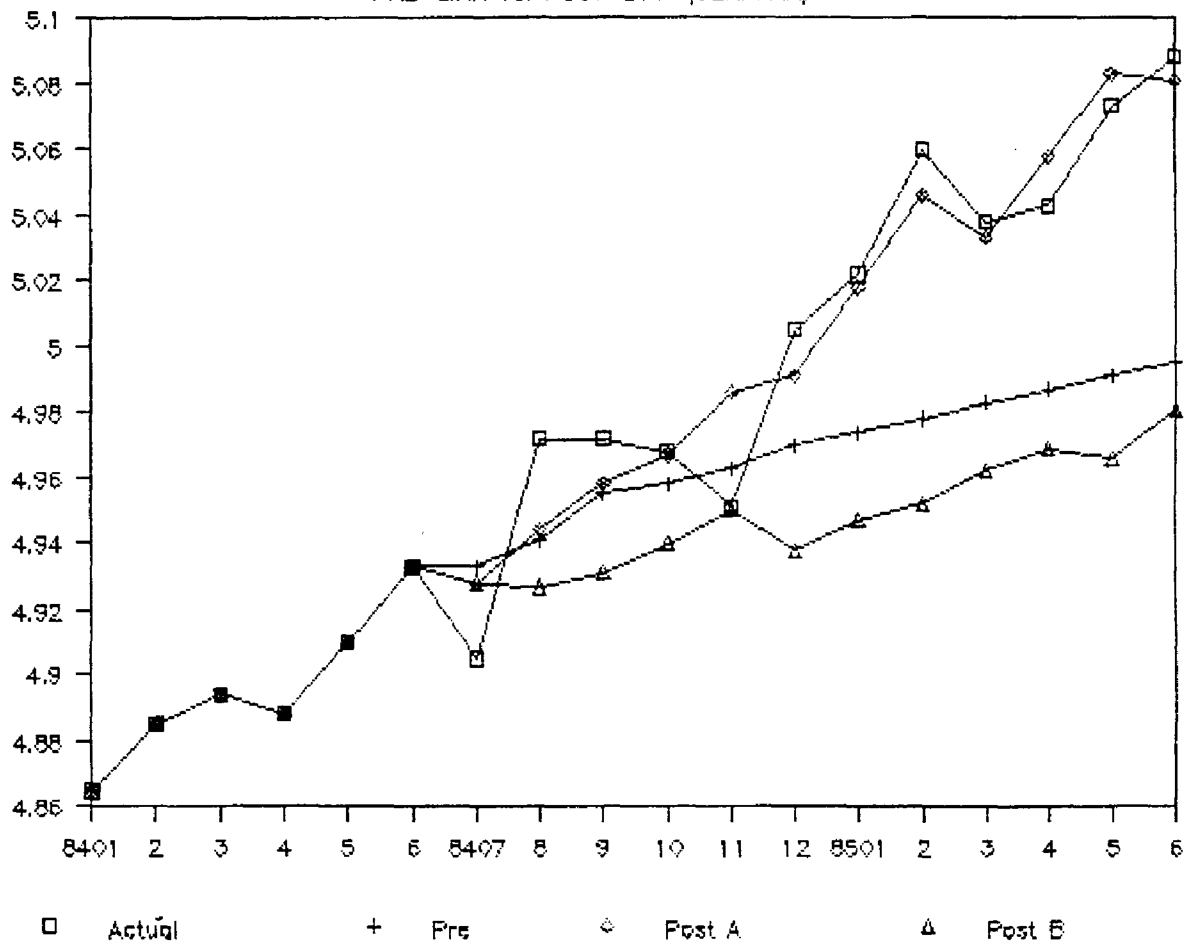


EXHIBIT (7.3.5) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (DENMARK)

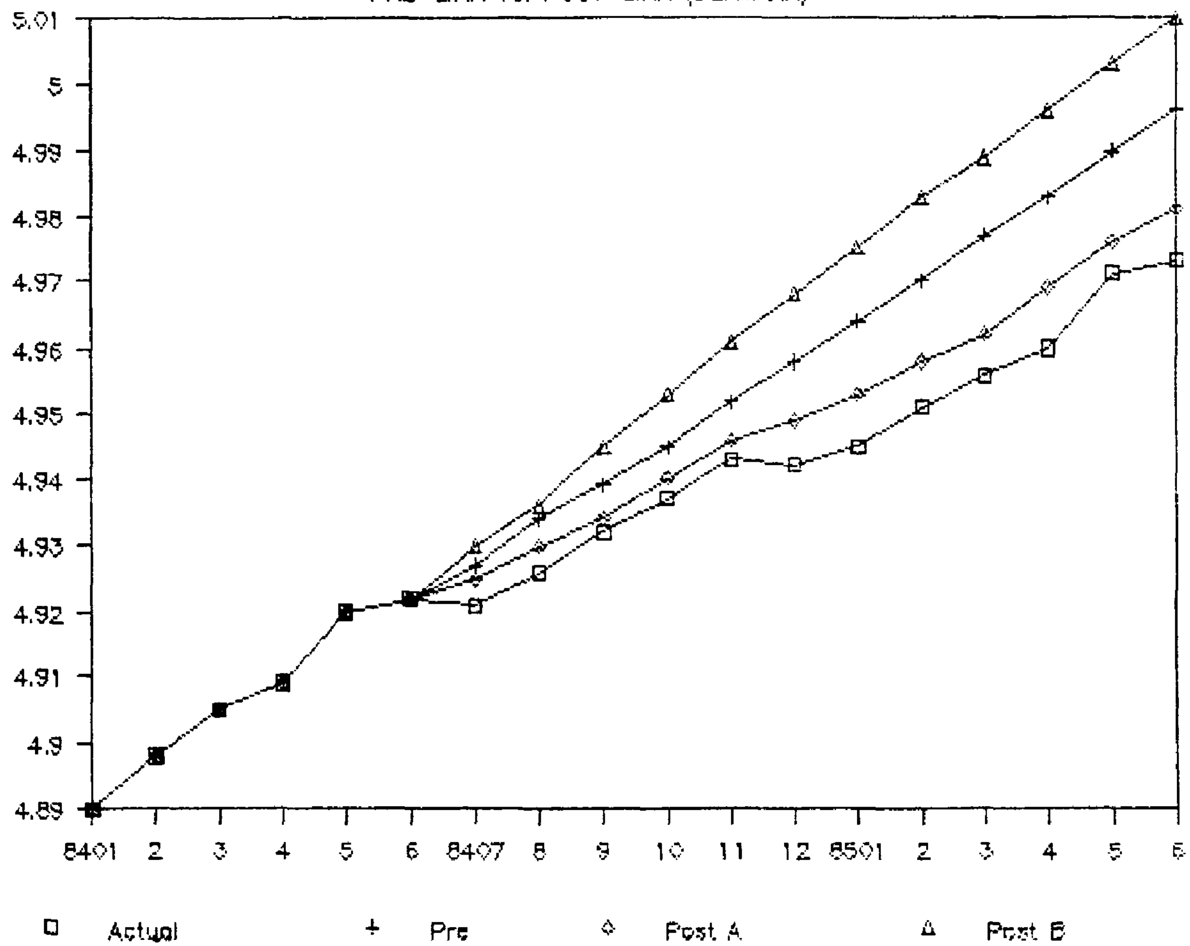
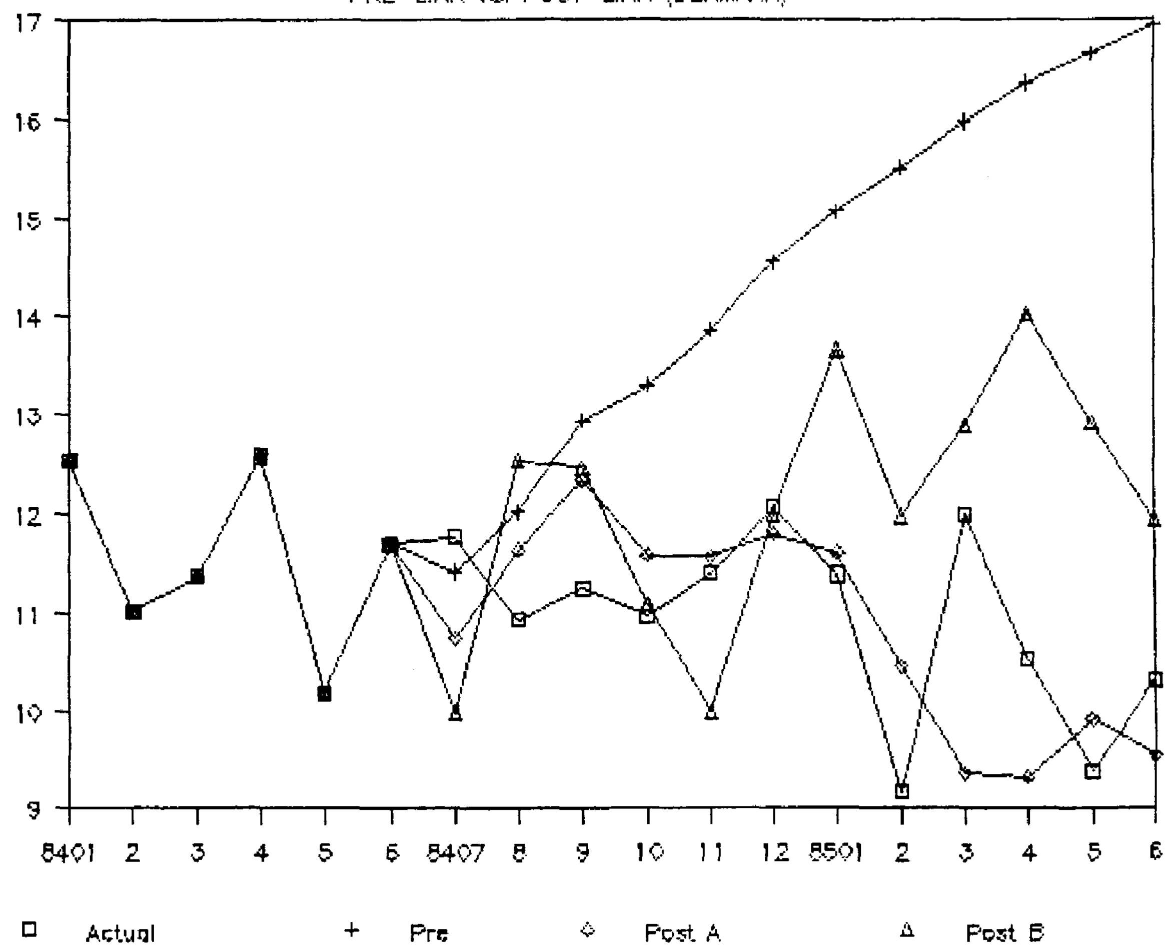


EXHIBIT (7.4.5) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (DENMARK)



All three price forecasts systematically overshoot the actual values, however the post-link A forecast again has the lowest forecast errors among them. Post-link A forecast is better for the entire forecast period and replicates the actual movements in the price variable relatively well. Post-link B forecast is the most explosive one, missing the mark completely for the entire twelve months.

The pre-link interest rate forecast is explosive and overshoots the actual values for the entire forecast horizon. Both post-link forecasts are reasonably well and post-link A has an edge over the post-link B forecast. The blip in the ninth month was not picked up by the post-link A, and the post-link B missed the downturn in the tenth month. Other than that, both post-link specifications generated very accurate forecasts.

The post-link A specification generated clearly better forecasts for three variables, money, price and interest rate and a comparable forecast for output indicating again the gains in forecast accuracy from international linkages. The post-link B, forecasts are less spectacular generating mixed results, improving two (output (marginally) and interest rate) and deteriorating the other two.

Finland

The forecast comparison of pre-link versus post-link selections are presented in Tables 7.1.6, 7.2.6 and Exhibits 7.1.6, 7.2.6, 7.3.6, and 7.4.6.

All three selections overpredicted the output variable especially in the last seven months of the forecast horizon. The pre-link and the post-link A, forecasts are reasonably close, where post-link A has a slight edge over pre-link in the first six months, while the reverse is true for the last six months. The post-link B forecast is more explosive and missed the mark after the second month over the entire period.

Money is forecasted fairly well by the post-link A selection, especially in the last six months. Pre-link and Post-link B forecasts are biased in the downward direction and have larger forecast errors than the post-link A fore- cast.

The best price forecast is generated by the post-link B specification. The post-link A, specification ranks second and although its forecast errors are not significantly lower than the pre-link selection, it forecasts the movements in the actual prices very well, especially in the first six months. The post-link B price forecast on the other hand, has the lowest errors, it is the least biased and has the

FINLAND

TABLE 7.1.6

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0309	-.0334	-.0449	.0314	.0192	.0380
Mean Absolute Error	.0339	.0350	.0459	.0314	.0236	.0380
Root-Mean-Sq. Error	.0388	.0417	.0507	.0372	.0323	.0443
Theil's Ineq. Coeff.	.0041	.0044	.0053	.0060	.0052	.0071
Fraction of Error due to a)Bias	.6323	.6407	.7844	.7118	.3522	.7367
b)Diff. Var.	.1345	.1447	.0809	.0226	.0427	.0076
c)Diff. Co-var	.2332	.2146	.1347	.2656	.6051	.2556

FINLAND

TABLE 7.2.6

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0095	.0063	.0010	——	——	——
Mean Absolute Error	.0095	.0074	.0041	——	——	——
Root-Mean-Sq. Error	.0113	.0098	.0049	——	——	——
Theil's Ineq. Coeff.	.0011	.0010	.0005	——	——	——
Fraction of Error due to a)Bias	.7068	.4213	.0438	——	——	——
b)Diff. Var.	.2197	.4079	.1761	——	——	——
c)Diff. Co-var	.0735	.1709	.7801	——	——	——

EXHIBIT (7.1.6) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (FINLAND)

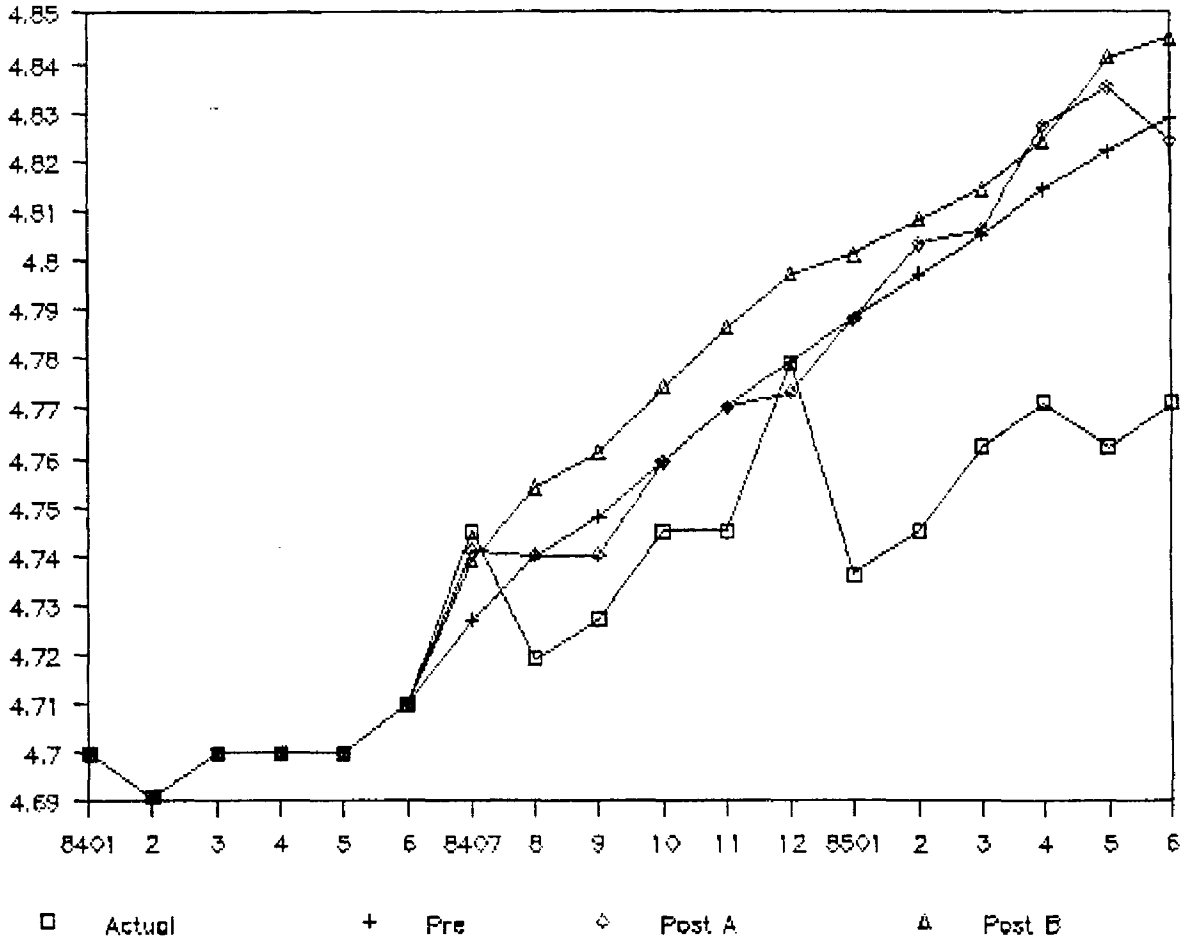


EXHIBIT (7.2.6) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (FINLAND)

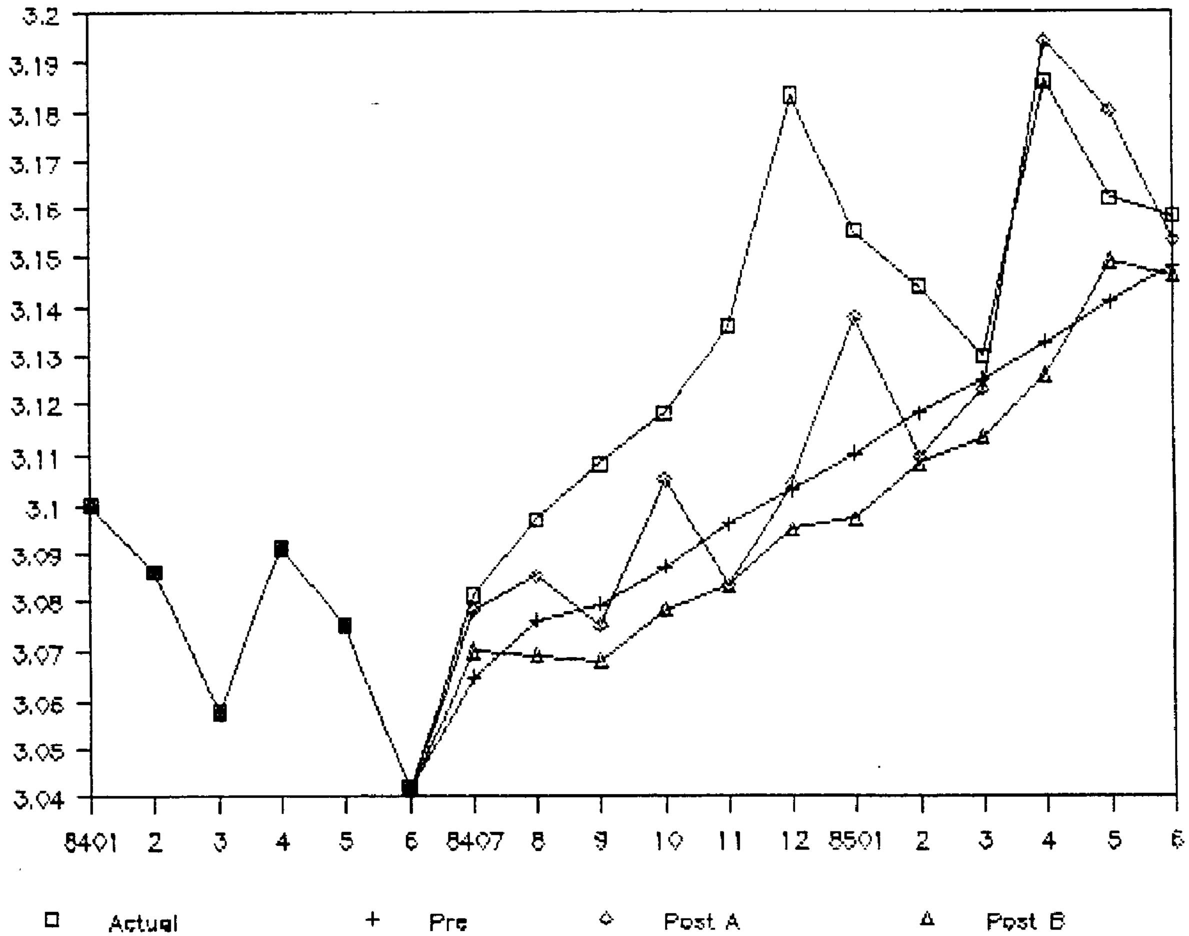
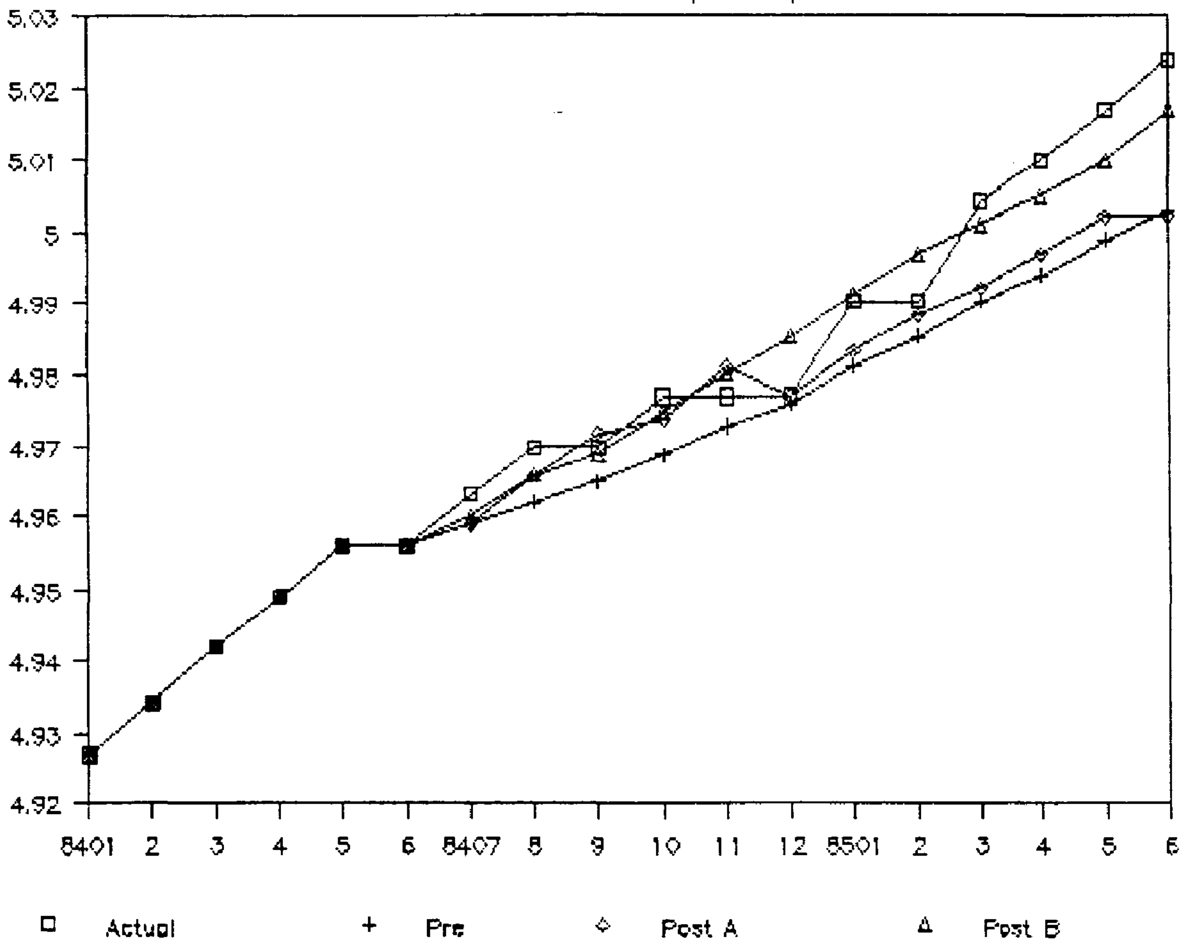


EXHIBIT (7.3.6) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (FINLAND)



lowest variance proportion of inequality.

Out of the three variables in Finland, post-link A improved two, money and price without deteriorating the output forecast, indicating a better forecasting performance with international linkages. A significant improvement is observed in the price forecasts with the post-link B, with the other two forecasts, inferior to the pre-link forecasts. Thus, the overall results indicate that only post-link A shows substantial improvement over the pre-link selection.

France

The comparison of the pre-link and post-link forecast performance for France is reported in Tables 7.1.7, 7.2.7, and Exhibits 7.1.7, 7.2.7, 7.3.7, and 7.4.7.

Both post-link forecasts are superior to the pre-link forecast in forecasting output. The post-link A specification has the lowest forecast errors and most of the error in the forecast can be attributed to the variance proportion. The pre-link forecast is explosive and misses the mark, especially in the last eight months of the prediction period. Although none of the forecasts predicted the wide fluctuations in the actual values, post-link forecasts are generally more accurate.

The post-link selections have significantly improved the forecast of money over the pre-link selection. The pre-link

FRANCE

TABLE 7.1.7

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summery Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0216	-.0162	-.0162	-.0422	-.0114	-.0045
Mean Absolute Error	.0322	.0242	.0277	.0422	.0175	.0138
Root-Mean-Sq. Error	.0380	.0294	.0327	.0462	.0196	.0154
Theil's Ineq. Coeff.	.0041	.0032	.0035	.0033	.0014	.0011
Fraction of Error due to a)Bias	.3241	.3025	.2450	.8354	.3358	.0865
b)Diff. Var.	.0756	.4374	.1721	.0217	.1211	.2616
c)Diff. Co-var	.6004	.2602	.5829	.1430	.5430	.6520

FRANCE

TABLE 7.2.7

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0258	-.0156	-.0126	-1.5400	-1.2870	-1.1580
Mean Absolute Error	.0258	.0156	.0126	1.5400	1.2870	1.1580
Root-Mean-Sq. Error	.0296	.0179	.0156	1.7610	1.4400	1.2260
Theil's Ineq. Coeff.	.0029	.0018	.0015	.0758	.0627	.0537
Fraction of Error due to a)Bias	.7617	.7574	.6487	.7653	.7986	.8923
b)Diff. Var.	.2324	.2331	.3399	.0003	.0130	.0139
c)Diff. Co-var	.0058	.0095	.0114	.2344	.1884	.0938

EXHIBIT (7.1.7) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (FRANCE)

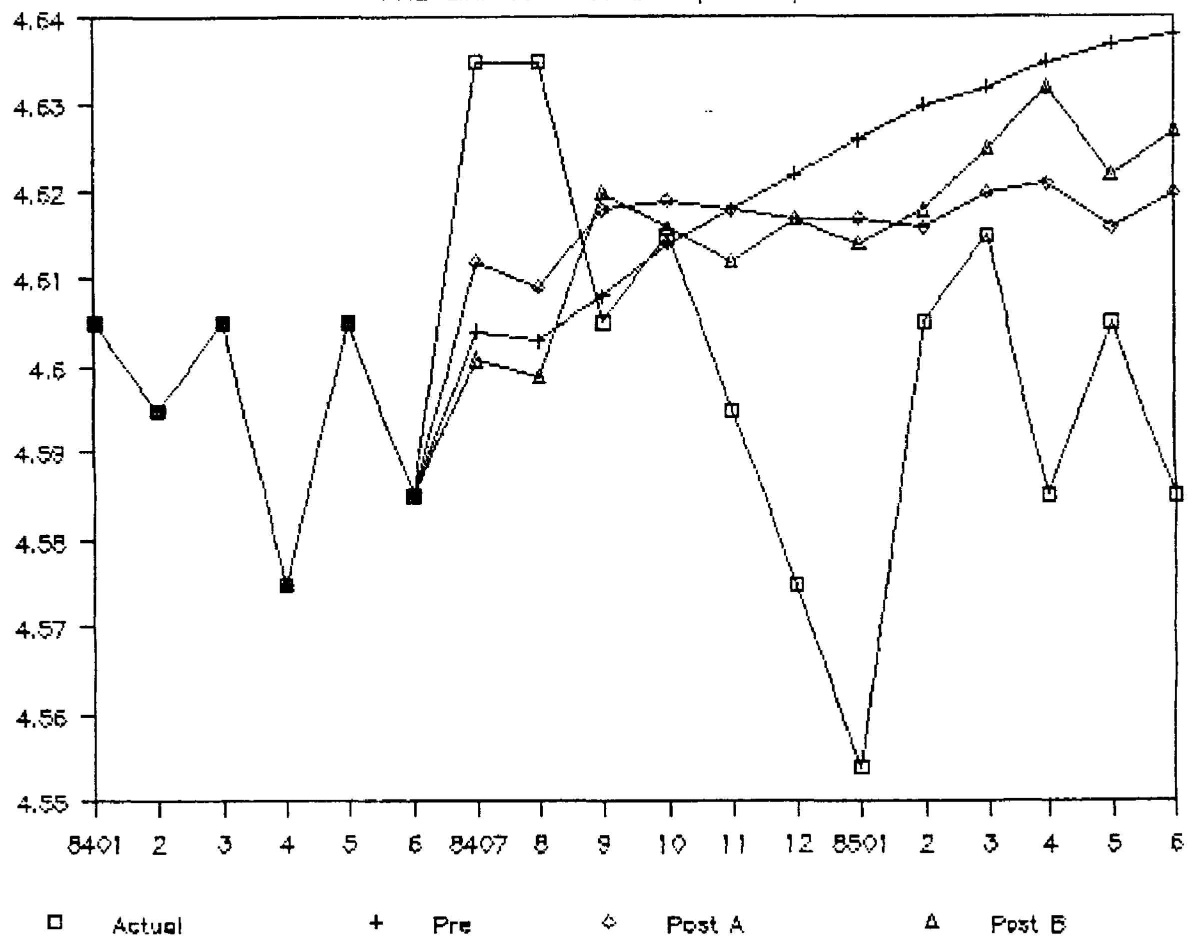
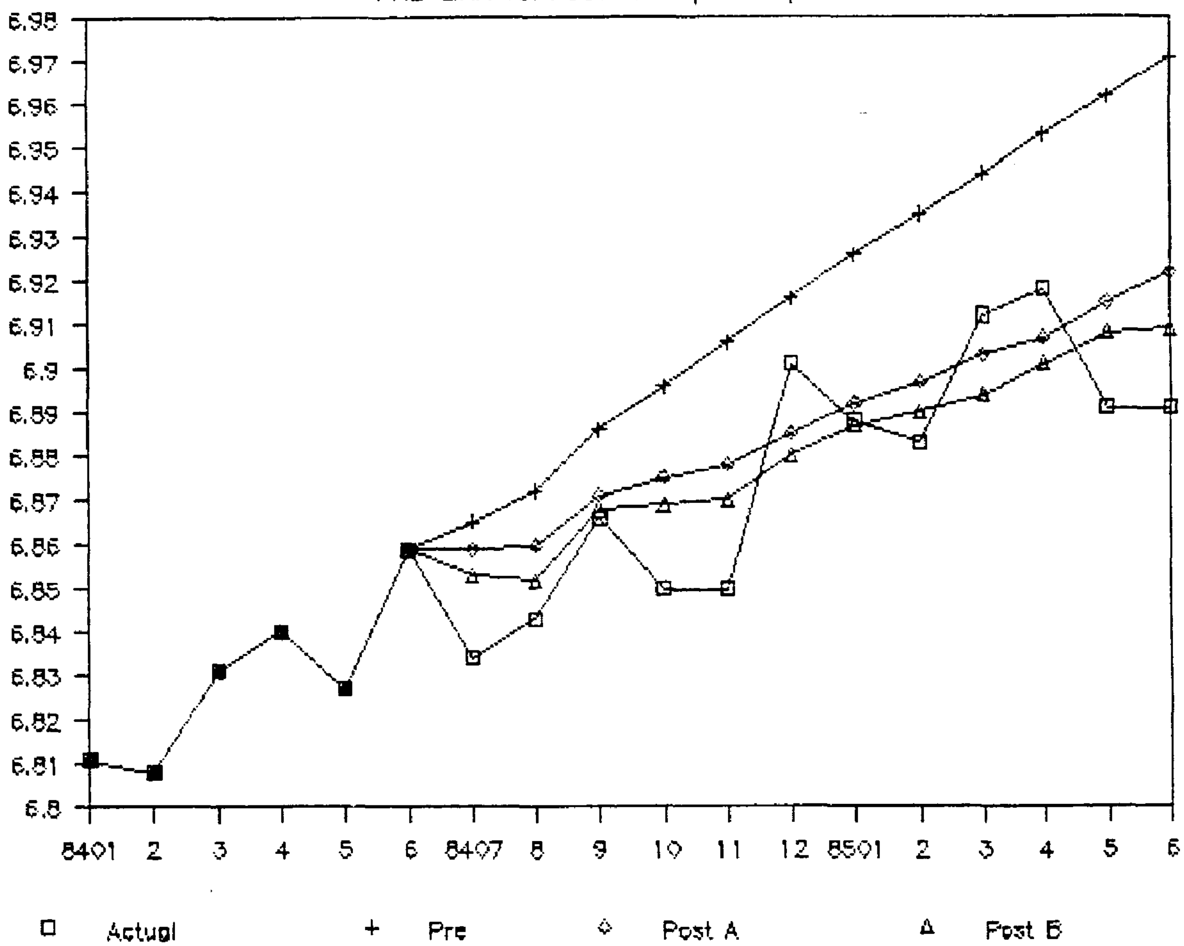


EXHIBIT (7.2.7) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (FRANCE)



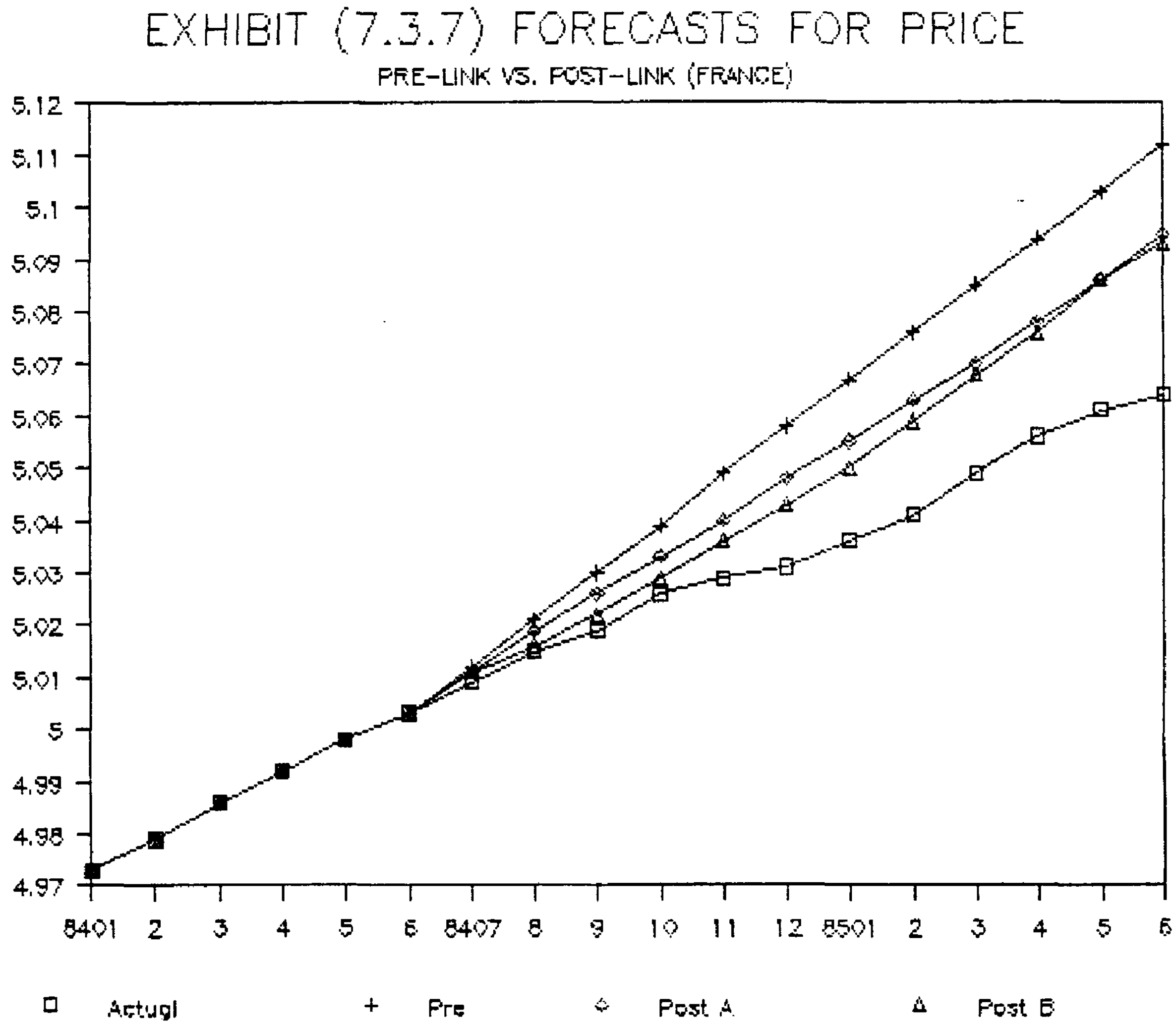
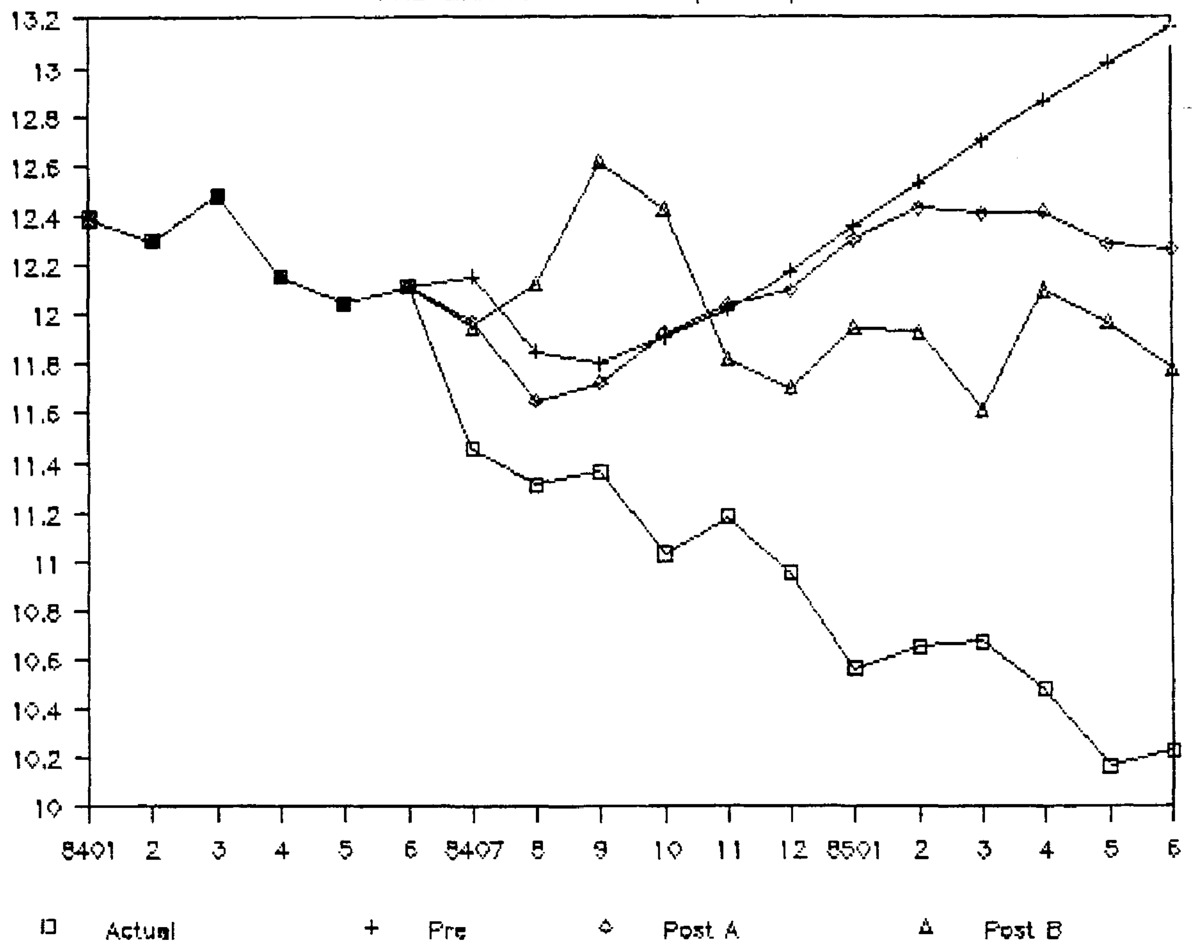


EXHIBIT (7.3.7) FORECASTS FOR PRICE
PRE-LINK VS. POST-LINK (FRANCE)
5.12
5.11
5.1
5.09
5.08
5.07
5.06
5.05
5.04
5.03
5.02
5.01
5
4.99
4.98
4.97
8401 2 3 4 5 6 8407 8 9 10 11 12 8501 2 3 4 5 6
Actual
Pre
Post A
Post B

EXHIBIT (7.4.7) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (FRANCE)



forecast is again explosive and overpredicts the money values in the entire period. Both post-link forecasts are remarkably accurate, with errors less than half the size of the pre-link errors. The decomposition of the Theil-U coefficient indicates that, most of the forecast errors for the post-link predictions can be attributed to the unsystematic error component. Also, post-link B forecast has a slight edge over the post-link A forecast of the money variable.

All three specifications overpredicted the price movements in the twelve months forecast horizon. Both post-link forecasts have smaller forecast errors compared to the pre-link forecast, where post-link B forecast is the best among the three.

The pre-link prediction of the interest rate is once again explosive, completely missing the mark. Both post-link selections forecasted interest rate fairly accurately. The best forecast is again the post-link B forecast, which has the lowest errors and also although more biased, it duplicates the interest rate movements relatively better than the others.

Both post-link specifications improved all four forecasts over the pre-link specification, showing how significant it is to have international influence incorporated into the forecasts of domestic variables. All pre-link forecasts were explosive and very inaccurate. The best forecasts are generated by the post-link B specification.

Germany (West)

The comparison of the pre-link versus post-link forecast performance for West Germany is presented in Tables 7.1.8, 7.2.8 and in Exhibits 7.1.8, 7.2.8, 7.3.8, and 7.4.8.

The output movements in Germany are underpredicted by all three specifications. The two post-link selections do relatively better than the pre-link selection, generating forecasts with smaller errors. Post-link A forecast is the best among the three.

There were two one month jumps in the actual money values, the sixth and the ninth months, which was not predicted by any of the three specifications. Rest of the period was forecasted fairly well by both post-link selections, where the pre-link selection missed the mark completely for the entire forecast horizon. Forecast errors from both post-link specifications are fairly close, while post-link B has a slight edge over the post-link A prediction.

The price values were forecasted fairly accurately by all three specifications, except for the first three months of the prediction period. Both post-link forecasts are marginally better than the pre-link forecast especially in the first seven months for post-link A, and for the entire period for post-link B.

GERMANY (WEST)

TABLE 7.1.8

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0397	.0188	.0296	-.0053	.0052	.0045
Mean Absolute Error	.0397	.0188	.0296	.0094	.0064	.0056
Root-Mean-Sq. Error	.0411	.0210	.0314	.0119	.0104	.0091
Theil's Ineq. Coeff.	.0045	.0023	.0034	.0011	.0009	.0008
Fraction of Error due to a)Bias	.9360	.8044	.8846	.1957	.2504	.2504
b)Diff. Var.	.0530	.1065	.0686	.0402	.2553	.2272
c)Diff. Co-var	.0110	.0891	.0468	.7641	.4943	.5224

GERMANY (WEST)

TABLE 7.2.8

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0032	-.0018	-.0028	.1495	-.7945	.0585
Mean Absolute Error	.0037	.0037	.0032	.2363	.8301	.2274
Root-Mean-Sq. Error	.0047	.0043	.0042	.2851	1.0940	.2616
Theil's Ineq. Coeff.	.0005	.0005	.0004	.0241	.0855	.0220
Fraction of Error due to a)Bias	.4644	.1796	.4432	.2752	.5274	.0500
b)Diff. Var.	.3808	.5467	.4772	.0366	.2370	.0543
c)Diff. Co-var	.1548	.2557	.0796	.6882	.2356	.8958

EXHIBIT (7.1.8) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (GERMANY)

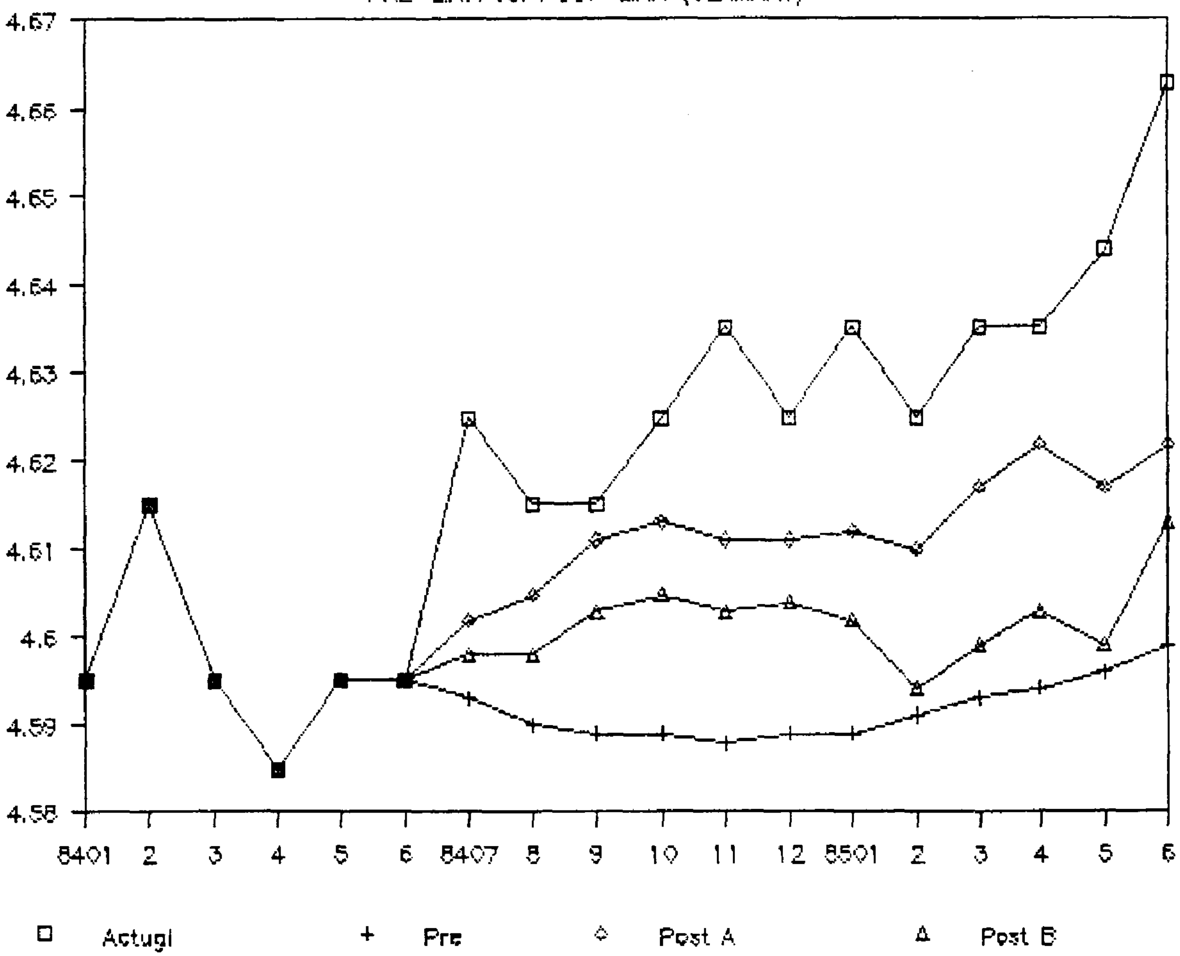


EXHIBIT (7.2.8) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (GERMANY)

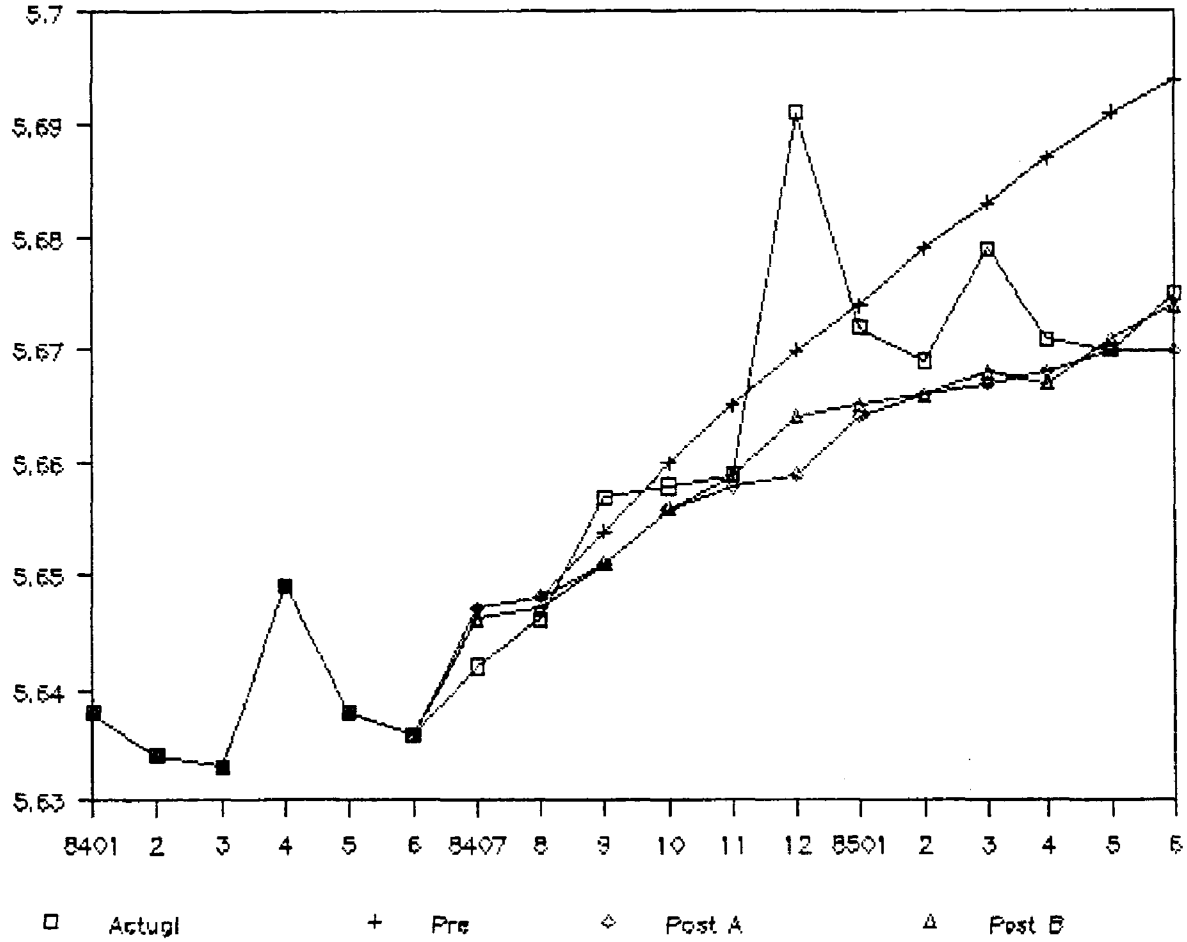


EXHIBIT (7.3.8) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (GERMANY)

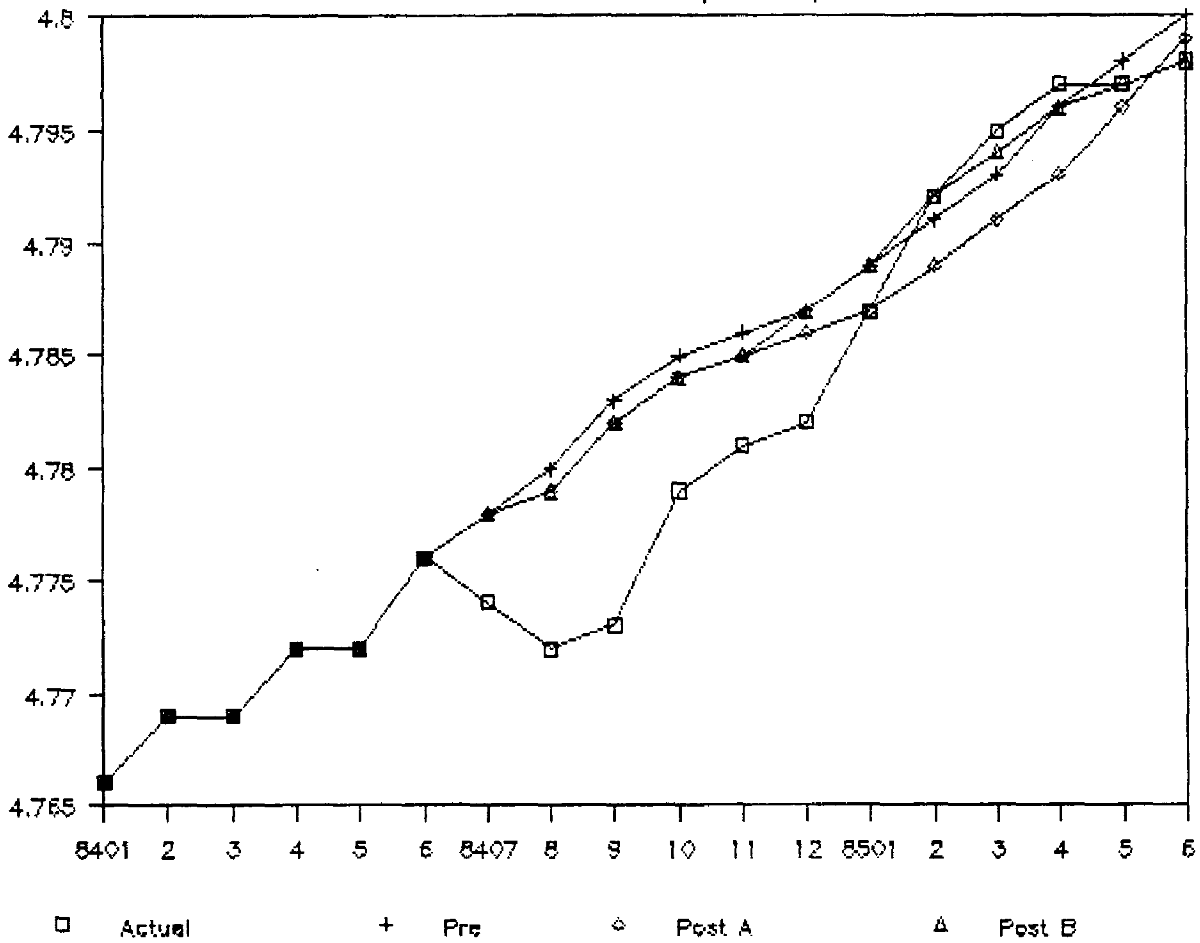
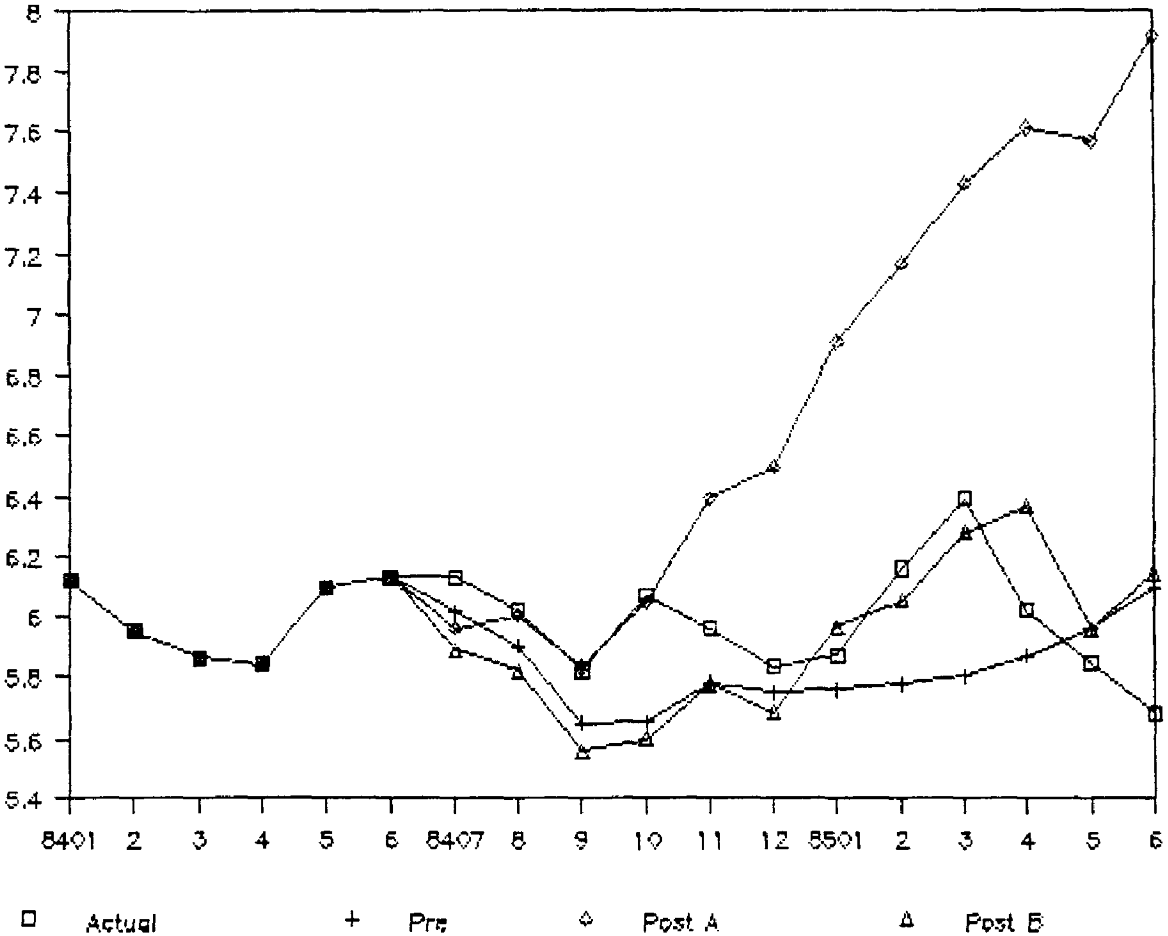


EXHIBIT (7.4.8) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (GERMANY)



The interest rate was predicted remarkably well by the post-link B selection, especially in the last seven months, while both post-link A and pre-link entirely missed the actual movements. The post-link A forecast is in fact the worst among the three, exploding after the third month. Although, the pre-link forecast has relatively small errors its performance in the last seven months of the forecast period is fairly bad. The post-link B forecast has not only the lowest errors but also it replicates the actual pattern of the interest rate much better than the others.

The pre-link forecasts of Germany were improved significantly by incorporating the international influence, except for price where the improvement is only marginal. Post-link B improved all four forecasts and post-link A generated better forecasts for three out of four variables, output, money and price.

Ireland

The forecast comparison of pre-link and post-link specifications for Ireland is reported in Tables 7.1.9, 7.2.9, and in Exhibits 7.1.9, 7.2.9, 7.3.9, and 7.4.9.

The output values were forecasted fairly accurately by all three selections. The post-link forecasts are better than the pre-link forecast, especially in the last five months of the forecast period. Post-link B forecast has the

IRELAND

TABLE 7.1.9

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0274	.0043	.0033	.0295	.0523	.0590
Mean Absolute Error	.0337	.0269	.0247	.0353	.0523	.0590
Root-Mean-Sq. Error	.0409	.0341	.0306	.0418	.0578	.0631
Theil's Ineq. Coeff.	.0042	.0035	.0032	.0027	.0038	.0042
Fraction of Error due to a)Bias	.4494	.0158	.0118	.4962	.8208	.8738
b)Diff. Var.	.2761	.4398	.3877	.0278	.0005	.0096
c)Diff. Co-var	.2745	.5444	.6004	.4759	.1787	.1167

IRELAND

TABLE 7.2.9

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0224	-.0125	-.0021	1.1250	1.1170	1.0140
Mean Absolute Error	.0228	.0146	.0064	1.3250	1.2860	1.3130
Root-Mean-Sq. Error	.0279	.0125	.0080	1.5030	1.4520	1.4480
Theil's Ineq. Coeff.	.0027	.0014	.0008	.0597	.0577	.0573
Fraction of Error due to a)Bias	.6434	.7381	.0676	.5603	.5919	.4980
b)Diff. Var.	.3529	.2294	.8629	.0037	.0030	.0072
c)Diff. Co-var	.0038	.0324	.0695	.4360	.4051	.5028

EXHIBIT (7.1.9) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (IRELAND)

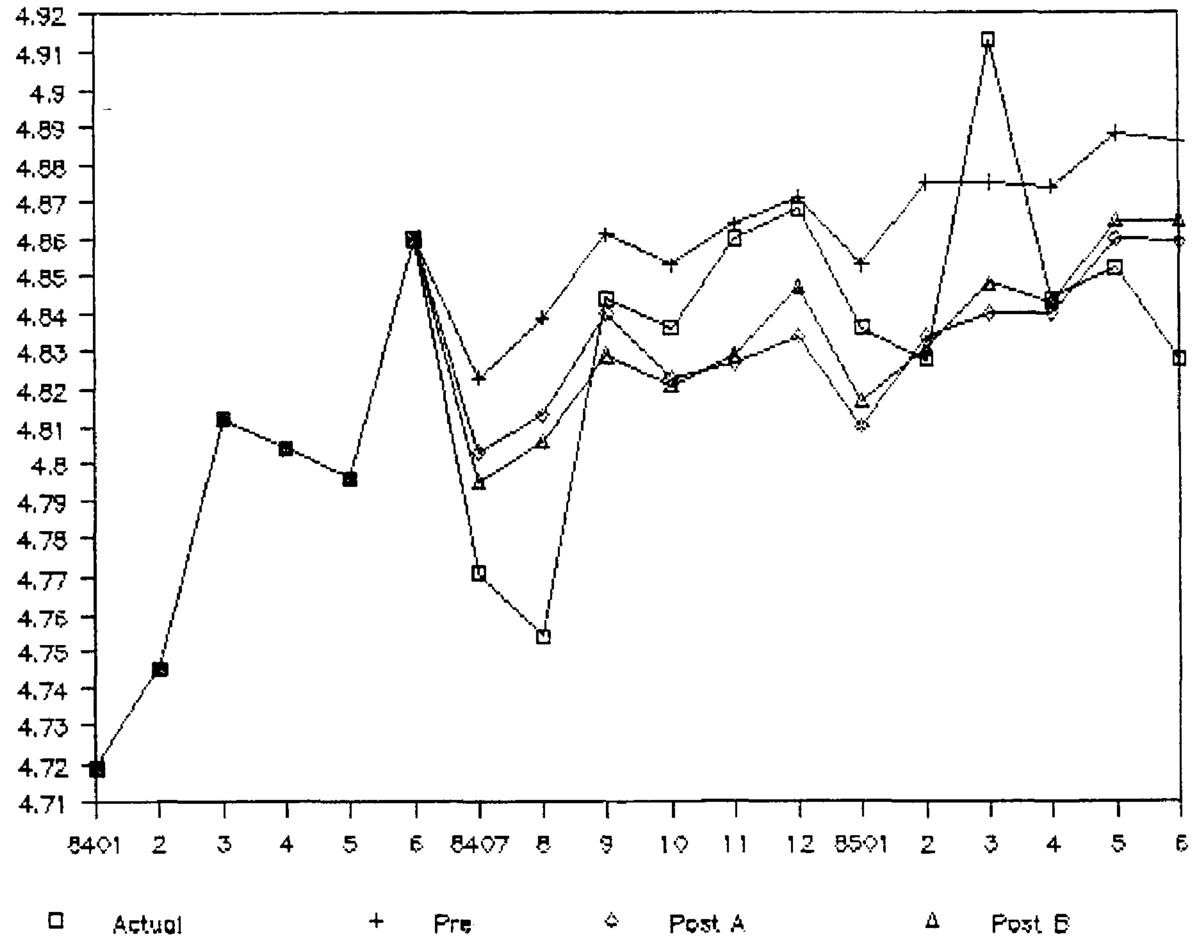


EXHIBIT (7.2.9) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (IRELAND)

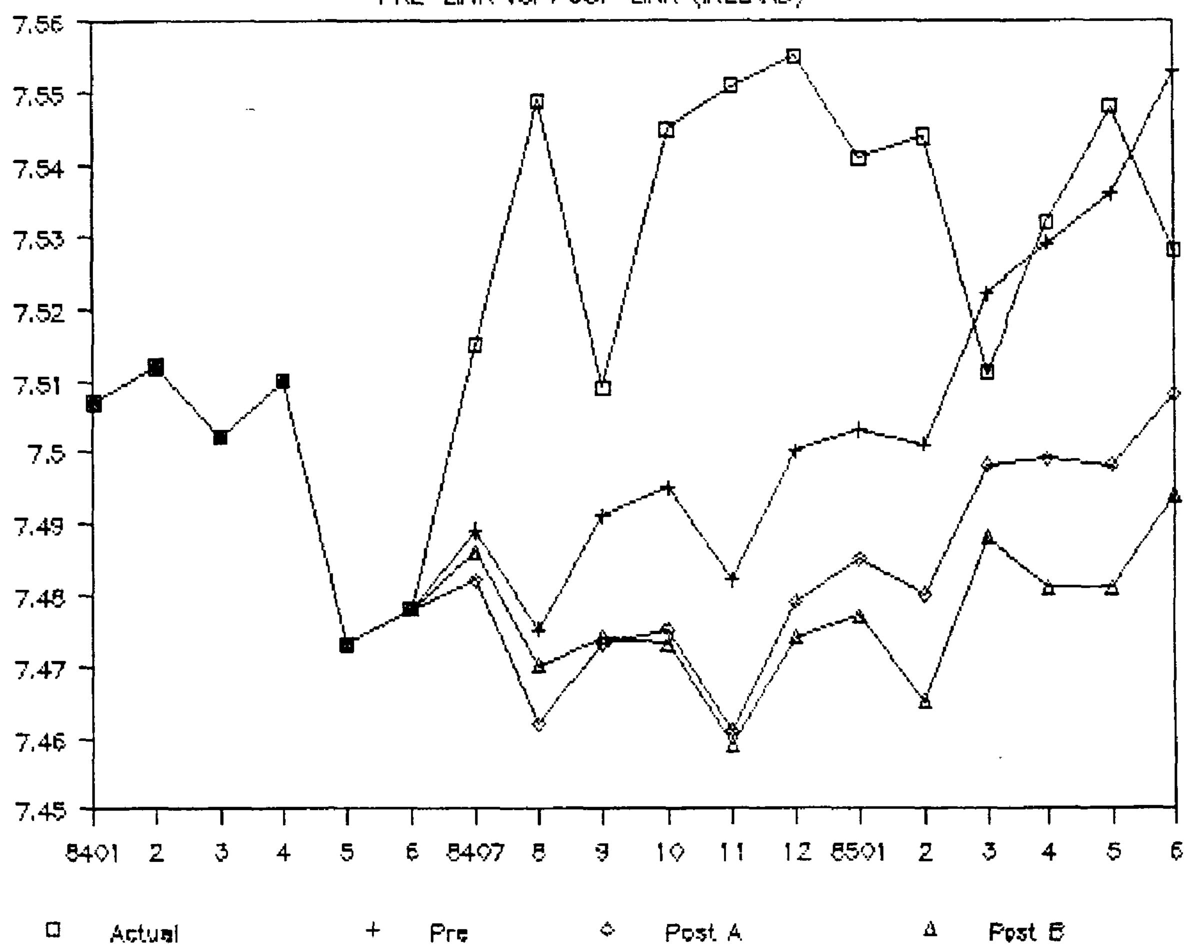
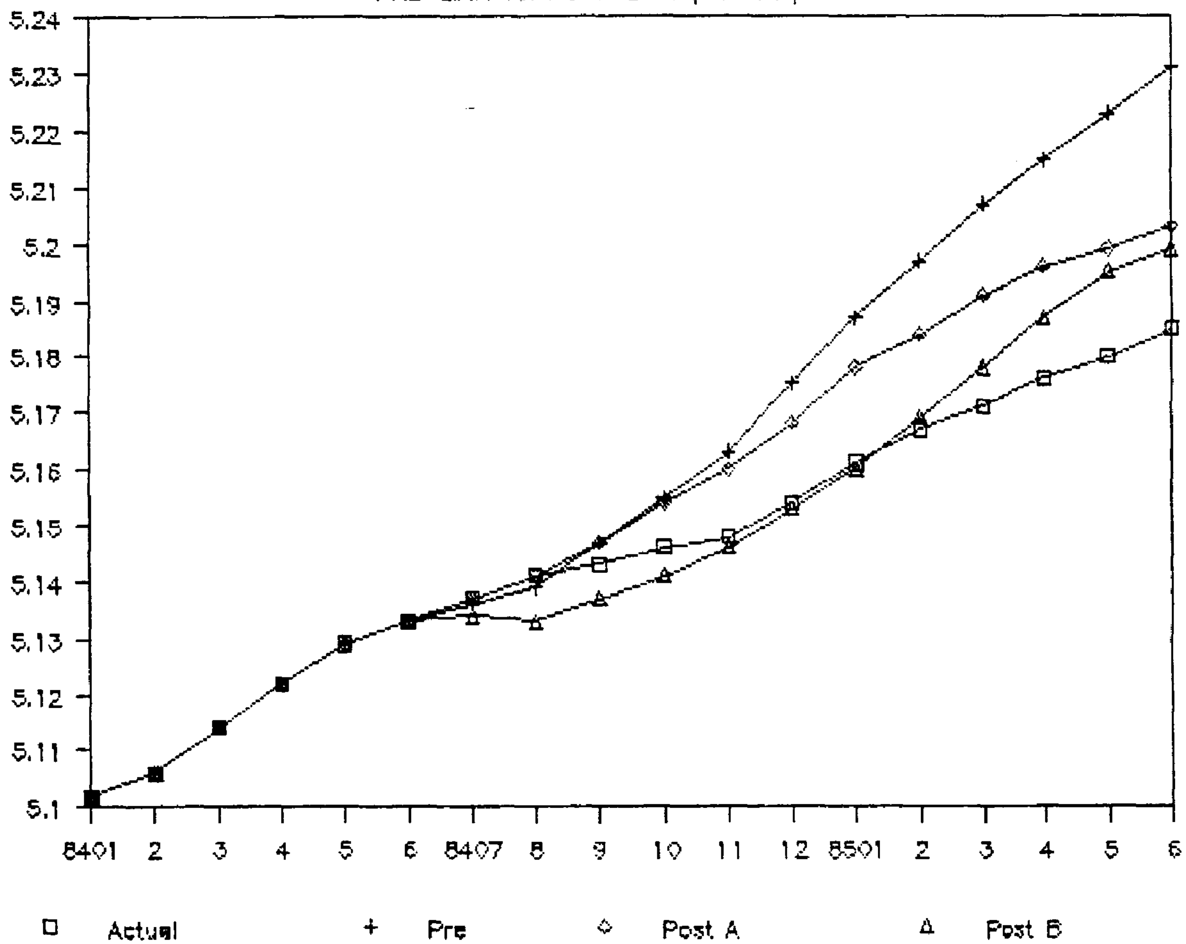


EXHIBIT (7.3.9) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (IRELAND)



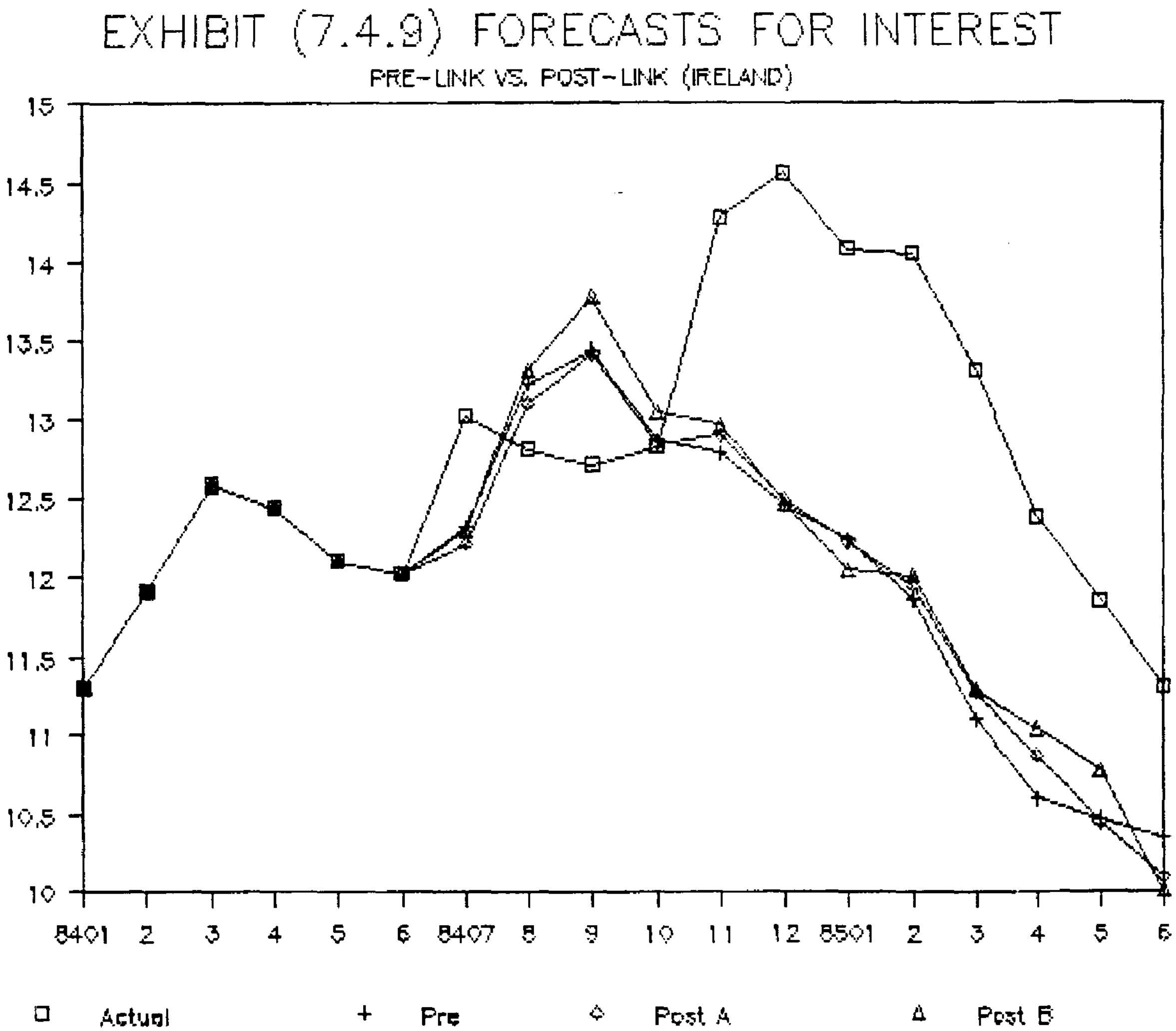


EXHIBIT (7.4.9) FORECASTS FOR INTEREST
PRE-LINK VS. POST-LINK (IRELAND)
15
14.5
14
13.5
13
12.5
12
11.5
11
10.5
10
8401 2 3 4 5 6 8407 8 9 10 11 12 8501 2 3 4 5 6
Actual
Pre
Post A
Post B

lowest errors and most of its forecast error is attributed to the least worrisome, the co-variance proportion.

The changes in the money supply were not forecasted accurately by all three selections. The actual values for money show wide fluctuations, which were not predicted by any of the three alternative specifications. The best forecast among these three inaccurate forecasts is the pre-link forecast with the lowest forecast errors. The pre-link forecast is accurate only at the ninth, tenth and the eleventh month of the forecast horizon.

Both post-link forecasts of price are better than the pre-link forecast. Pre-link selection overpredicts price after the second month and continues in that way for the entire period. Post-link A, which reduces the size of the pre-link errors to half, also overpredicts the actual values. The post-link B, which has the lowest forecast errors underpredicts price in the first five months and overpredicts it in the last five months.

All three selections predicted the movements in the interest rate fairly accurately. The forecast errors are very close and no selection seems to have a significant superiority over the others.

International linkages help the forecast performance in Ireland which is indicated by the two better (output, price), one almost the same (interest rate) and one worse (money) forecasts.

Italy

The comparison of the pre-link and post-link forecast performance for Italy is presented in Tables 7.1.10, 7.2.10 and in Exhibits 7.1.10, 7.2.10, 7.3.10, and 7.4.10.

The output in Italy is forecasted fairly well by both post-link specifications, while the pre-link forecast is explosive. The pre-link forecast errors are almost three times the size of the post-link forecast errors. The rapid decline in the seventh and the tenth months were not picked up by neither post-link selection. A comparison between the two post-link specifications indicate that, post-link B forecast is marginally better than the post-link A forecast.

Best money forecasts are generated again by the two post-link specification, while the pre-link forecast is very explosive. Post-link A has lower forecast errors than post-link B, whereas the bias in A (.4252) is significantly larger than the bias in B (.094). Post-link A duplicates the movement in the actual money values slightly closer than post-link B.

The price variable is overpredicted by the pre-link and post-link A selections and underpredicted by the post-link B selection. The most accurate of all is the post-link B specification with lower forecast errors and a smaller bias component. The post-link A specification which overpredicts

ITALY

TABLE 7.1.10

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0689	-.0162	-.0169	-.0586	-.0119	-.0073
Mean Absolute Error	.0689	.0247	.0253	.0586	.0160	.0171
Root-Mean-Sq. Error	.0794	.0313	.0298	.0661	.0183	.0237
Theil's Ineq. Coeff.	.0086	.0034	.0033	.0026	.0007	.0010
Fraction of Error due to a)Bias	.7542	.2666	.3232	.7868	.4252	.0964
b)Diff. Var.	.0200	.1299	.0241	.1443	.0027	.1933
c)Diff. Co-var	.2258	.6034	.6527	.0689	.5721	.7104

ITALY

TABLE 7.2.10

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0341	-.0205	.0061	-4.8770	-3.0720	.2139
Mean Absolute Error	.0341	.0205	.0070	4.8770	3.0720	.3208
Root-Mean-Sq. Error	.0404	.0231	.0081	5.6650	3.6210	.3979
Theil's Ineq. Coeff.	.0039	.0022	.0008	.1668	.1129	.0139
Fraction of Error due to a)Bias	.7134	.7824	.5684	.7413	.7199	.2888
b)Diff. Var.	.2813	.2048	.2593	.0903	.0415	.1519
c)Diff. Co-var	.0053	.0129	.1723	.1684	.2386	.5593

EXHIBIT (7.1.10) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (ITALY)

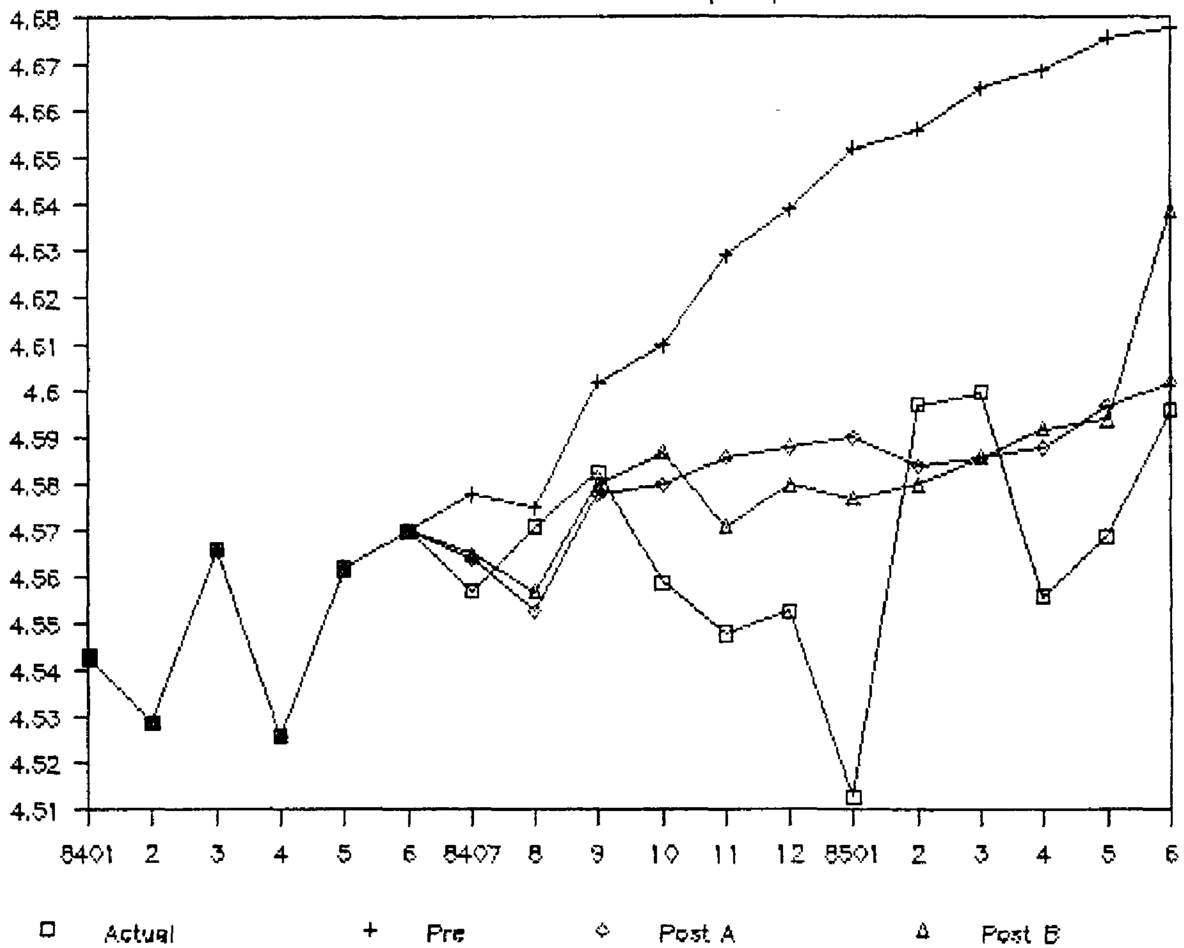


EXHIBIT (7.2.10) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (ITALY)

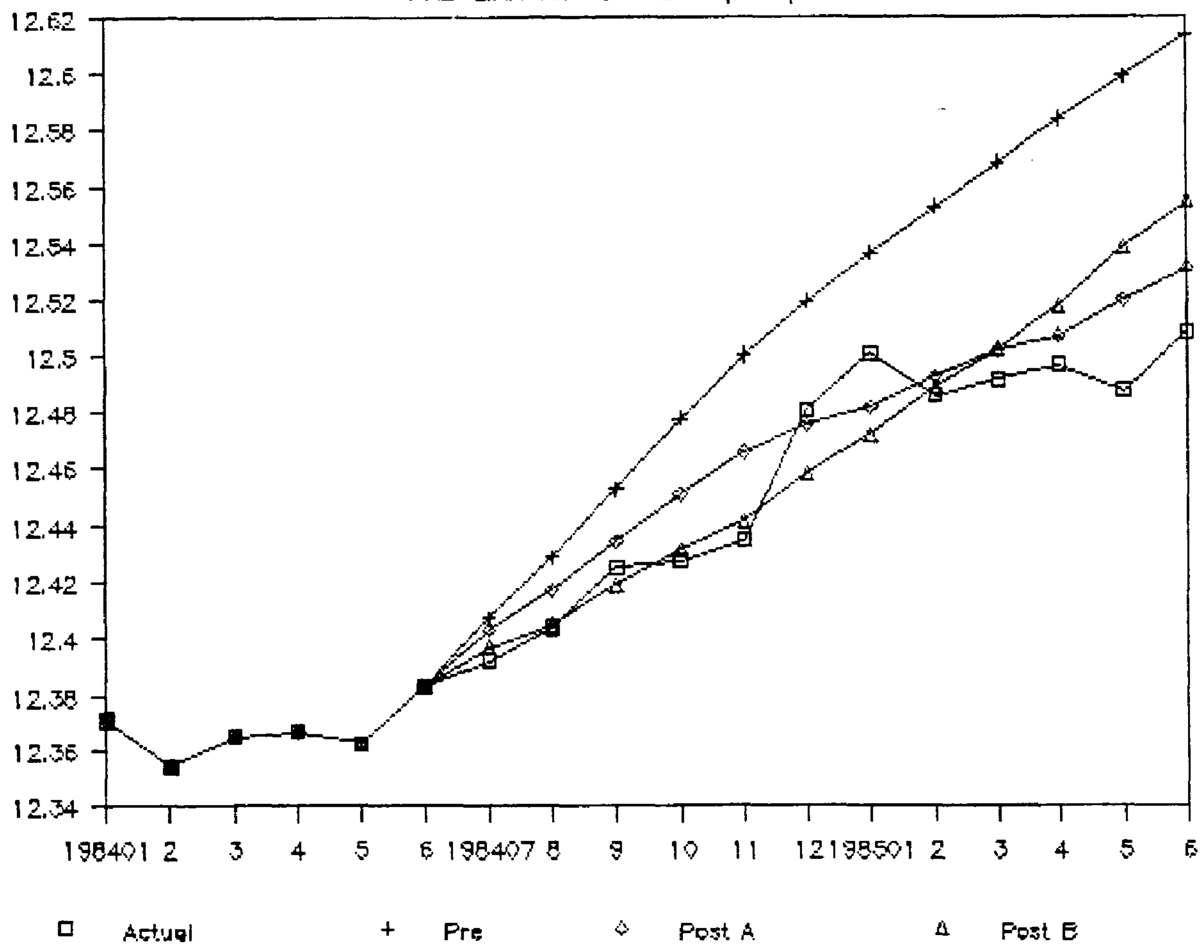
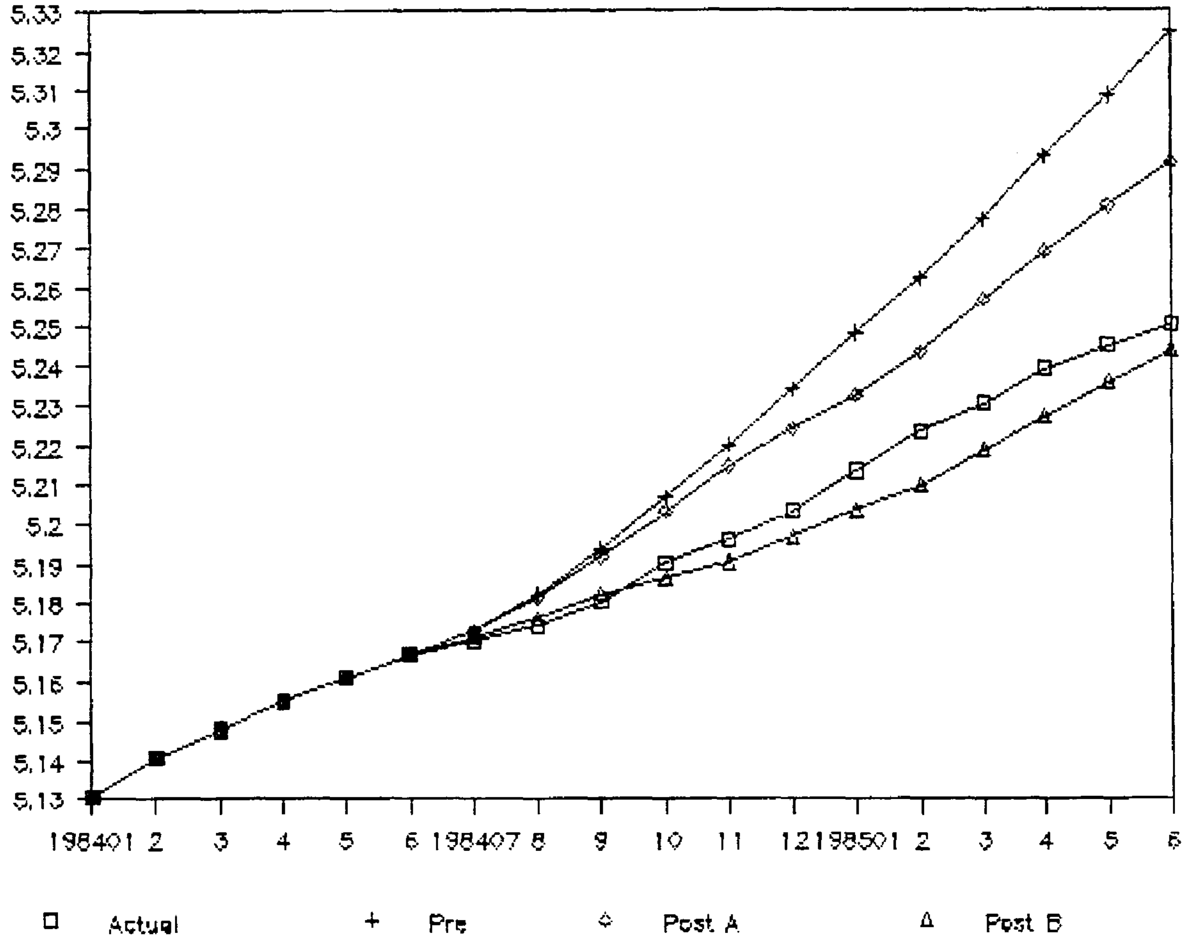


EXHIBIT (7.3.10) FORECASTS FOR PRICE

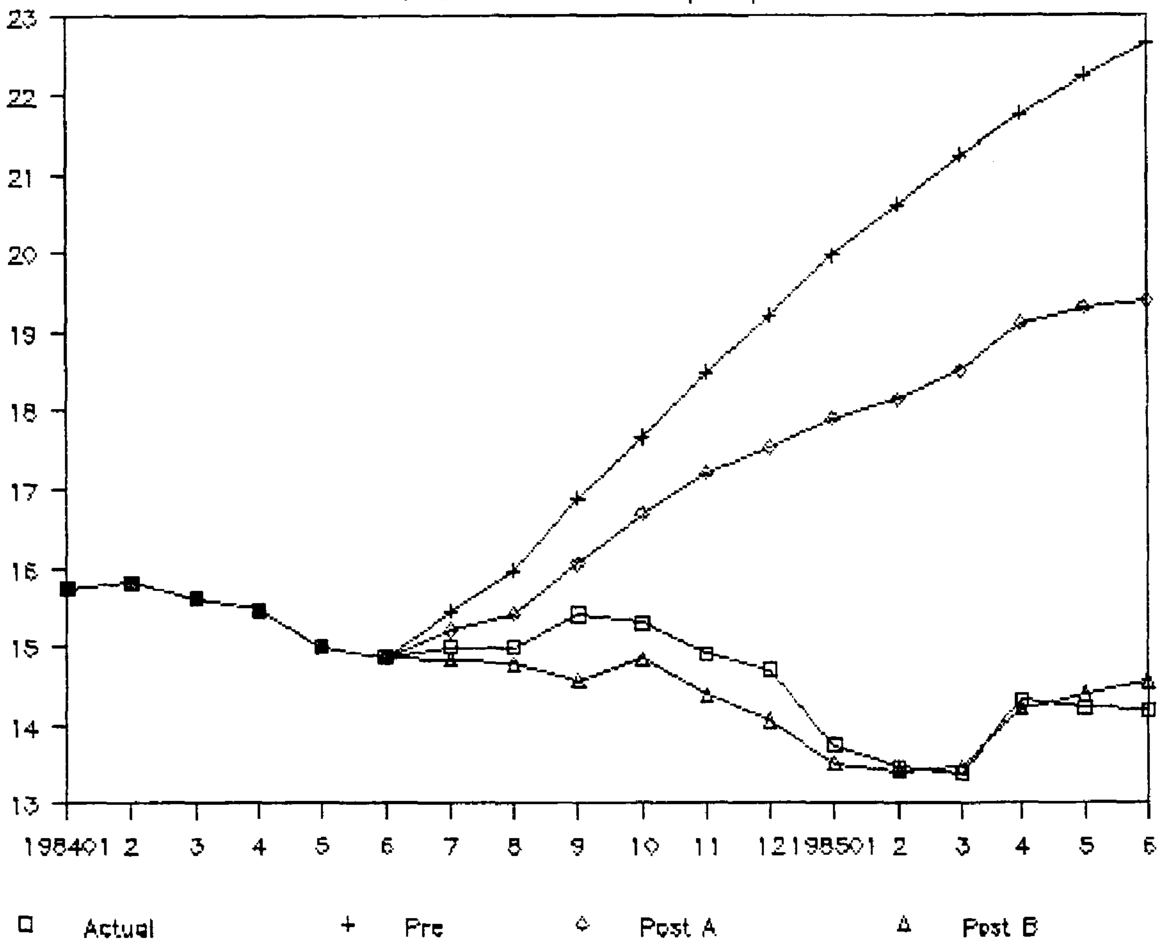
PRE-LINK VS. POST-LINK (ITALY)



274

EXHIBIT (7.4.10) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (ITALY)



the actual values is still much better than the pre-link specification.

The interest rate in Italy was overpredicted by pre-link and post-link forecasts, while the post-link B forecast was remarkably accurate. Post-link B selection generated the lowest forecast errors and almost duplicated the actual movements in the interest rate. Although, post-link A prediction was explosive, it was still closer to the actual values than the forecast of the pre-link selection.

The results of Italy clearly shows the significant gains in forecasting by using the link variables. All four forecasts under both linkage mechanisms are superior over the pre-link forecasts, while post-link B has an edge over post-link A selection.

Japan

The comparison of the pre-link and post-link forecast performance for Japan is reported in Tables 7.1.11, 7.2.11 and in Exhibits 7.1.11, 7.2.11, 7.3.11, and 7.4.11.

Both pre-link and post-link A forecasts of output are fairly accurate, while post-link B forecast overpredicts the actual values over the entire forecast horizon. There is no significant difference between the post-link A and the pre-link predictions as indicated by both the summary statistics and the illustrations. The post-link B forecast does

JAPAN

TABLE 7.1.11

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0014	.0007	-.0260	.0142	.0241	.0091
Mean Absolute Error	.0079	.0083	.0260	.0149	.0241	.0112
Root-Mean-Sq. Error	.0107	.0116	.0302	.0177	.0278	.0140
Theil's Ineq. Coeff.	.0011	.0012	.0031	.0008	.0012	.0006
Fraction of Error due to a)Bias	.0167	.0045	.7422	.6372	.7549	.4226
b)Diff. Var.	.1074	.2212	.0475	.2457	.2320	.4887
c)Diff. Co-var	.8759	.7743	.2104	.1171	.0131	.0887

JAPAN

TABLE 7.2.11

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0077	-.0061	.0045	-.0572	-1.0270	-1.2130
Mean Absolute Error	.0094	.0061	.0057	.1698	1.0270	1.2130
Root-Mean-Sq. Error	.0105	.0071	.0063	.2326	1.1250	1.4320
Theil's Ineq. Coeff.	.0011	.0007	.0007	.0177	.0840	.1053
Fraction of Error due to a)Bias	.5473	.7441	.5139	.0682	.8346	.7182
b)Diff. Var.	.3834	.0063	.1054	.0052	.0774	.1826
c)Diff. Co-var	.0693	.2495	.3807	.9267	.0881	.0993

EXHIBIT (7.1.11) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (JAPAN)

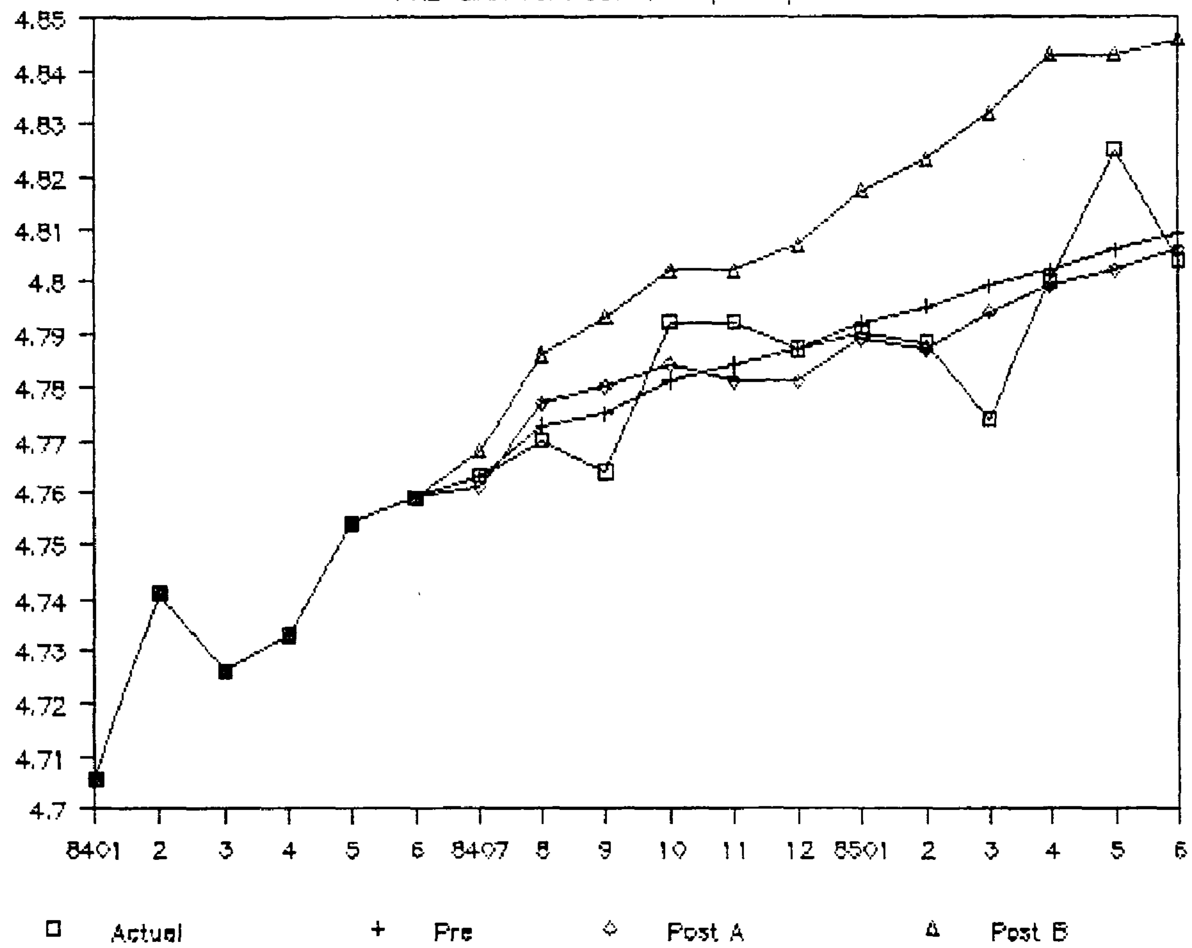


EXHIBIT (7.2.11) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (JAPAN)

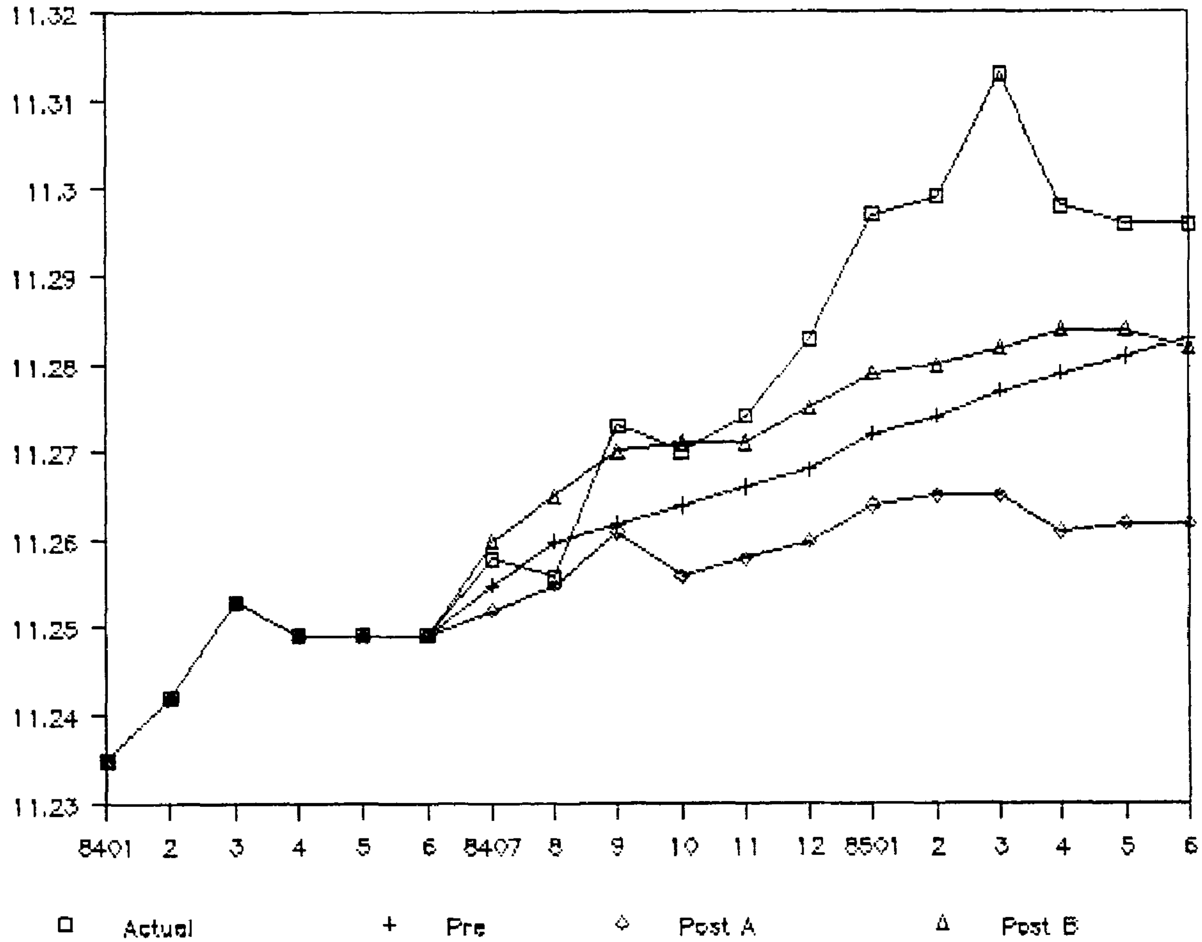


EXHIBIT (7.3.11) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (JAPAN)

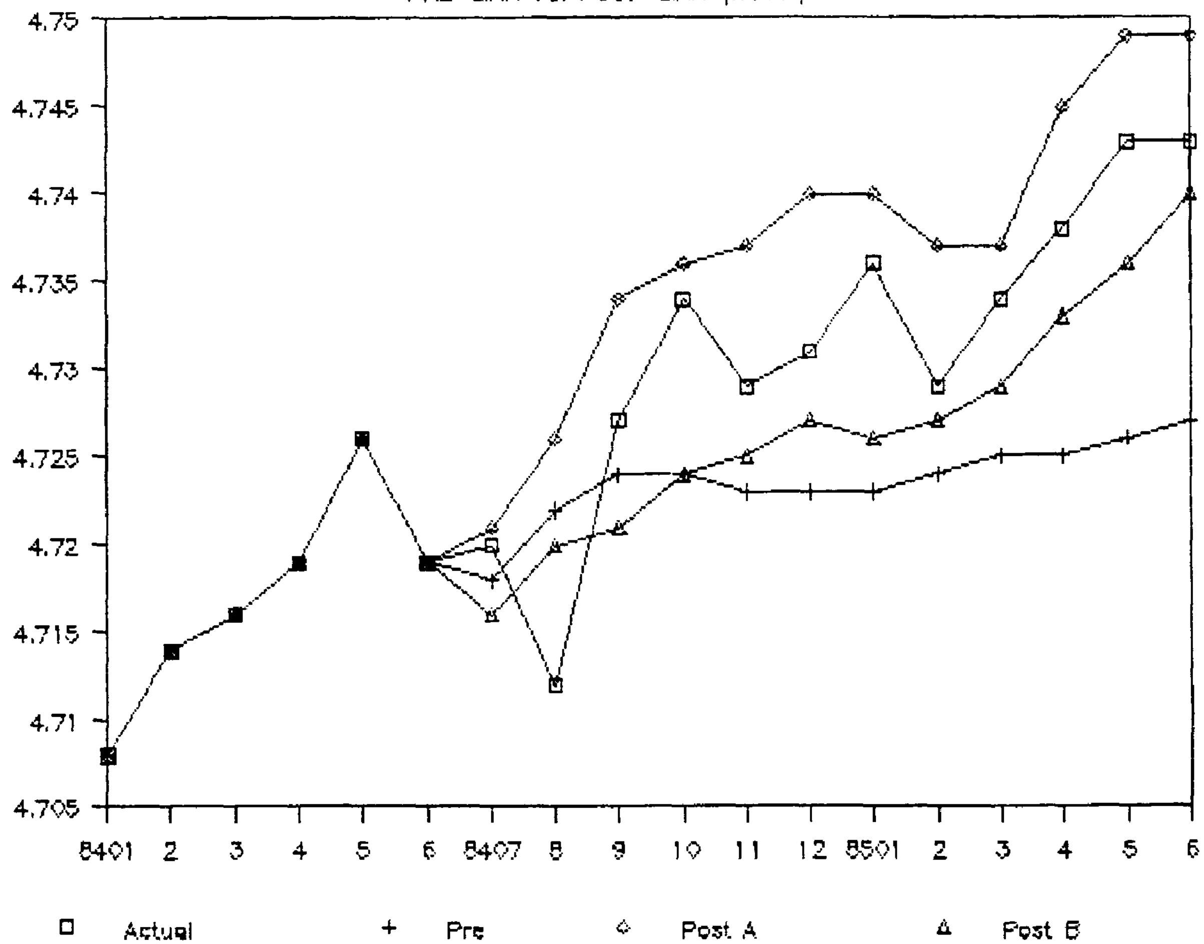
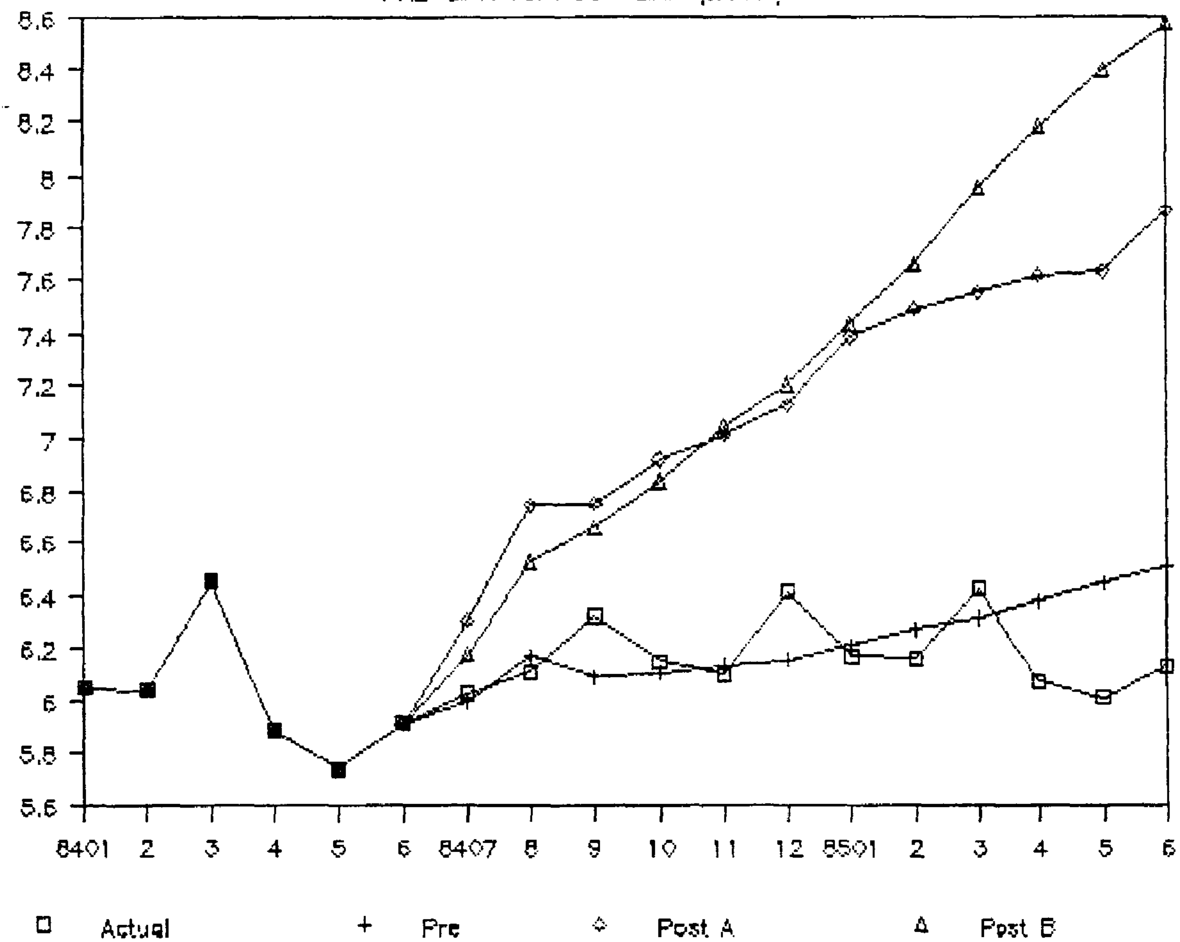


EXHIBIT (7.4.11) FORECASTS FOR INTEREST

EXHIBIT (7.4.11) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (JAPAN)



not show any improvement over the pre-link forecast.

The erratic movements in the actual values of the money supply were not predicted by either of the three competing forecasts. The best forecast, specifically in the first five months, was generated by the post-link B specification. Pre-link and post-link A forecasts are both biased in the downward direction, while pre-link prediction is better than the post-link A prediction.

Both post-link forecasts are substantially better than the pre-link forecast of price. The best forecast is the post-link B forecast, with the lowest forecast errors. It also follows the pattern in the actual series very closely, with the exception of the fourth and seventh months. The post-link A forecast, although replicating the actual movements very well, consistently overpredicts. The pre-link forecast resembles a straight line extrapolation, which also underpredicts the price movements in the last nine months of the forecast period.

The pre-link forecast of the interest rate is by far the best among the three. Both post-link forecasts were explosive, overshooting the actual values over the entire twelve months.

The overall results for Japan indicate that the international linkages help to produce competitive forecasts at best. The post-link B forecasts improve two, money and price, while making the other two worse. The post-link A forecasts compares even less favorably, with only one better forecast for price, one 'no change' forecast for output, and two worse forecasts for money and interest rate.

Netherlands

The forecast comparison of pre-link versus post-link specifications for Netherlands is reported in Tables 7.1.12, 7.2.12 and graphically illustrated in Exhibits 7.1.12, 7.2.12, 7.3.12, and 7.4.12.

The movements in the output variable within the first six months of the forecast horizon were predicted reasonably well by both pre-link and post-link A selections. The wide fluctuations in the later part of the prediction period on the other hand, were not predicted accurately at all. The post-link A forecast, which has the lowest forecast errors, is the best among the three. The post-link B forecast has higher forecast errors and also biased in the downward direction. Both post-link selections predicted the actual upswing in the last three months of the horizon, while the pre-link selection predicted a continuous downturn.

The money supply forecasts of all three selections are completely of the mark, underpredicting the actual values over the entire horizon. The post-link A forecast and pre-link forecast have almost the same forecast errors, while post-link B has the highest errors among the three.

NETHERLANDS

TABLE 7.1.12

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0363	.0308	.0523	.0777	.0764	.0855
Mean Absolute Error	.0376	.0342	.0523	.0777	.0764	.0855
Root-Mean-Sq. Error	.0476	.0438	.0625	.0840	.0837	.0951
Theil's Ineq. Coeff.	.0052	.0047	.0068	.0096	.0096	.0109
Fraction of Error due to a)Bias	.5821	.4966	.7005	.8541	.8321	.8087
b)Diff. Var.	.1181	.1610	.0225	.0828	.0590	.0156
c)Diff. Co-var	.2997	.3424	.2770	.0631	.1089	.1757

NETHERLANDS

TABLE 7.2.12

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0115	.0005	-.0026	-3.6630	-4.4680	-1.5510
Mean Absolute Error	.0115	.0030	.0028	3.6630	4.4680	1.6150
Root-Mean-Sq. Error	.0131	.0035	.0038	3.7880	4.7180	1.7970
Theil's Ineq. Coeff.	.0014	.0004	.0004	.2345	.2773	.1276
Fraction of Error due to a)Bias	.7714	.0229	.4504	.9351	.8965	.7446
b)Diff. Var.	.1722	.5772	.0147	.0066	.0336	.0795
c)Diff. Co-var	.0564	.4000	.5349	.0583	.0699	.1758

EXHIBIT (7.1.12) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (NETHERLANDS)

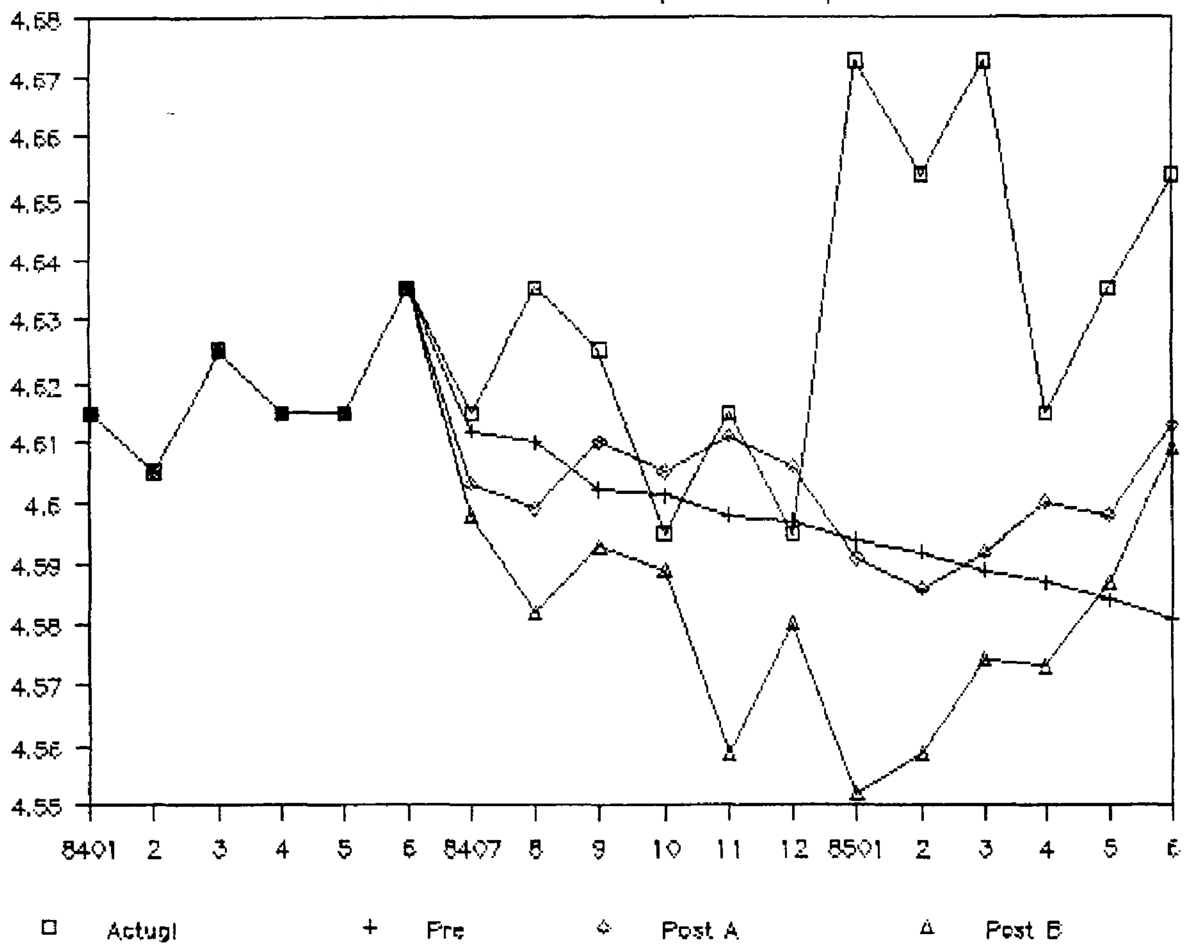


EXHIBIT (7.2.12) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (NETHERLANDS)

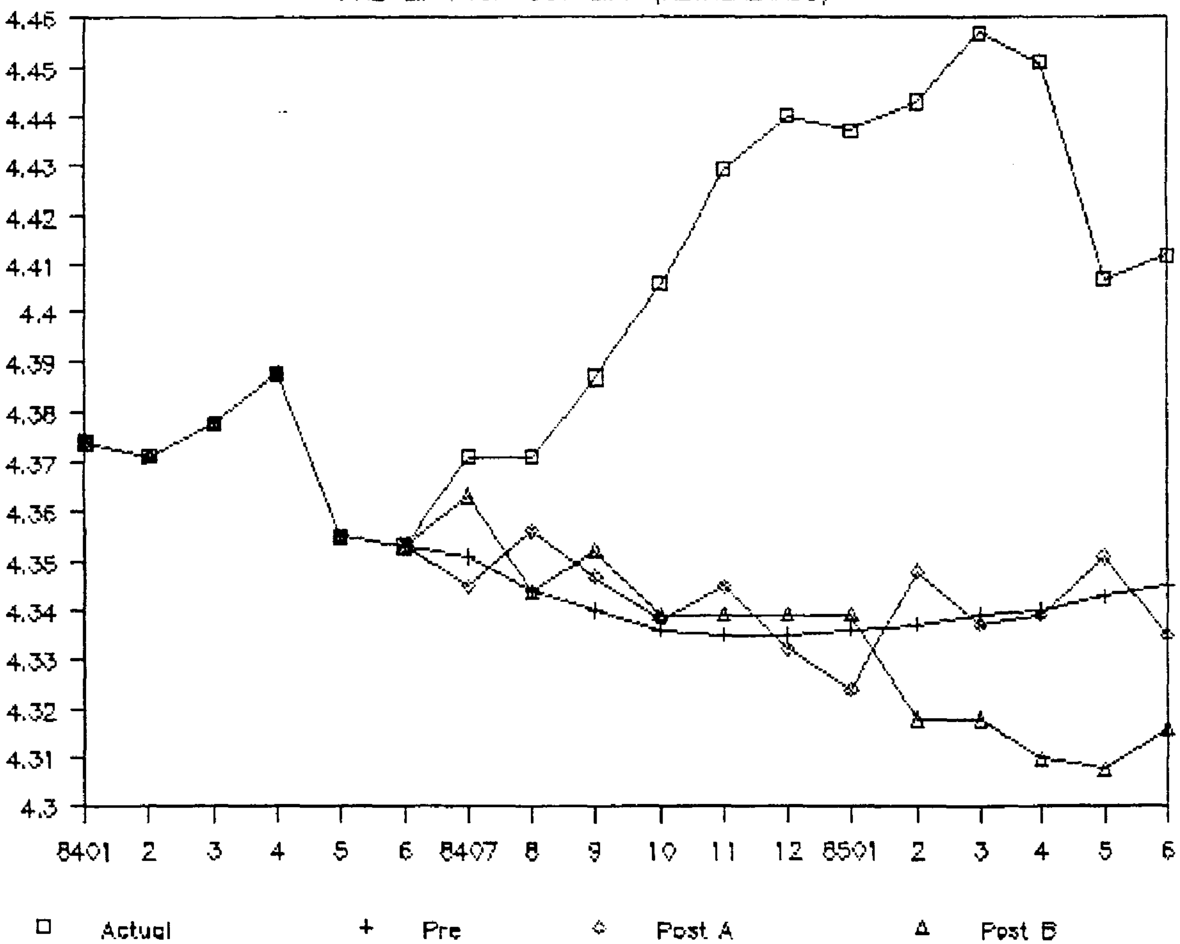


EXHIBIT (7.3.12) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (NETHERLANDS)

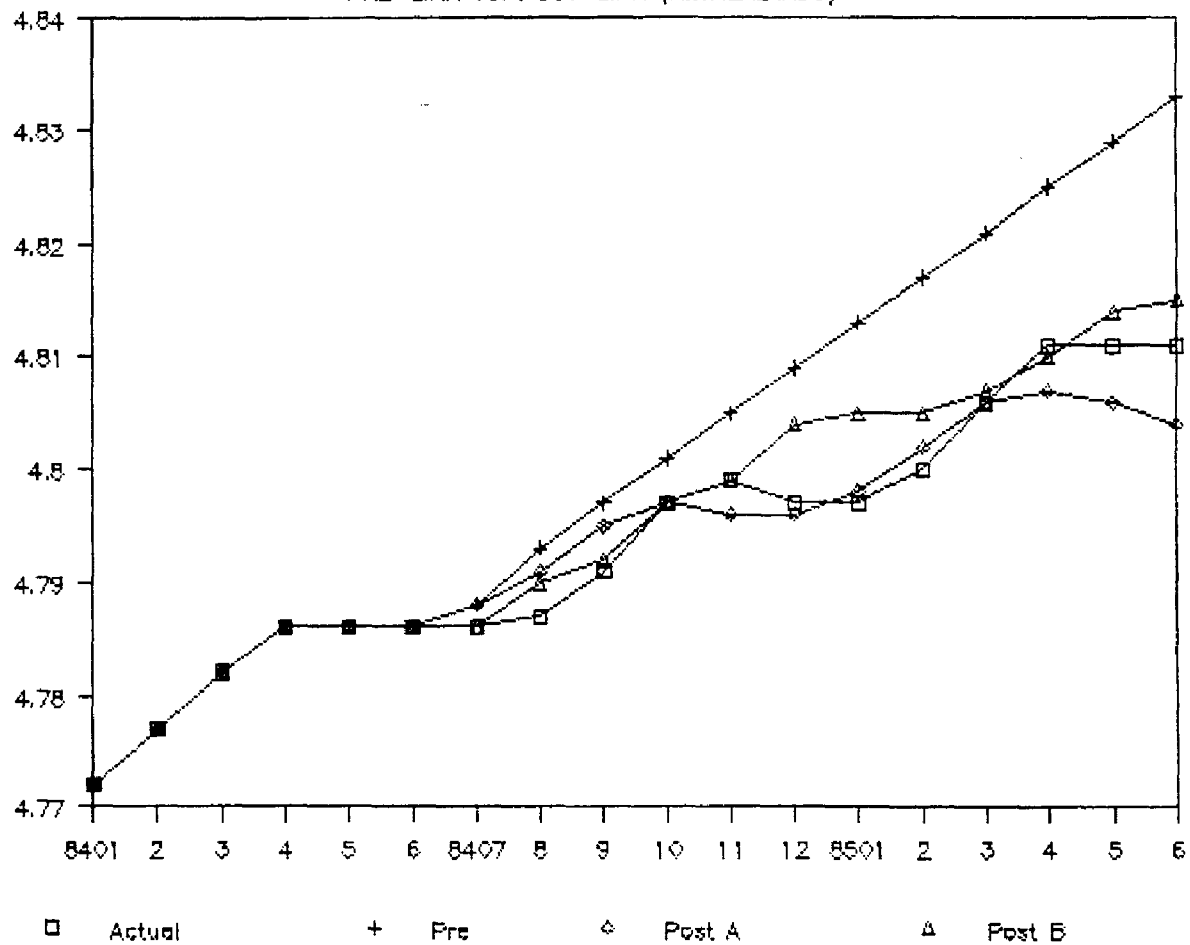
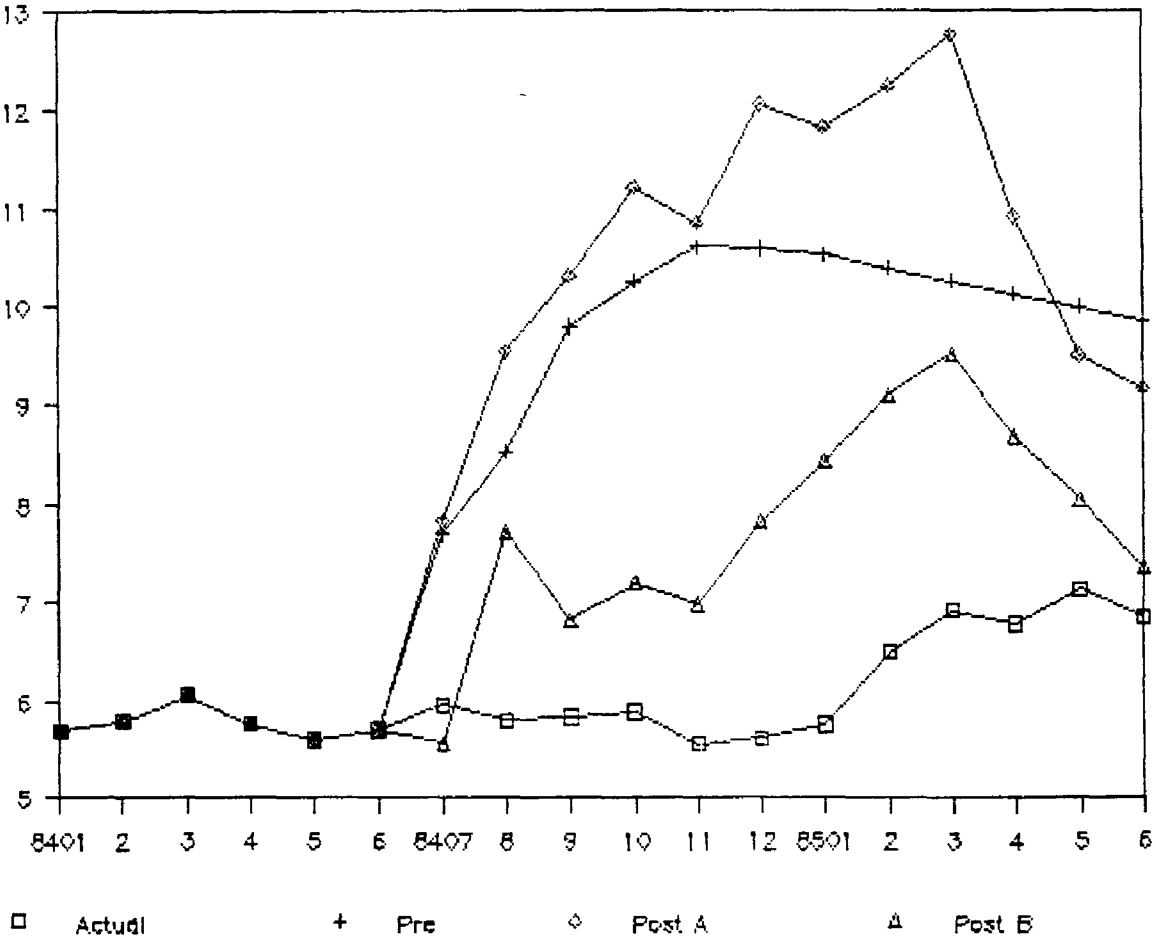


EXHIBIT (7.4.12) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (NETHERLANDS)



The price variable was forecasted remarkably well by both post-link specifications. The pre-link forecast is explosive with forecast errors three times the errors of the post-link selections. The post-link A forecast has a slight edge over the other post-link forecast, specifically in the first nine months.

The interest rate forecasts were all explosive. Only the post-link B selection generated relatively accurate forecasts. The post-link A, which has the highest forecast errors is the worse among the three.

The results for Netherlands indicate that link variables improve at least two forecasts, while making only one forecast worse. Post-link A improved the output and price and the post-link B improved price and interest rate. In both cases there was only one inferior forecast in comparison to the pre-link predictions.

Norway

The comparison of pre-link versus post-link forecast performance for Norway is presented in Tables 7.1.13, 7.2.13 and illustrated in Exhibits 7.1.13, 7.2.13, 7.3.13, and 7.4.13.

All three selections overpredicted output, particularly in the second half of the forecast period. The pre-link forecast which has the lowest prediction errors was the best

NORWAY

TABLE 7.1.13

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0221	-.0368	-.0334	.0523	.0452	.0802
Mean Absolute Error	.0241	.0385	.0343	.0533	.0470	.0802
Root-Mean-Sq. Error	.0332	.0537	.0464	.0653	.0569	.0968
Theil's Ineq. Coeff.	.0035	.0056	.0049	.0069	.0060	.0103
Fraction of Error due to a)Bias	.4422	.4692	.5168	.6400	.6310	.6863
b)Diff. Var.	.0216	.0409	.0080	.3326	.3148	.3032
c)Diff. Co-var	.5362	.4899	.4752	.0274	.0543	.0104

NORWAY

TABLE 7.2.13

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0245	.0013	-.0148	-.0139	.0912	-.6964
Mean Absolute Error	.0245	.0048	.0148	1.3920	.6440	.8172
Root-Mean-Sq. Error	.0264	.0060	.0157	1.5800	.8240	1.0250
Theil's Ineq. Coeff.	.0026	.0006	.0016	.0606	.0335	.0404
Fraction of Error due to a)Bias	.8587	.0509	.8891	.7758	.0123	.4619
b)Diff. Var.	.1260	.7640	.0741	.0822	.1331	.2650
c)Diff. Co-var	.0153	.1851	.0368	.1421	.8547	.2731

EXHIBIT (7.1.13) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (NORWAY)

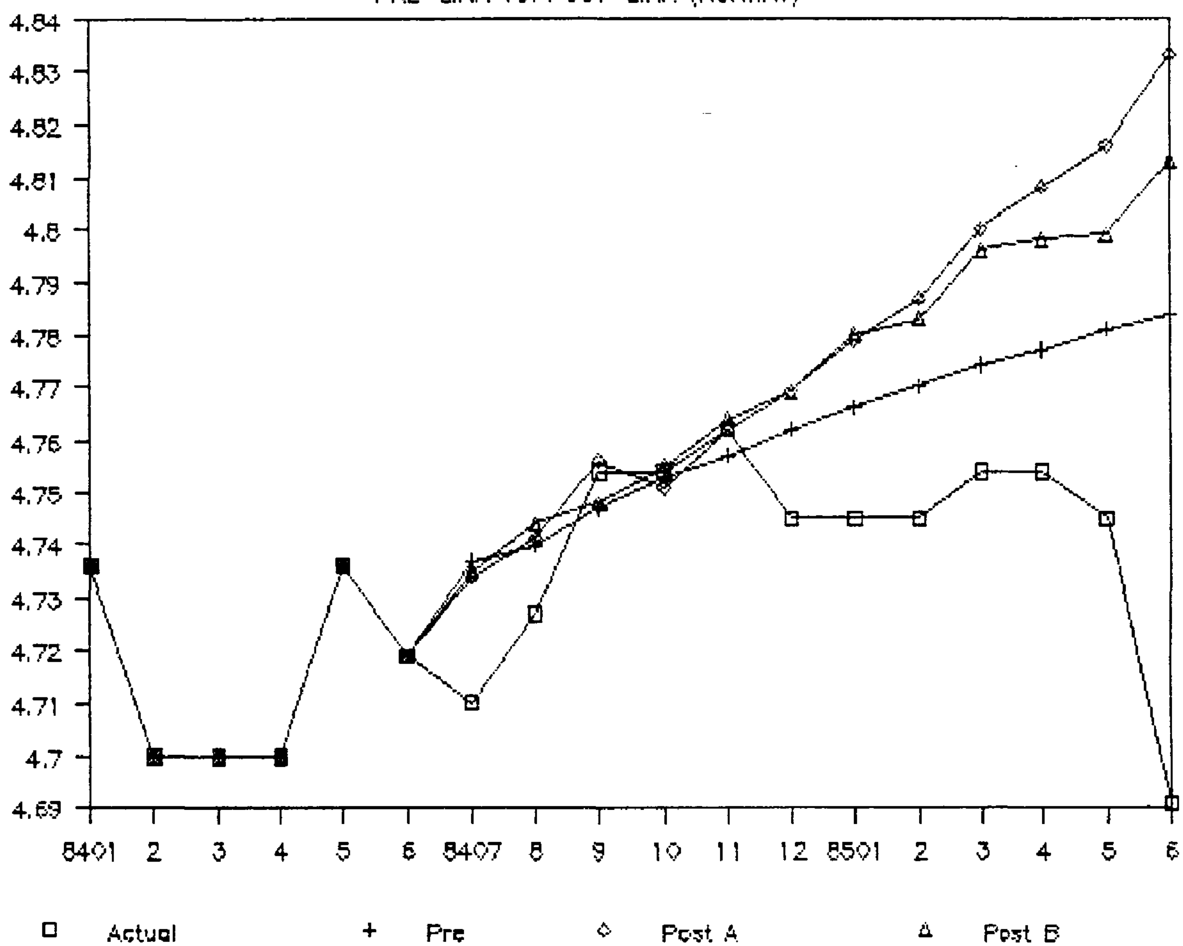


EXHIBIT (7.2.13) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (NORWAY)

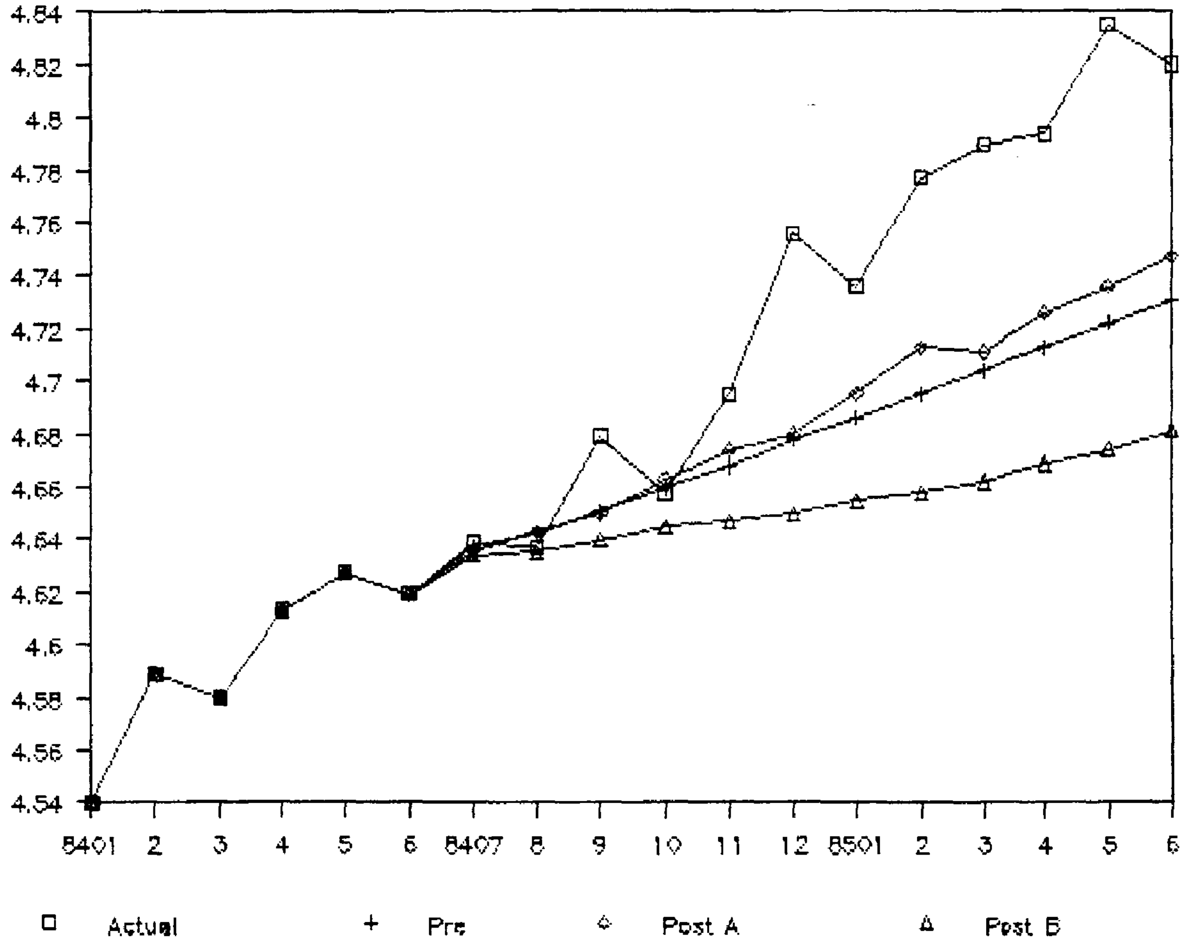
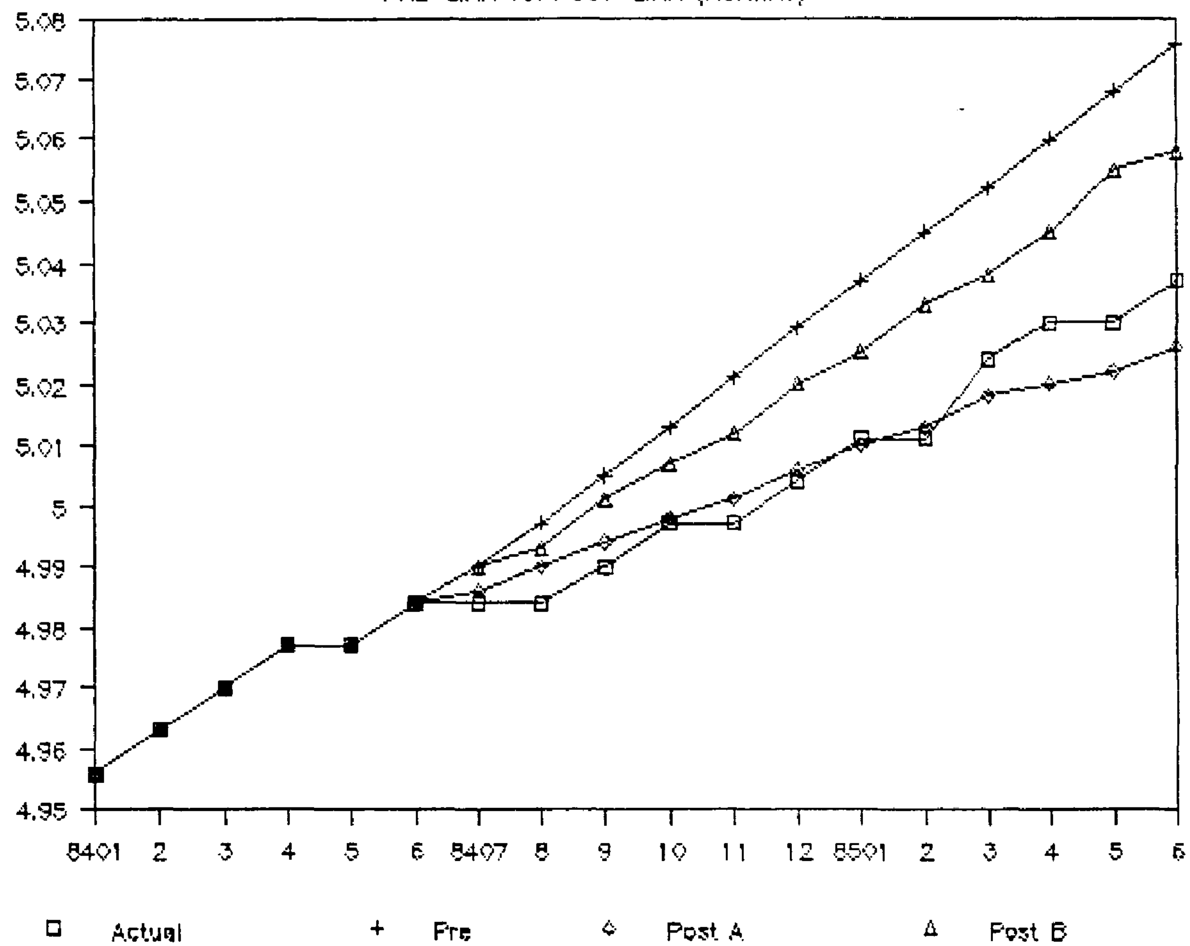


EXHIBIT (7.3.13) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (NORWAY)



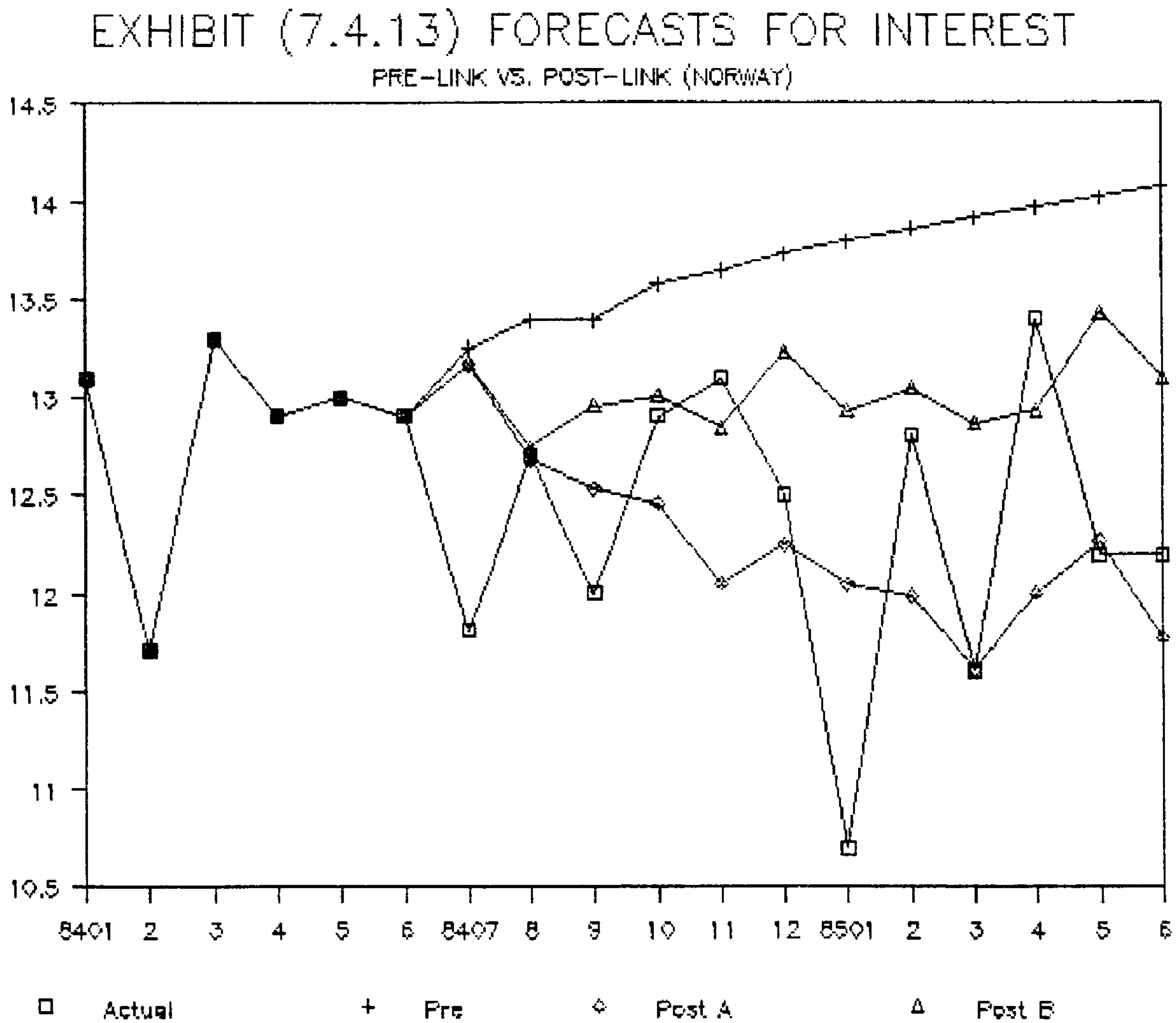


EXHIBIT (7.4.13) FORECASTS FOR INTEREST
PRE-LINK VS. POST-LINK (NORWAY)
14.5
14
13.5
13
12.5
12
11.5
11
10.5
8401
2
3
4
5
6
8407
8
9
10
11
12
8501
2
3
4
5
6
Actual
Pre
Post A
Post B

among the three.

The money supply was underpredicted by all three specifications. The post-link A forecast has a slight edge over the pre-link forecast, while post-link B forecast is clearly the worst.

Both post-link selections generated a better forecast of price than the pre-link selection. The post-link A forecast is in fact, remarkably accurate with forecast errors five times smaller than the pre-link forecast errors. The post-link B forecast, although not as accurate, still has lower forecast errors than the pre-link forecast.

The interest rate was forecasted fairly accurately by both post-link specifications, whereas the pre-link specification completely missed the mark. The actual values of the interest rate fluctuated widely over the entire twelve months and the post-link forecasts, although unable to capture these fluctuations, were reasonably accurate. The post-link A forecast which has the lowest forecast errors is the best among the three.

Under the linkage mechanism A, three improved forecasts were generated, money (marginal), price and interest rate. The post-link B selection produced two better forecasts, price and interest rate. Thus, it seems reasonable to conclude that, incorporating the international influence into the domestic model helped the forecast performance.

Spain

The comparison of the pre-link and the post-link forecast performance for Spain is presented in Tables 7.1.14, and 7.2.14 and illustrated in Exhibits 7.1.14, 7.2.14, and 7.3.14.

All three selections generated fairly inaccurate forecast of output. The post-link forecasts overpredicted and the pre-link forecast underpredicted the actual values over the entire forecast period. Although, the pre-link selection has the lowest prediction errors, it is hard to claim that the pre-link forecast is superior over the post-link forecasts. All forecasts of output should be considered equally bad.

The money forecasts for Spain do not indicate much accuracy on the part of either specification. The post-link A forecast fluctuates widely, while the actual values do not. The pre-link forecast has an upward bias, and the post-link B forecast underpredicts the actuals in the first nine months. The post-link B prediction with the lowest forecast errors can be considered as the best among the three. The post-link a forecast, which has a bias component of almost hundred percent is the worst of the three.

Both post-link predictions of price were fairly accurate and better than the pre-link prediction. The post-link A

SPAIN

TABLE 7.1.14

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0161	-.0219	-.0182	-.0614	-.0621	.0239
Mean Absolute Error	.0171	.0264	.0226	.0614	.0662	.0256
Root-Mean-Sq. Error	.0214	.0313	.0269	.0642	.0916	.0306
Theil's Ineq. Coeff.	.0023	.0034	.0029	.0037	.0053	.0018
Fraction of Error due to a)Bias	.5650	.4883	.4612	.9140	.4602	.6097
b)Diff. Var.	.2050	.0074	.0011	.0641	.2922	.2522
c)Diff. Co-var	.2300	.5043	.5377	.0219	.2476	.1382

SPAIN

TABLE 7.2.14

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0126	.0073	-.0079	——	——	——
Mean Absolute Error	.0141	.0073	.0094	——	——	——
Root-Mean-Sq. Error	.0166	.0086	.0110	——	——	——
Theil's Ineq. Coeff.	.0017	.0008	.0011	——	——	——
Fraction of Error due to a)Bias	.5749	.7137	.5153	——	——	——
b)Diff. Var.	.3225	.0591	.2424	——	——	——
c)Diff. Co-var	.1025	.2272	.2423	——	——	——

EXHIBIT (7.1.14) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (SPAIN)

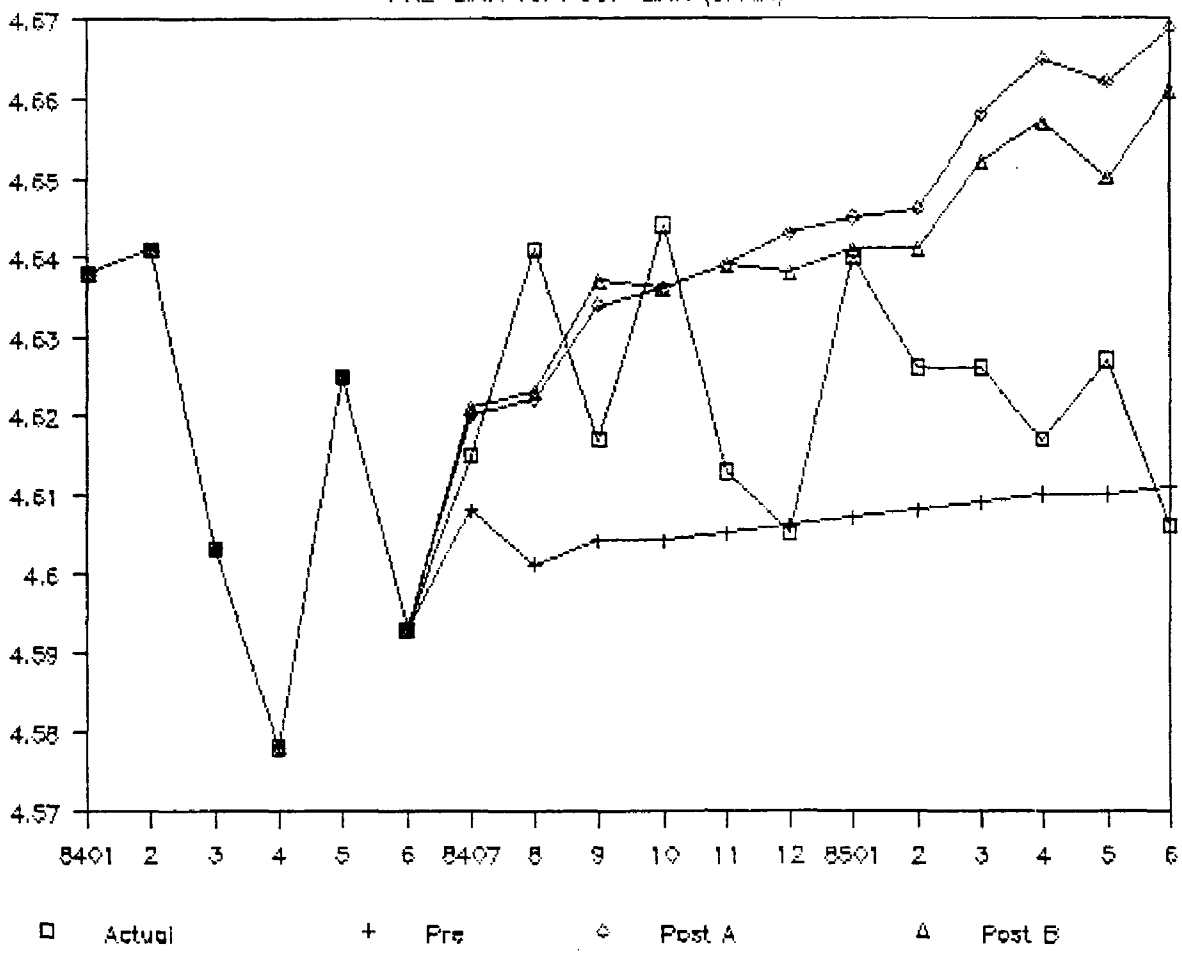


EXHIBIT (7.2.14) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (SPAIN)

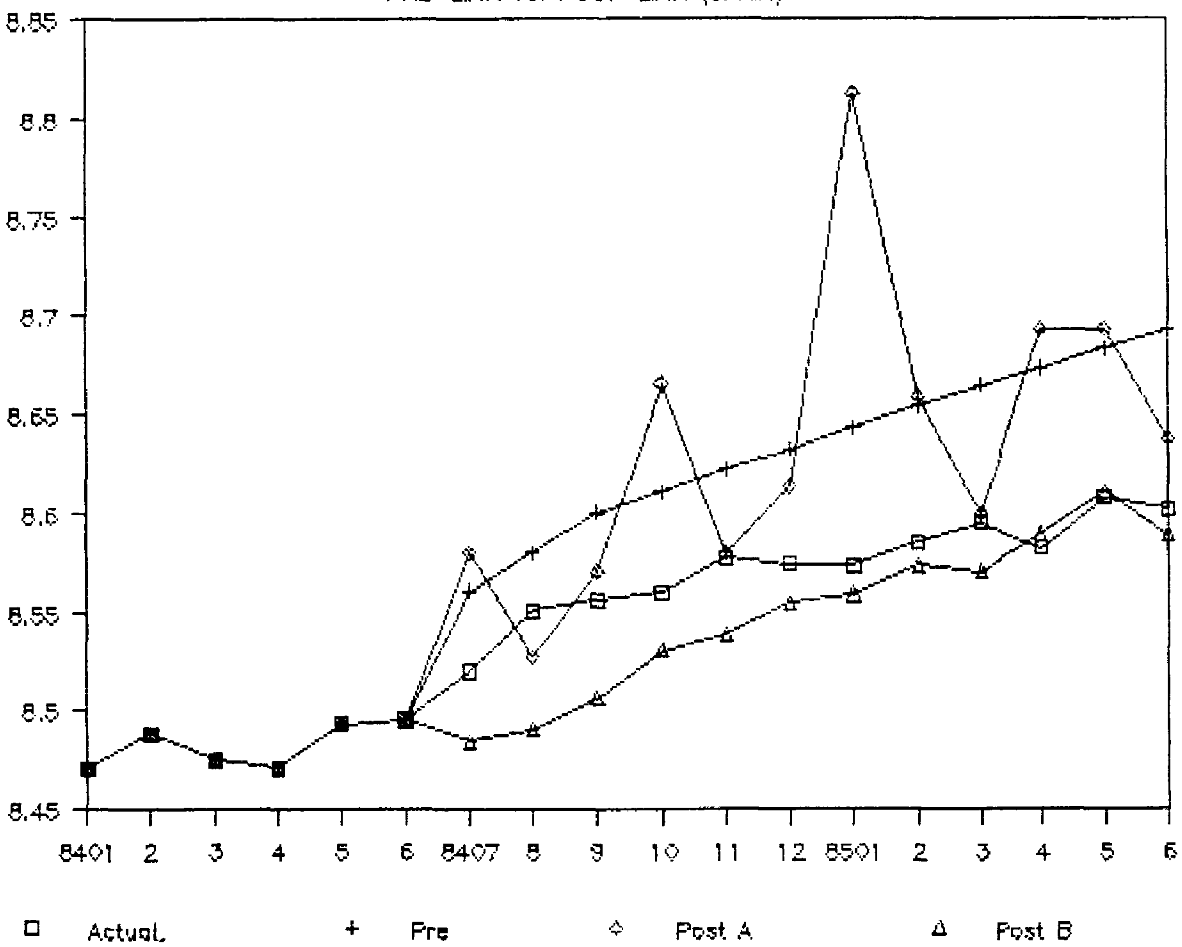
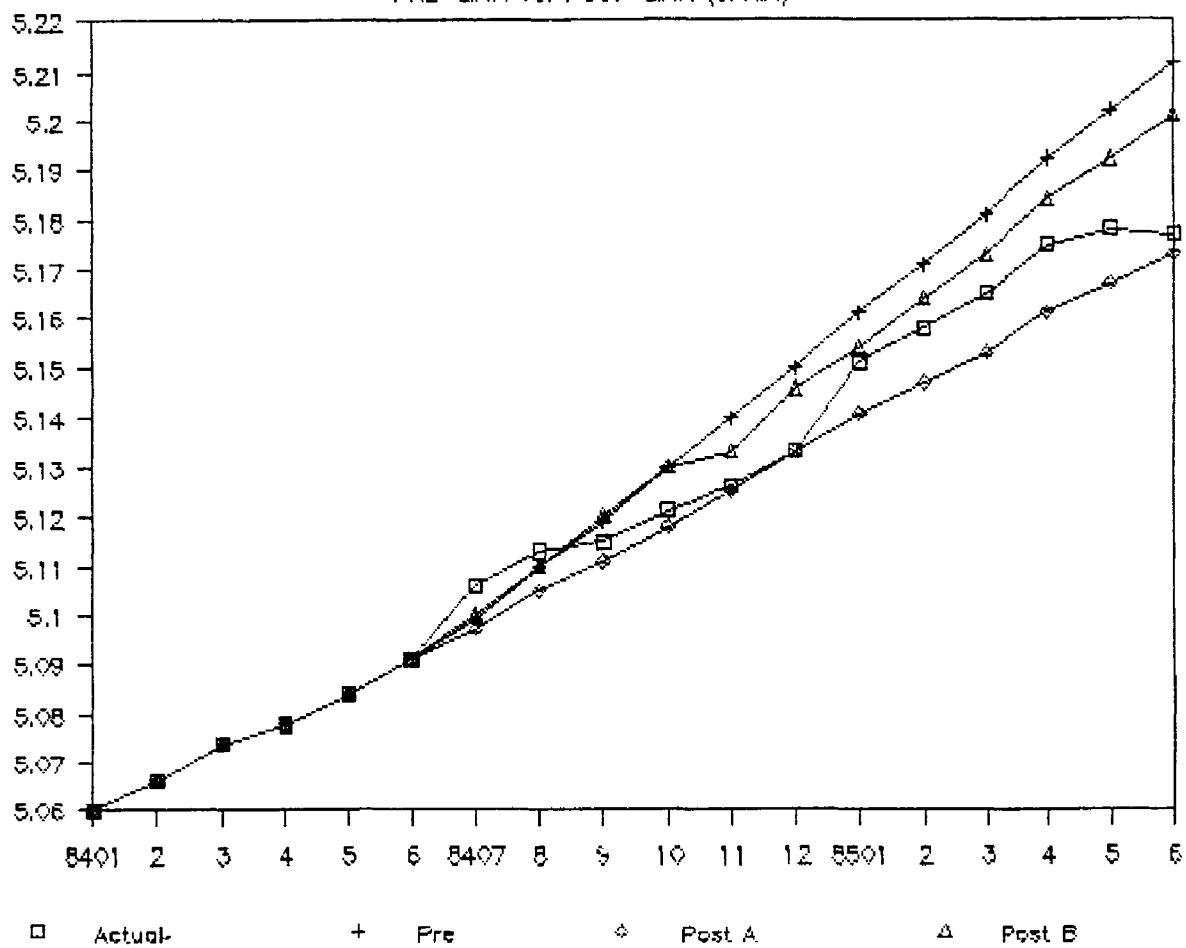


EXHIBIT (7.3.14) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (SPAIN)



specification generated the most accurate prediction as evident from the low forecast errors.

The overall results for Spain indicate that, the international linkages, in the case of post-link A, helps to one variable, does not change one, and does make the third worse. The post-link B selection on the other hand, improved two out of three forecasts.

Sweden

The forecast comparison of the pre-link and the post-link specifications for Sweden is reported in Tables 7.1.15, 7.2.15, and graphically shown in Exhibits 7.1.15, 7.2.15, 7.3.15, and 7.4.15.

The actual values of output showed some wide fluctuations within the forecast horizon. These movements in the actual output were not captured by any of the three alternative selection. The forecast errors of all three specifications are very close. In terms of the decomposition of Theil's inequality coefficient, the post-link B has the most favorable distribution of errors.

The money forecasts for Sweden were again not so accurate. The one period jump in the sixth month, and the three periods decline in the last three months were not captured by any of the three selections. The post-link B forecast, specifically over the first four months, shows some marginal

SWEDEN

TABLE 7.1.15

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0158	-.0092	.0081	.0116	.0066	.0033
Mean Absolute Error	.0218	.0201	.0222	.0144	.0167	.0142
Root-Mean-Sq. Error	.0302	.0280	.0320	.0224	.0238	.0205
Theil's Ineq. Coeff.	.0032	.0030	.0034	.0019	.0020	.0017
Fraction of Error due to a)Bias	.2744	.1080	.0643	.2685	.0776	.0253
b)Diff. Var.	.5789	.8434	.4150	.1189	.0041	.0645
c)Diff. Co-var	.1468	.0486	.5207	.6126	.9184	.9102

SWEDEN

TABLE 7.2.15

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0110	-.0131	-.0249	2.1460	1.4700	1.9810
Mean Absolute Error	.0110	.0131	.0249	2.2260	1.6670	1.1360
Root-Mean-Sq. Error	.0124	.0149	.0274	2.6340	1.9490	1.3530
Theil's Ineq. Coeff.	.0012	.0015	.0027	.1082	.0779	.0514
Fraction of Error due to a)Bias	.7858	.7743	.8252	.6635	.5690	.0214
b)Diff. Var.	.1252	.1623	.1414	.1824	.3396	.2360
c)Diff. Co-var	.0890	.0634	.0334	.1541	.0914	.7428

EXHIBIT (7.1.15) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (SWEDEN)

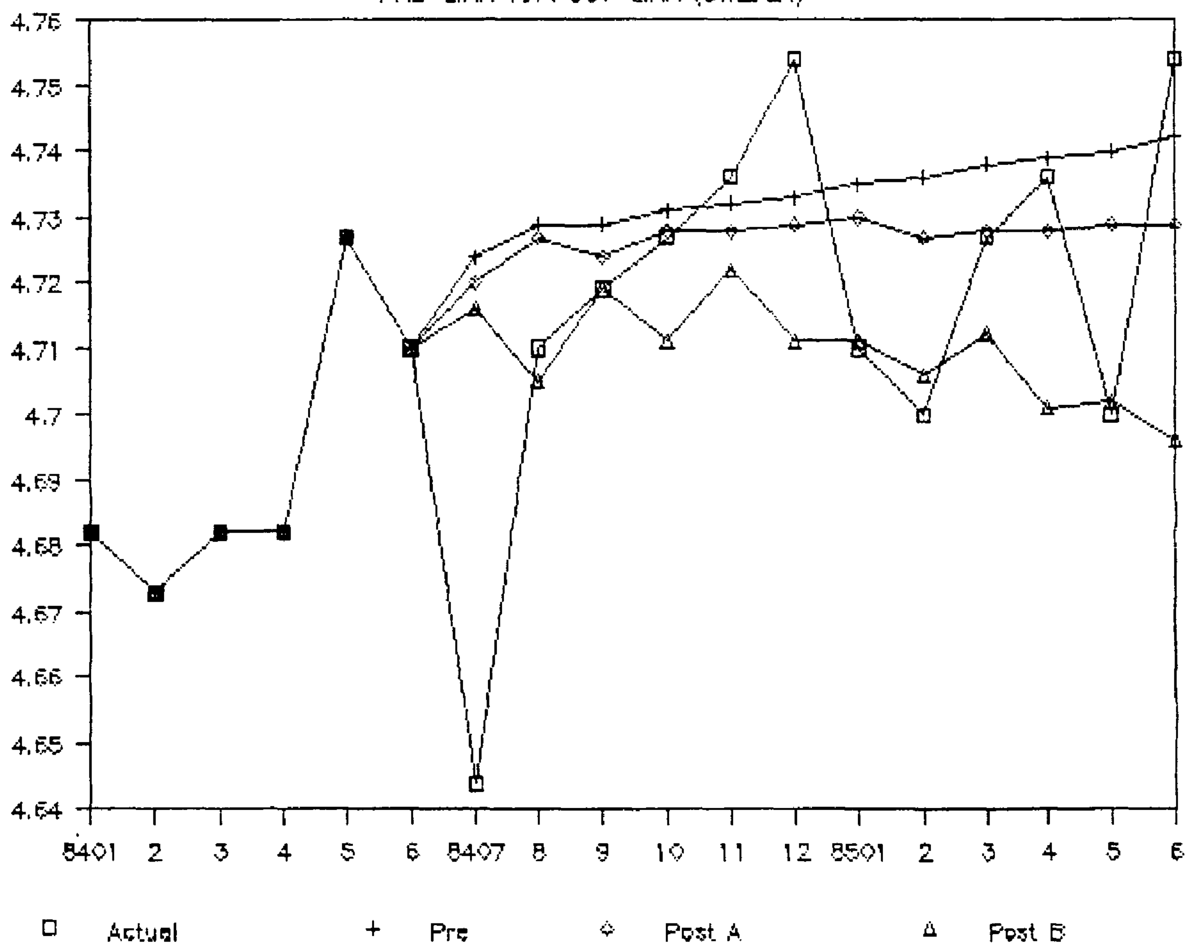


EXHIBIT (7.2.15) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (SWEDEN)

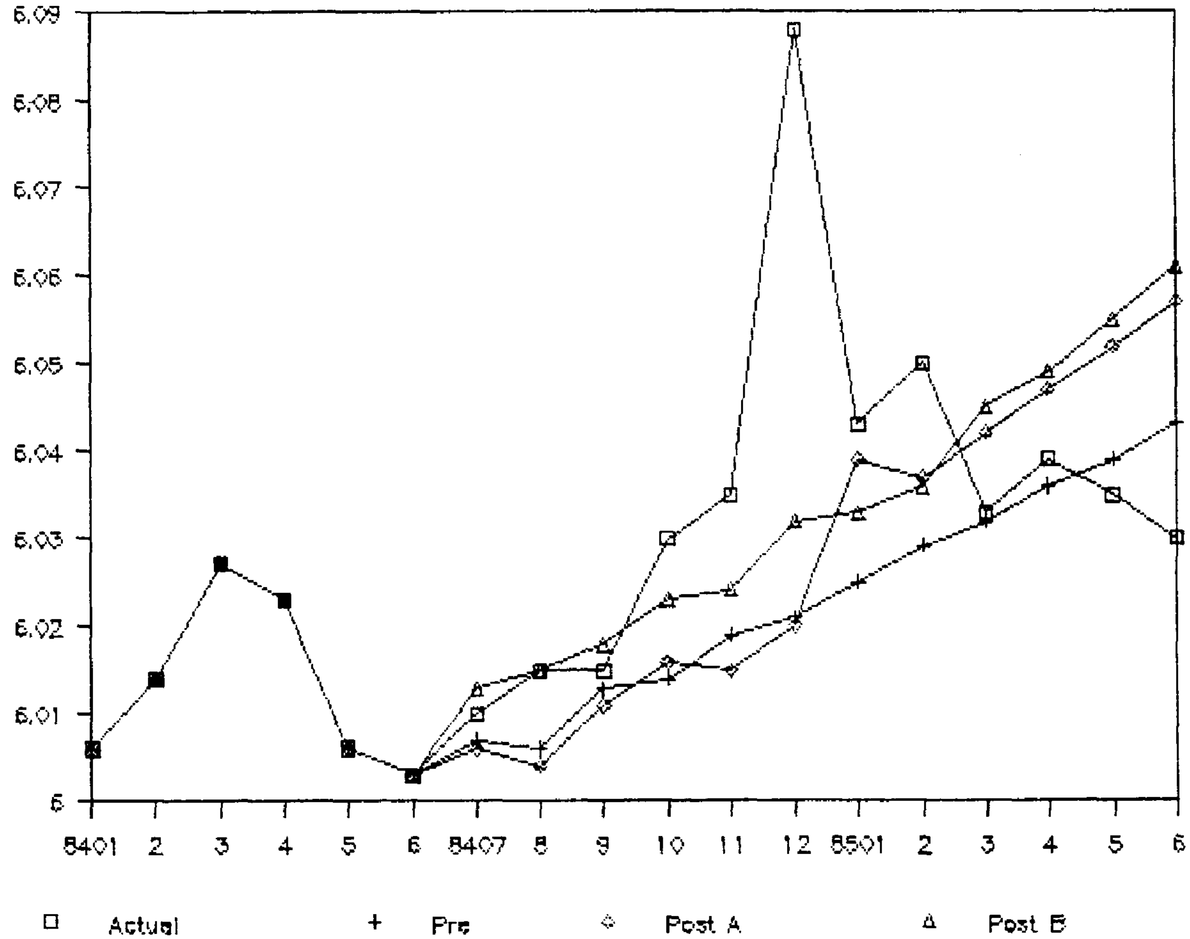


EXHIBIT (7.3.15) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (SWEDEN)

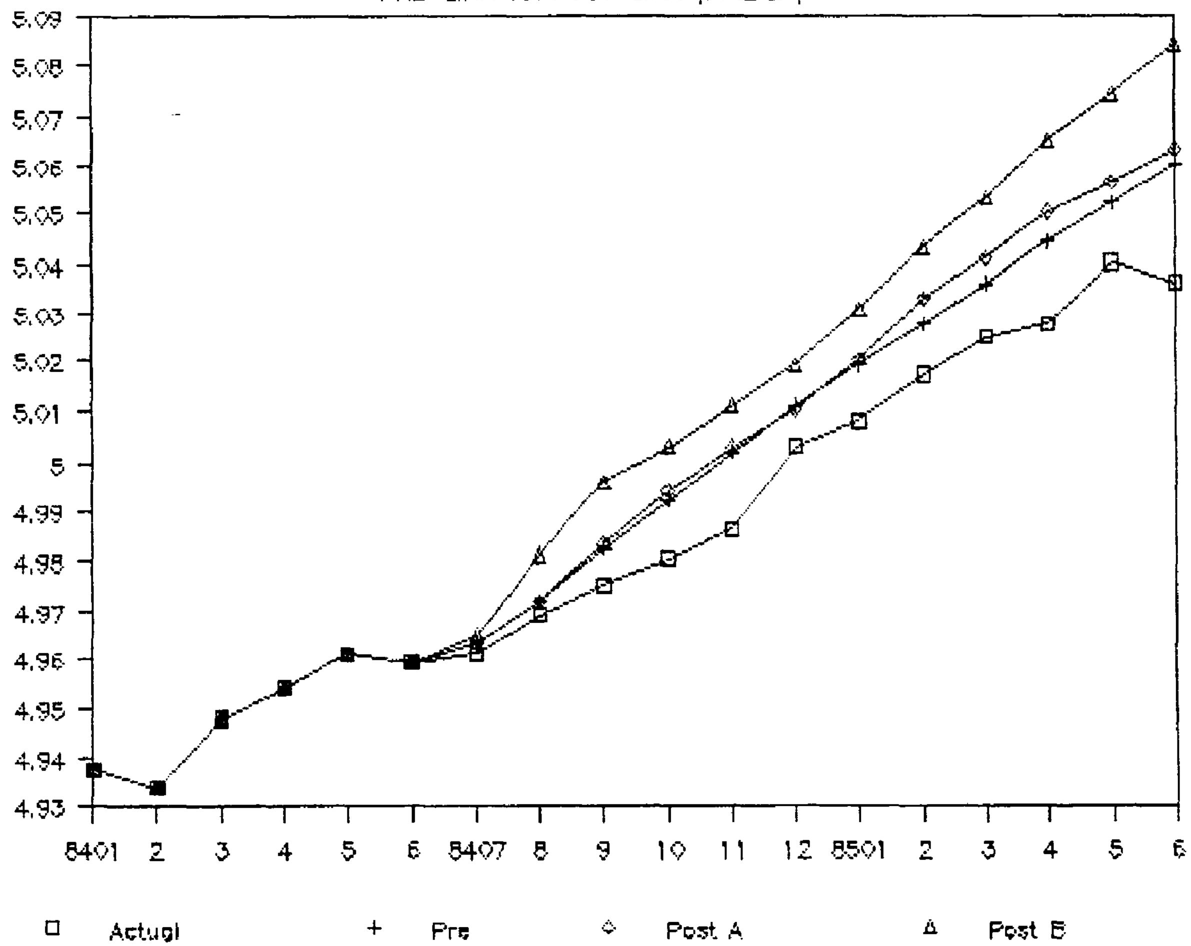
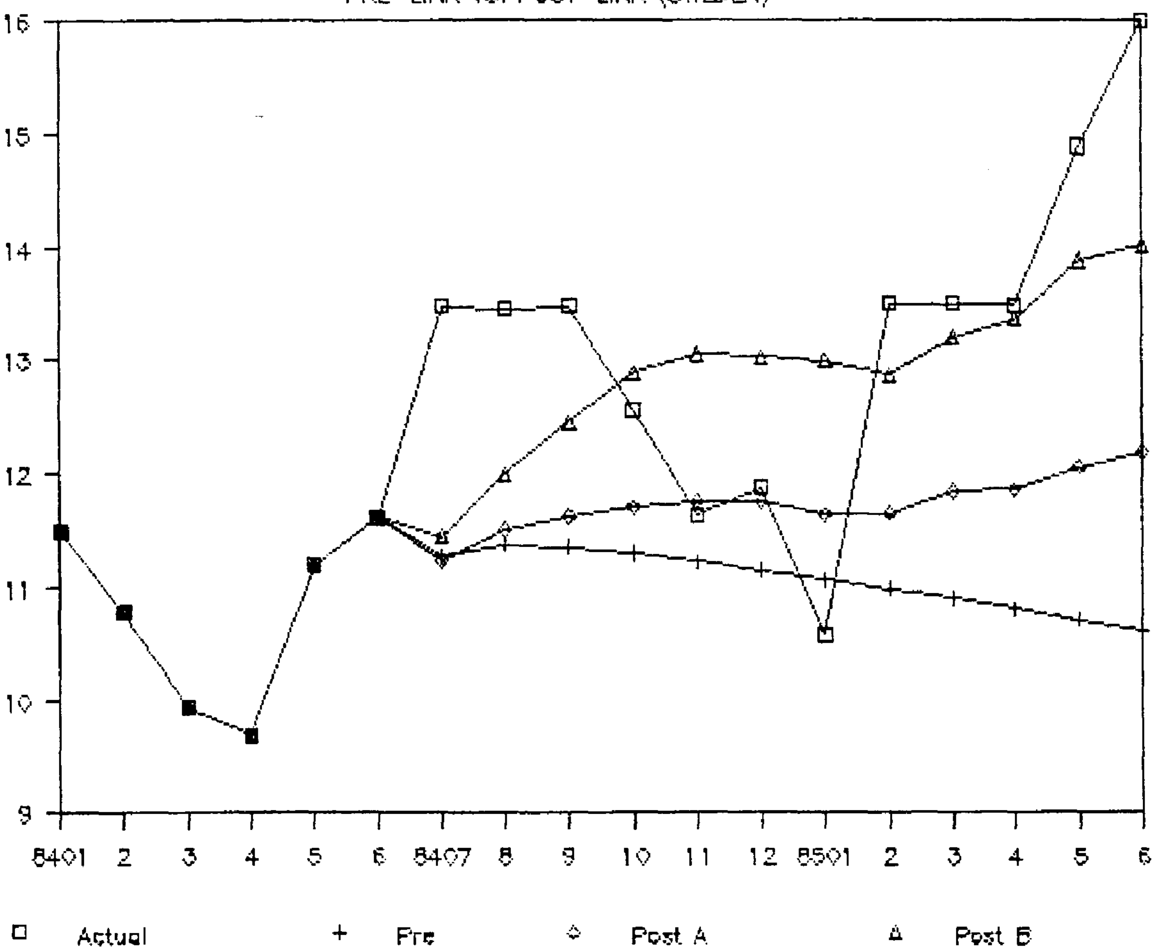


EXHIBIT (7.4.15) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (SWEDEN)



superiority over the post-link A as well as pre-link forecasts. Both pre-link and post-link A predictions can be considered equally inaccurate.

The price variable was consistently overpredicted by all three specifications. Pre-link and post-link A forecasts are almost identical, while the post-link B forecast is worse than the two. The distribution of error among the fractions of the Theil's U coefficient seems to be fairly similar in all three forecasts.

The actual interest rate values showed some erratic movements over the forecast horizon. These fluctuations were not picked up by any of the three specifications. The pre-link forecast was completely of the mark. The post-link A forecast was relatively better than pre-link, while the post-link B forecast was the best among the three.

An overall assessment of the post-link A forecast performance shows that, there was a slight improvement in the interest rate forecast without any changes in the other three variables. Post-link B on the other hand, was more successful and generated two better forecasts and one no change forecast with only one inferior forecast over the pre-link selection.

Switzerland

The comparison of the pre-link versus the post-link forecast performance for Switzerland is presented in Tables 7.1.16, 7.2.16, and illustrated in Exhibits 7.1.16, 7.2.16, 7.3.16, and 7.4.16.

The pre-link forecast for output, which has the lowest forecast errors is the best among the three alternative selections. Both post-link forecasts of output are explosive. The actual output values showed some fluctuations over the twelve month period, which was not captured by any of the three specifications. Even the pre-link forecast which can be considered the best among the three does not replicate the actual movement in the output.

The money supply was forecasted remarkably well by the pre-link selection. The pre-link forecast is almost identical to the actual values and even the one period jumps like the one in the sixth month was picked up by this forecast. The post-link forecasts on the other hand were fairly inaccurate. Among the two post-link selections, A has an edge over the B.

The price variable was forecasted most accurately by again the pre-link specification, while the post-link selections consistently overpredicted the actual values over the entire twelve months period. The pre-link selection

SWITZERLAND

TABLE 7.1.16

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0049	-.0206	-.0343	-.0013	-.0129	.0592
Mean Absolute Error	.0108	.0206	.0343	.0074	.0237	.0601
Root-Mean-Sq. Error	.0126	.0230	.0371	.0084	.0290	.0724
Theil's Ineq. Coeff.	.0014	.0025	.0040	.0010	.0035	.0088
Fraction of Error due to a)Bias	.1503	.8021	.8527	.0226	.1980	.6701
b)Diff. Var.	.6884	.0099	.0368	.0036	.1395	.0127
c)Diff. Co-var	.1612	.1880	.1105	.9738	.6625	.3173

SWITZERLAND

TABLE 7.2.16

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0016	-.0083	-.0135	.3681	-.4331	-.4893
Mean Absolute Error	.0045	.0083	.0135	.3681	.4473	.5026
Root-Mean-Sq. Error	.0051	.0101	.0143	.4055	.5335	.5744
Theil's Ineq. Coeff.	.0005	.0010	.0014	.0447	.0540	.0578
Fraction of Error due to a)Bias	.1005	.6735	.8838	.8240	.6589	.7256
b)Diff. Var.	.4180	.0649	.0363	.0000	.2524	.2001
c)Diff. Co-var	.4815	.2616	.0799	.1760	.0887	.0743

EXHIBIT (7.1.16) FORECASTS FOR OUTPUT

PRE-LINK VS POST-LINK (SWITZERLAND)

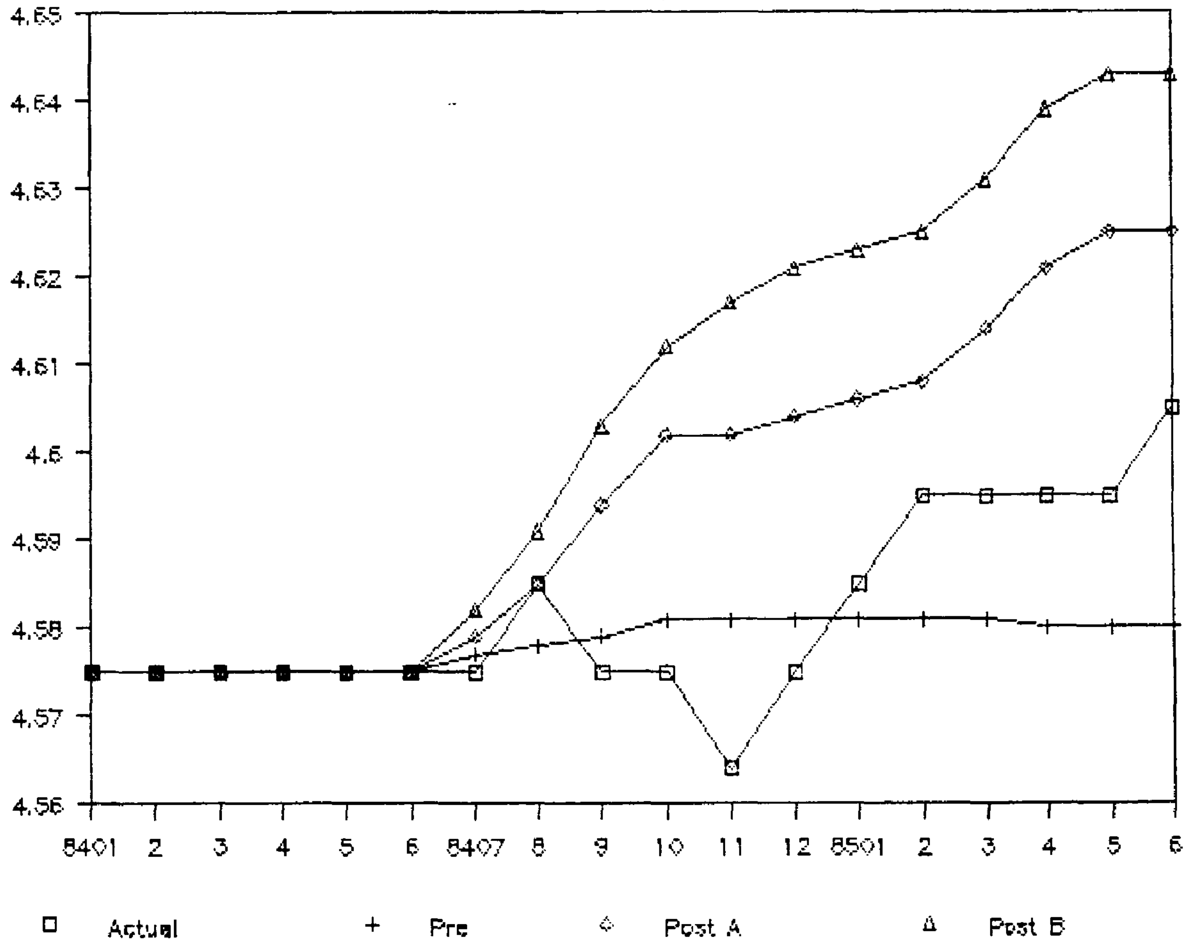


EXHIBIT (7.2.16) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (SWITZERLAND)

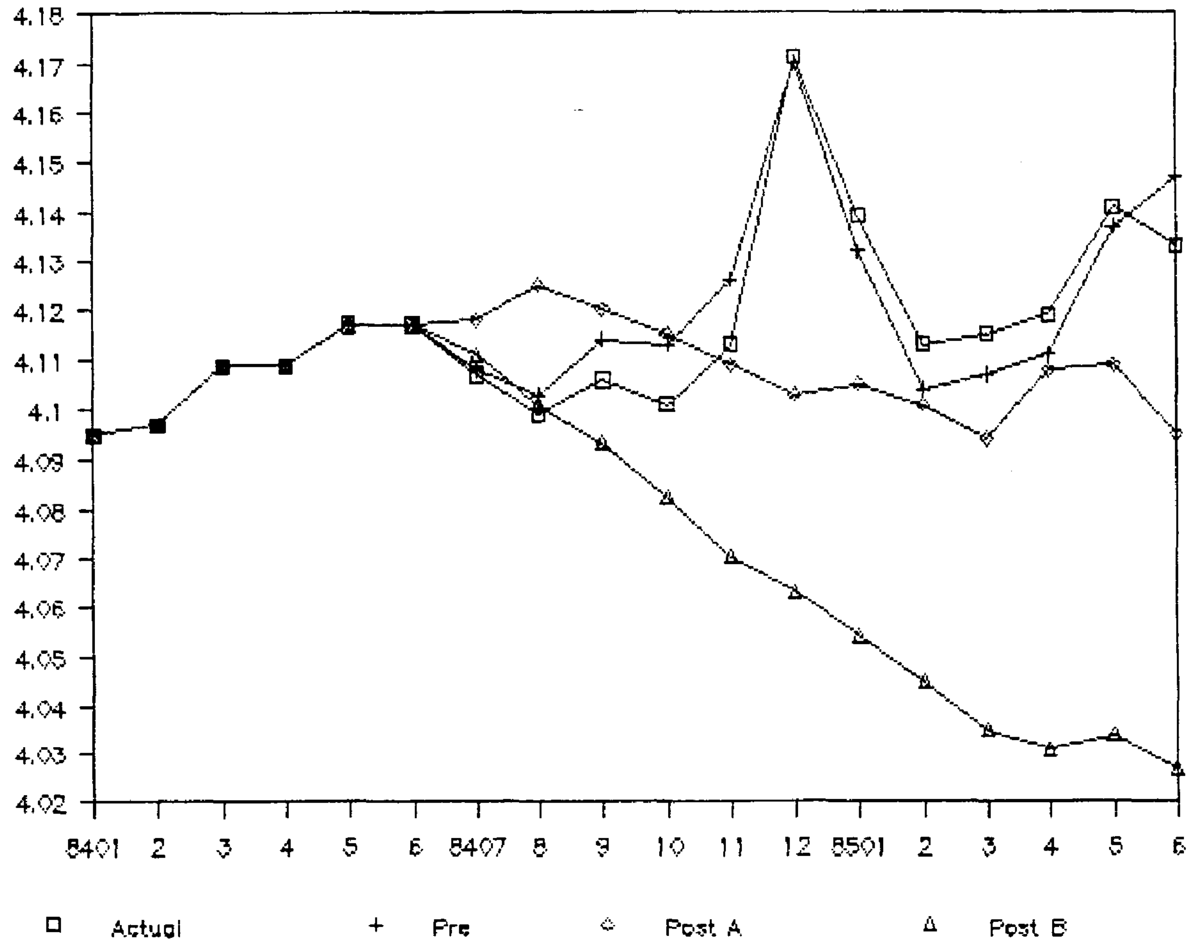


EXHIBIT (7.3.16) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (SWITZERLAND)

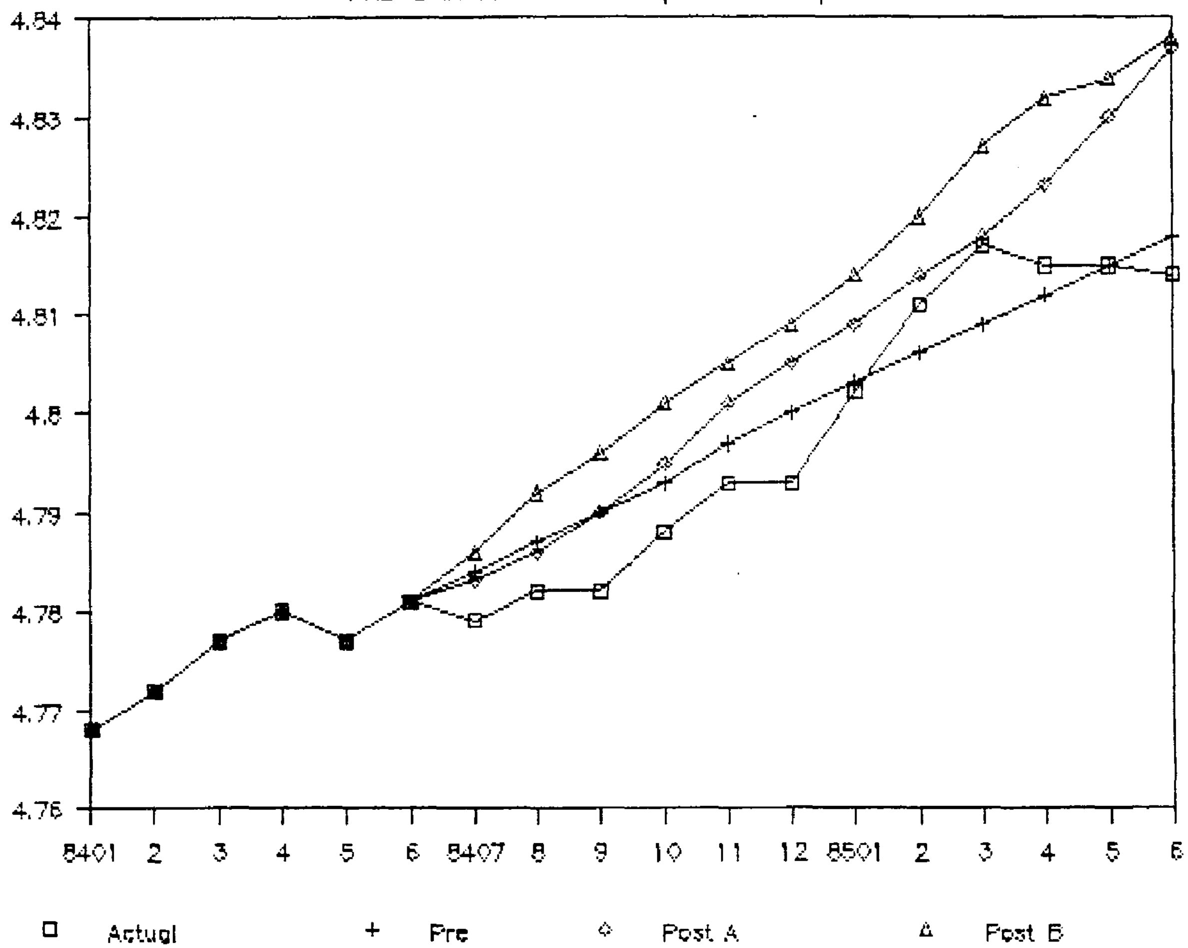
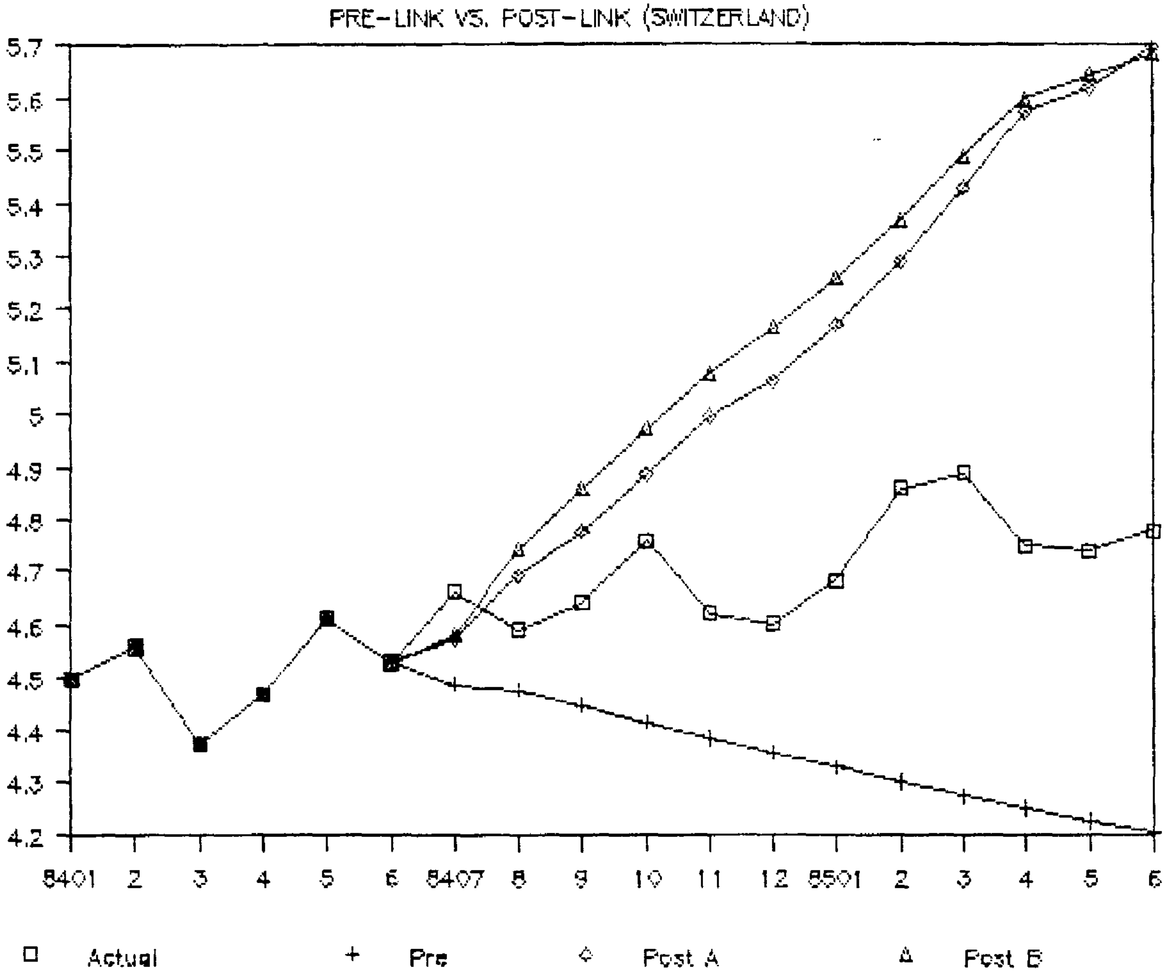


EXHIBIT (7.4.16) FORECASTS FOR INTEREST



generated a straight line forecast which is more accurate than the forecasts of the post-link selections.

All three specifications missed the actual interest rate movements over the forecast period. The post-link forecasts exploded in the upward direction, while the pre-link forecast exploded in the downward direction. The pre-link forecast is the best among the three in terms of the summary statistics.

In all four cases post-link specifications did not help improve forecasting any of the four variables. The pre-link selection in all four cases generated better forecasts. These findings were also reported in Tables 6.2A.16 and 6.2B.16 of Chapter VI. It was argued then that, the transmission of international influence could show a different lag structure, other than the ones imposed in this study. For instance, it was shown in Tables 6.2A.16 and 6.2B.16 that, the twelve to twenty four lag structures in fact showed substantial improvement over the pre-link selection. Therefore, it would be pre-mature to conclude that, the forecast performance of the four variables in Switzerland could not be improved with the link variables.

United Kingdom

The comparison of the pre-link versus the post-link forecast performance for the United Kingdom is reported in Tables 7.1.17, 7.2.17 and illustrated in Exhibits 7.1.17, 7.2.17, 7.3.17, and 7.4.17.

The pre-link specification generated the best output forecast for the United Kingdom. Both post-link specifications generated explosive forecasts, specifically in the first four months. The post-link A forecast has an edge over the post-link B forecast, where the latter has forecast errors three times the magnitude of the former's forecast errors.

The money forecasts for the United Kingdom were equally accurate from all three selections. Both post-link forecasts were marginally better than the pre-link forecast, specifically in the last four months of the forecast period. Post-link B has the lowest forecast errors and is slightly better than the post-link A selection.

The price variable was predicted more accurately again by the two post-link selections, especially over the last four months of the forecast horizon. The best prediction was the post-link B prediction, which has errors one third the magnitude of the pre-link forecast errors.

There were three instances in the forecast period, where

UNITED KINGDOM

TABLE 7.1.17

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0101	-.0321	-.0838	.0297	.0336	.0286
Mean Absolute Error	.0125	.0321	.0838	.0324	.0343	.0301
Root-Mean-Sq. Error	.0148	.0383	.0902	.0447	.0399	.0376
Theil's Ineq. Coeff.	.0016	.0041	.0096	.0021	.0018	.0017
Fraction of Error due to a)Bias	.4616	.7022	.8623	.4416	.7094	.5800
b)Diff. Var.	.3503	.0023	.0021	.4544	.0842	.2513
c)Diff. Co-var	.1881	.2955	.1357	.1040	.2064	.1687

UNITED KINGDOM

TABLE 7.2.17

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	.0069	.0045	-.0024	-.2413	-.3751	.9020
Mean Absolute Error	.0085	.0055	.0034	.9487	1.1600	1.4620
Root-Mean-Sq. Error	.0126	.0075	.0044	1.2190	1.3340	1.6820
Theil's Ineq. Coeff.	.0013	.0008	.0004	.0544	.0612	.0792
Fraction of Error due to a)Bias	.2992	.3599	.2936	.0392	.0711	.2876
b)Diff. Var.	.5241	.4788	.0008	.0677	.1477	.2862
c)Diff. Co-var	.1767	.1613	.7056	.8923	.7732	.4263

EXHIBIT (7.1.17) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (UNITED KINGDOM)

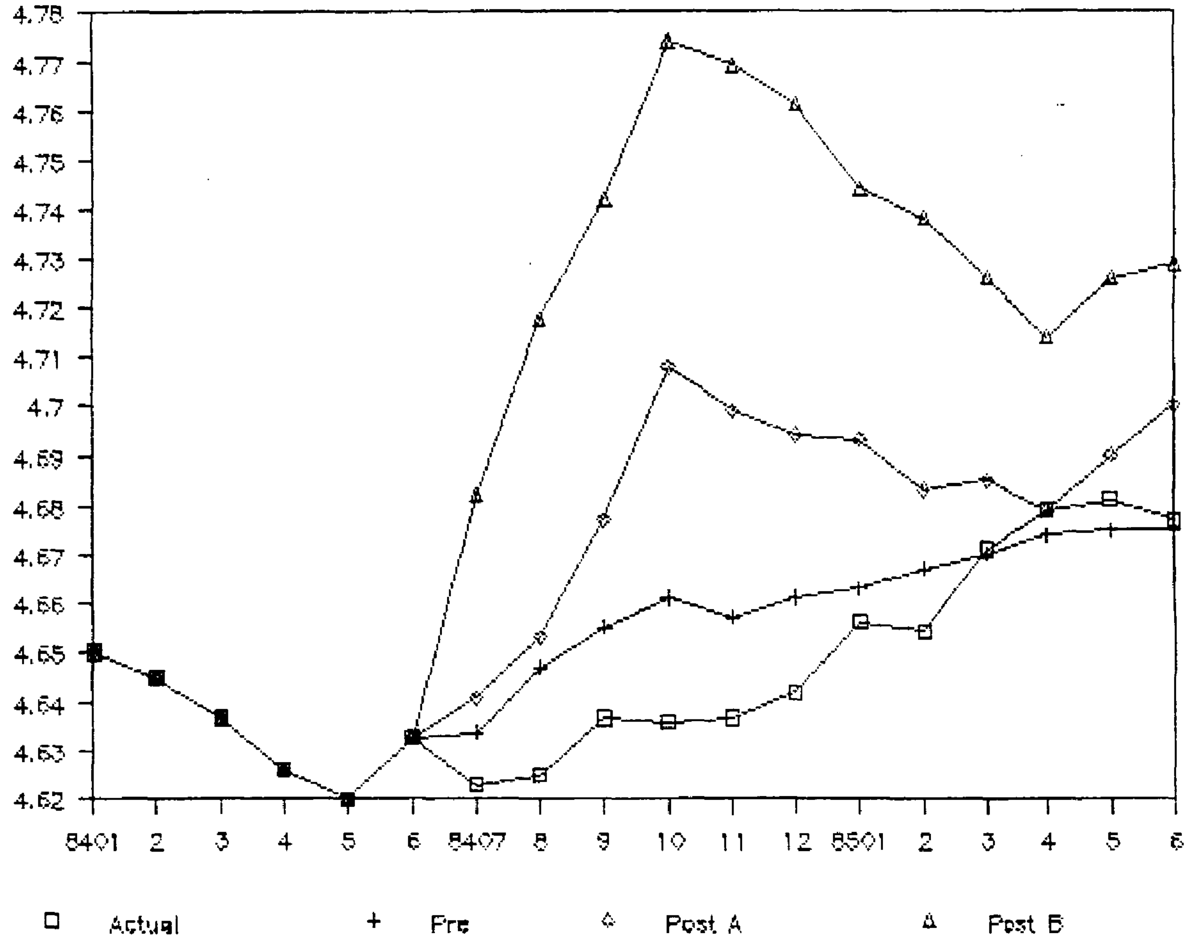


EXHIBIT (7.2.17) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (UNITED KINGDOM)

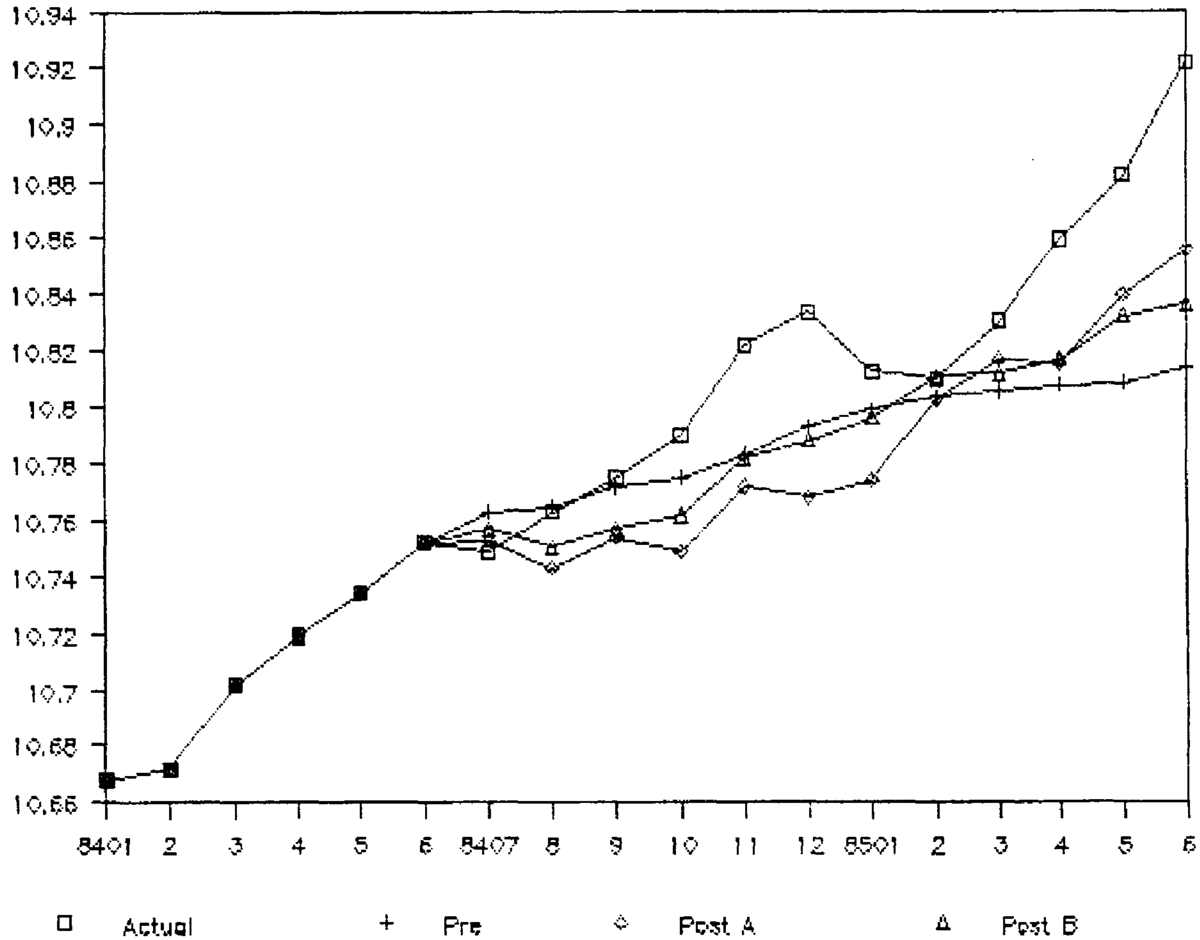


EXHIBIT (7.3.17) FORECASTS FOR PRICE

PRE-LINK VS. POST-LINK (UNITED KINGDOM)

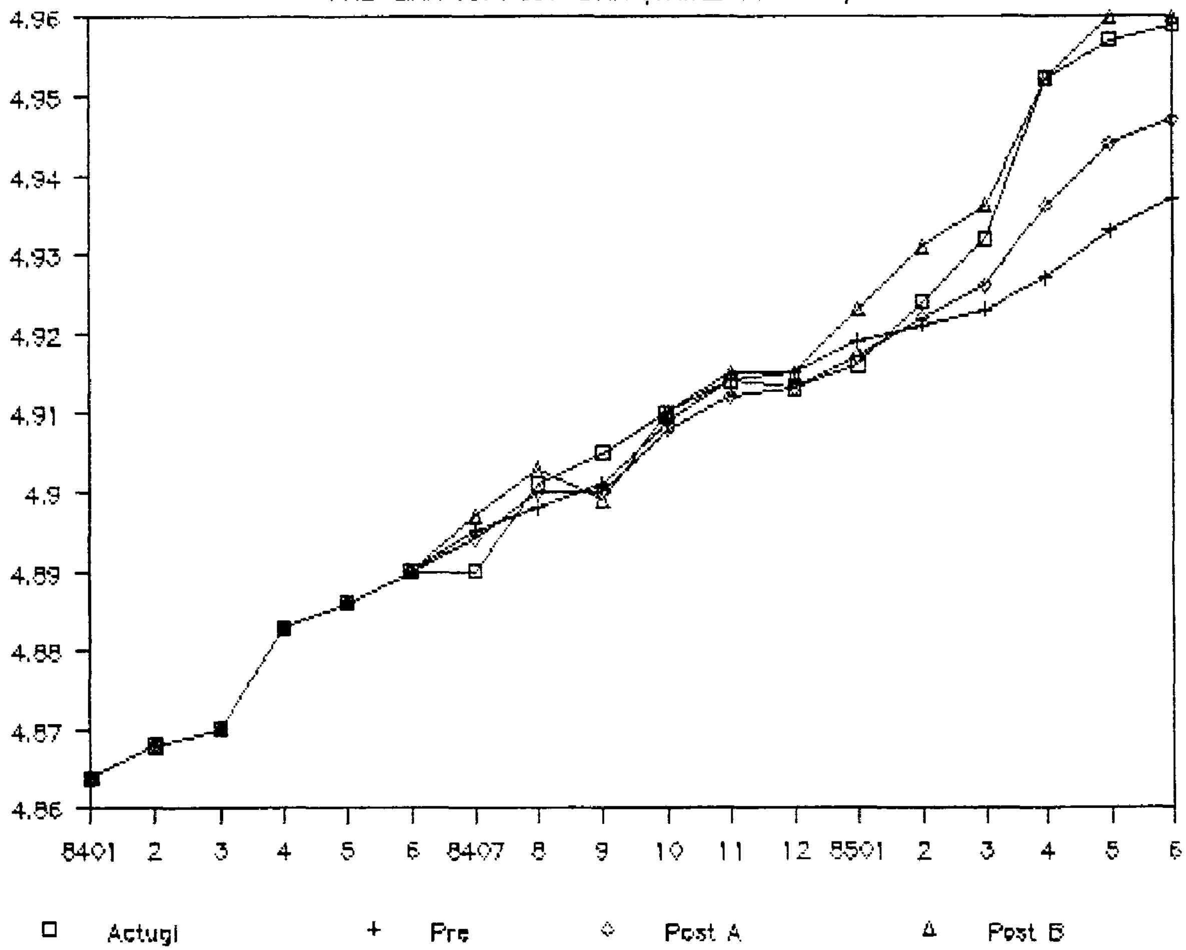
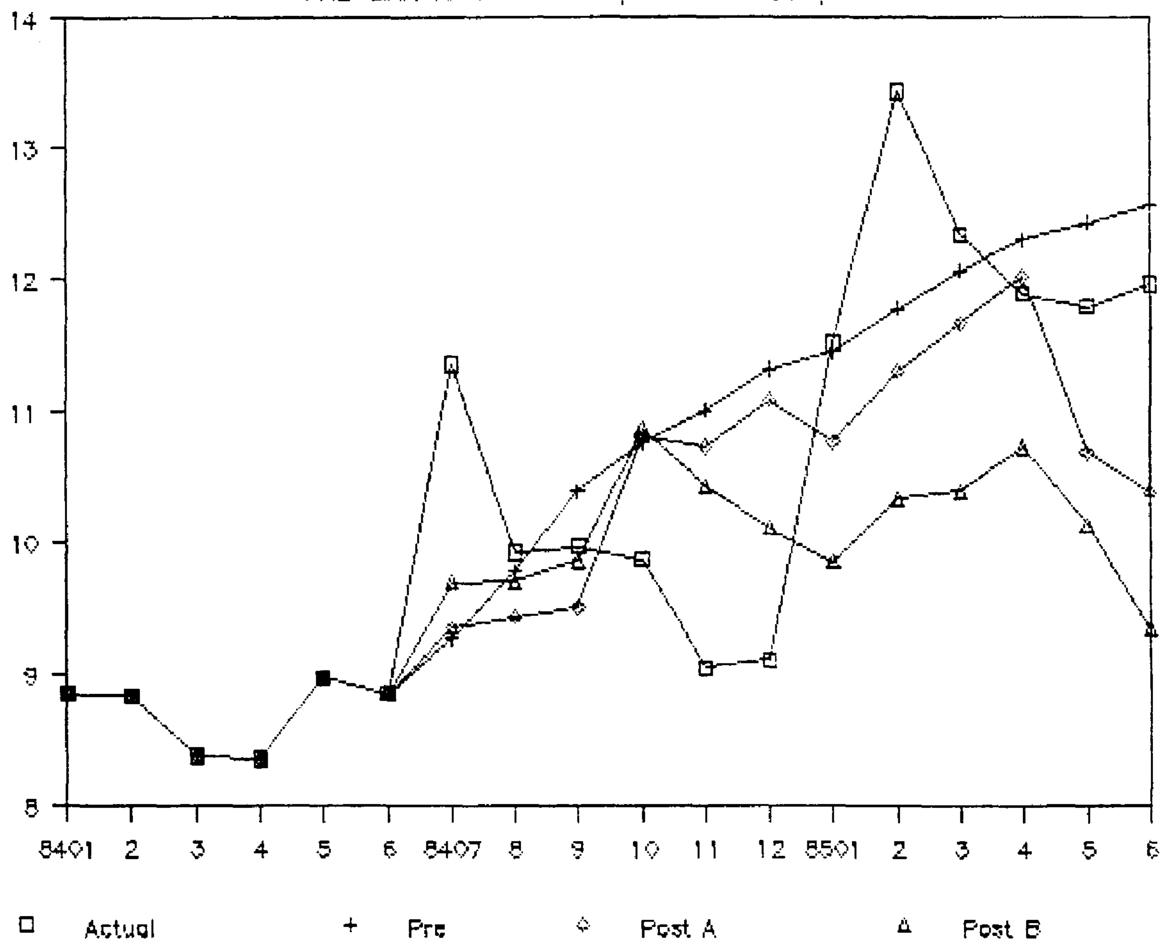


EXHIBIT (7.4.17) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (UNITED KINGDOM)



the actual interest rate values showed a one period jump, i.e., the second, the eighth and the ninth months. These jumps were practically missed by all three forecasts. The forecast errors of all three selections were very close. Although, the pre-link selection has the lowest forecast errors, the post-link A selection replicates the movements in the interest rate substantially better than all three selections. Therefore, it can be argued that the post-link A forecast is marginally better than the pre-link, as well as the post-link B forecasts. The post-link B forecast is not really inferior to the pre-link forecast, specifically in the first six months.

The results for the United Kingdom indicates that, international linkages improve three out of four variables under the linkage mechanism A and two variables are improved with one 'no change' forecast under the linkage mechanism B. Therefore, one can claim that, link variables help increase forecast accuracy over the pre-link selection only marginally by the post-link B and more decisively by the post-link A selections.

United States

The comparison of the pre-link versus the post-link forecast performance for the United States is presented in Tables 7.1.18, 7.2.18 and illustrated in Exhibits 7.1.18, 7.2.18, 7.3.18, and 7.4.18.

The pre-link and the post-link A forecasts of output overshot the actual values, while the post-link B forecast undershot it. The post-link selection generated the lowest prediction errors, nevertheless, the post-link B forecast replicates the movements in actual output better than any other forecast. The pre-link forecast was the worst among the three, with the highest forecast errors and the highest bias component.

The movements in the money supply were overpredicted by all three selections. The most accurate forecast among the three was the pre-link forecast. Both post-link forecasts were more explosive than the pre-link prediction.

The best price forecast was generated by the post-link B specification. Both pre-link and post-link A forecasts overpredicted the actual price movements over the last seven months of the forecast horizon. The post-link B forecast errors on the other hand, were lower than the pre-link errors. The post-link B selection generated a forecast with errors almost one fourth the size of the pre-link errors.

UNITED STATES

TABLE 7.1.18

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR OUTPUT AND MONEY.

(1) Summary Stats.	(2) Output			(3) Money		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0214	-.0148	.0144	-.0163	-.0282	-.0224
Mean Absolute Error	.0215	.0148	.0172	.0163	.0282	.0224
Root-Mean-Sq. Error	.0236	.0170	.0204	.0176	.0297	.0234
Theil's Ineq. Coeff.	.0025	.0018	.0022	.0014	.0023	.0018
Fraction of Error due to a)Bias	.8211	.7518	.4973	.8639	.9000	.9186
b)Diff. Var.	.0821	.1068	.0000	.0092	.0606	.0111
c)Diff. Co-var	.0989	.1413	.5027	.1269	.0394	.0703

UNITED STATES

TABLE 7.2.18

THE COMPARISON OF PRE-LINK(CLOSED-ECONOMY) VERSUS POST-LINK (OPEN-ECONOMY) FORECAST PERFORMANCE FOR PRICE AND INTEREST.

(1) Summary Stats.	(2) Price			(3) Interest		
	pre link	post link a	post link b	pre link	post link a	post link b
Mean Error	-.0370	-.0064	.0038	-1.8070	-.6777	.3112
Mean Absolute Error	.0156	.0099	.0042	1.9970	1.2840	.6814
Root-Mean-Sq. Error	.0193	.0118	.0052	2.4670	1.4300	.8568
Theil's Ineq. Coeff.	.0020	.0012	.0005	.1292	.0796	.0504
Fraction of Error due to a)Bias	.5020	.2943	.5391	.5364	.2247	.1319
b)Diff. Var.	.4180	.5299	.0125	.0434	.3839	.2362
c)Diff. Co-var	.0800	.1758	.4484	.4202	.3914	.6319

EXHIBIT (7.1.18) FORECASTS FOR OUTPUT

PRE-LINK VS. POST-LINK (UNITED STATES)

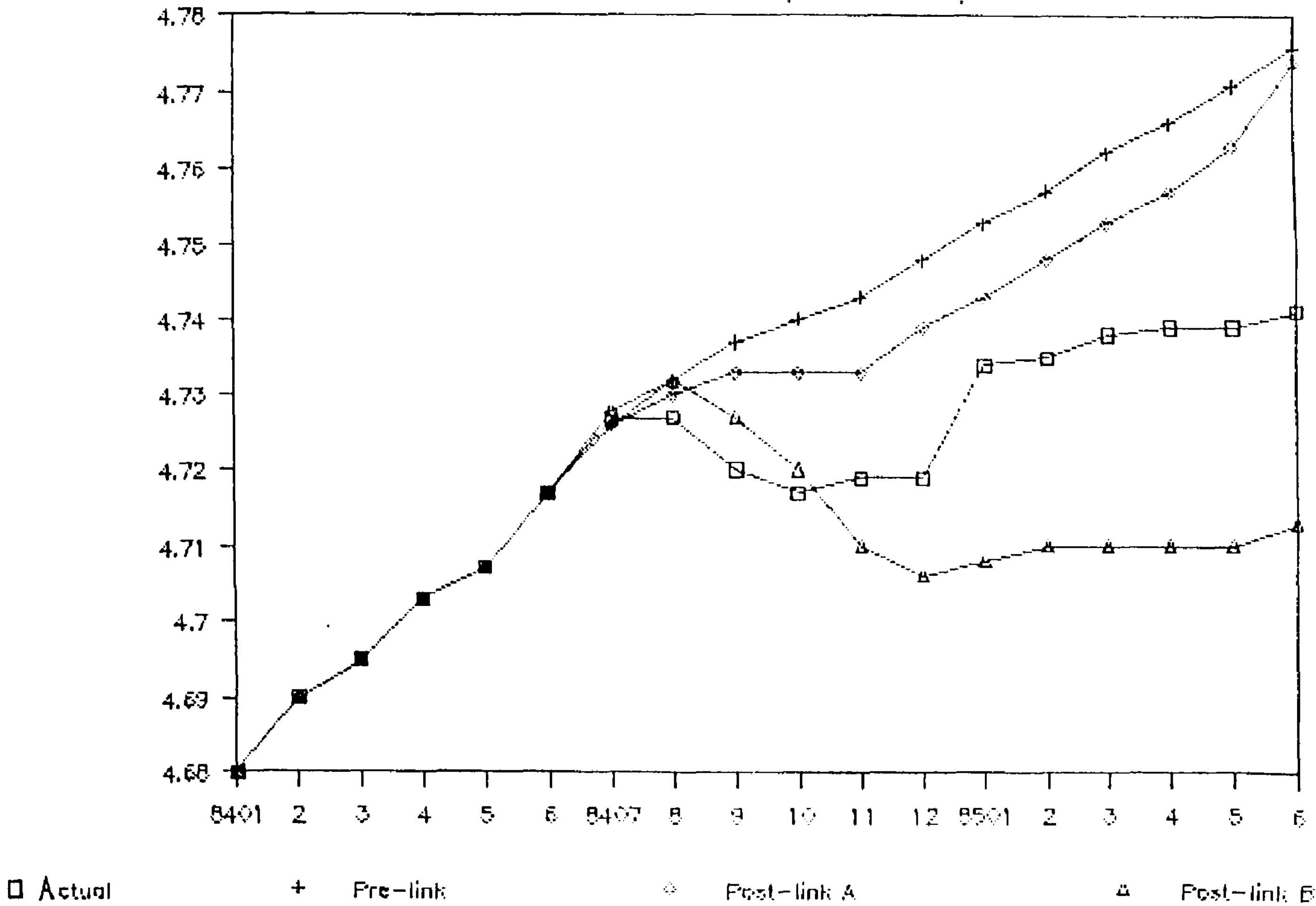
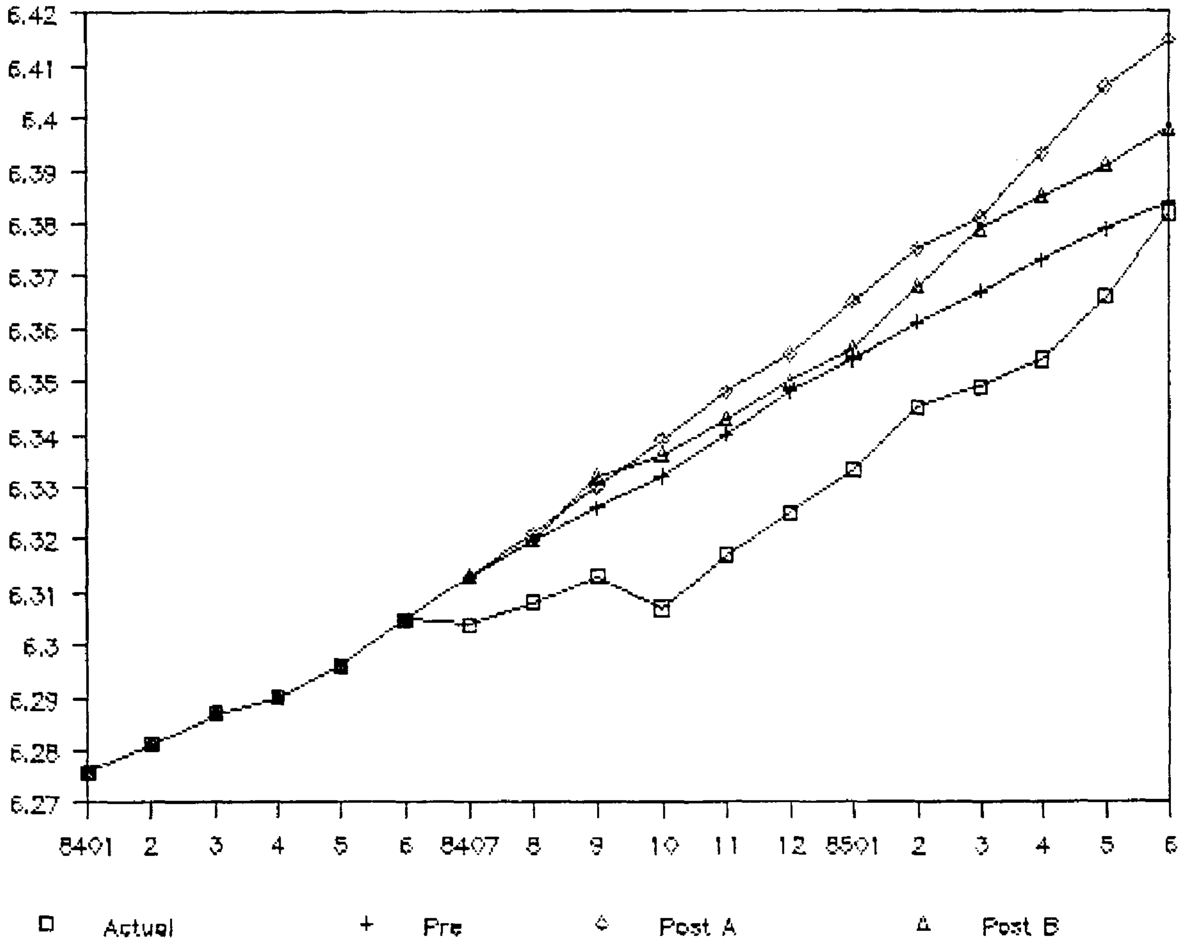


EXHIBIT (7.2.18) FORECASTS FOR MONEY

PRE-LINK VS. POST-LINK (UNITED STATES)



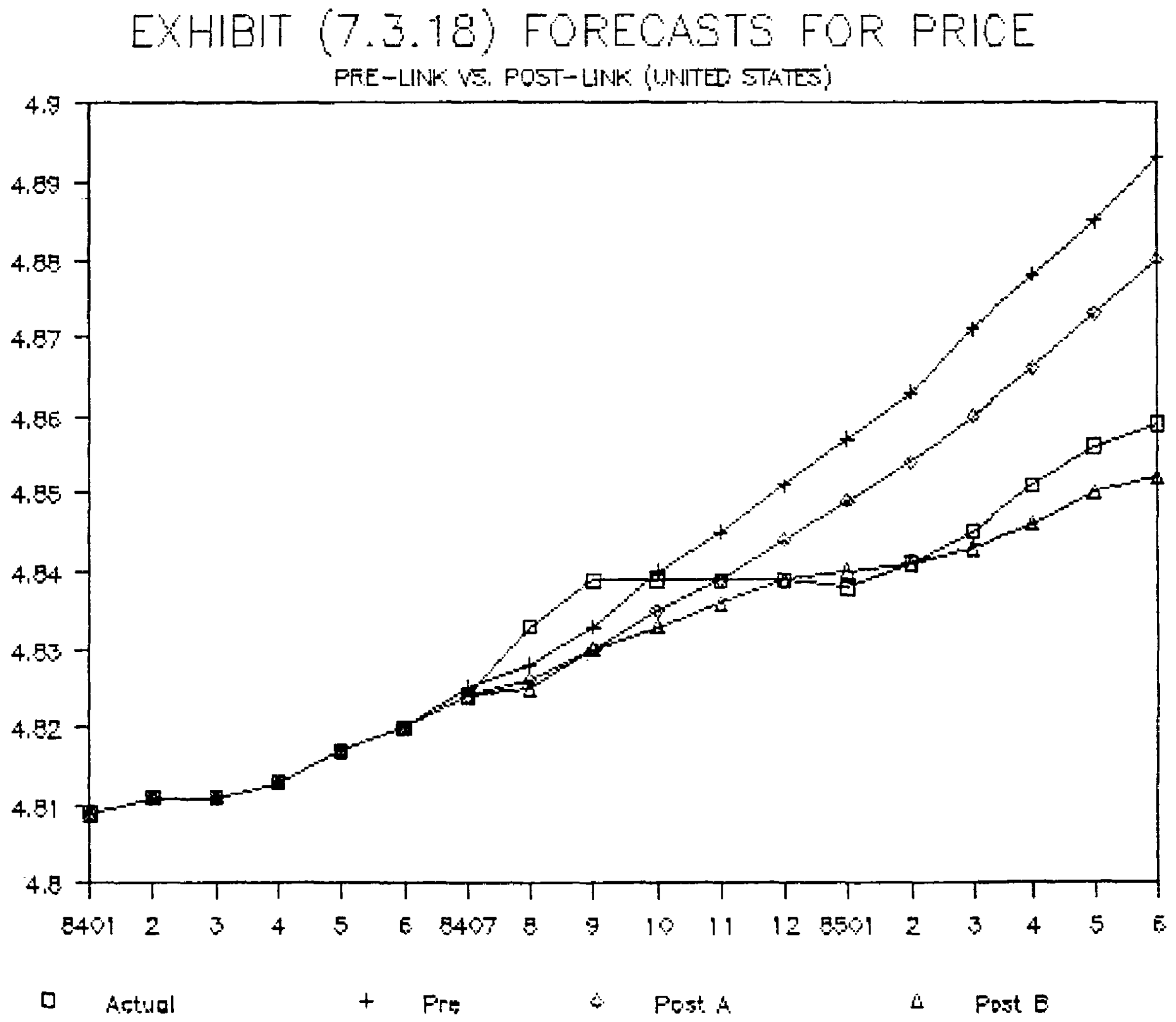
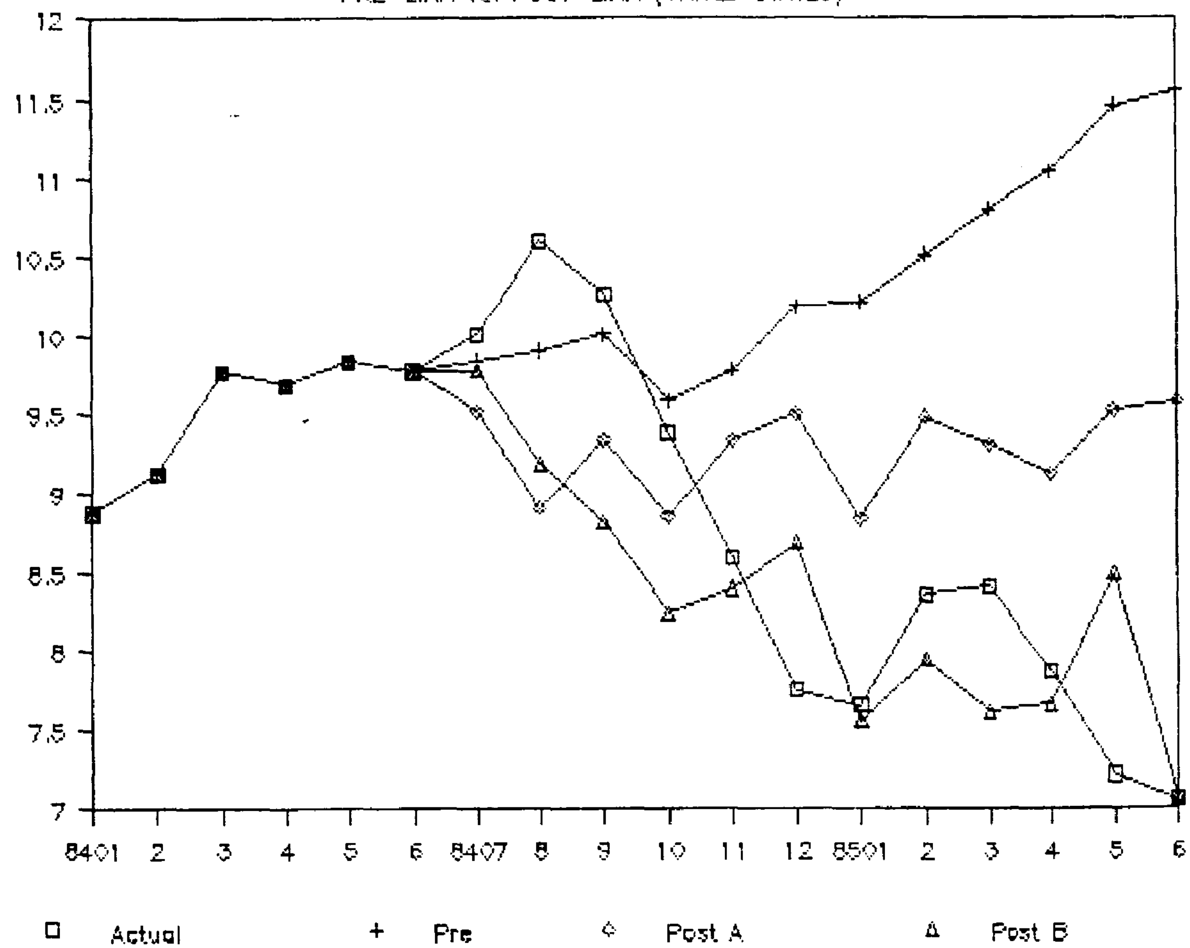


EXHIBIT (7.3.18) FORECASTS FOR PRICE
PRE-LINK VS. POST-LINK (UNITED STATES)
4.9
4.89
4.88
4.87
4.86
4.85
4.84
4.83
4.82
4.81
4.8
8401
2
3
4
5
6
8407
8
9
10
11
12
8501
2
3
4
5
6
Actual
Pre
Post A
Post B

EXHIBIT (7.4.18) FORECASTS FOR INTEREST

PRE-LINK VS. POST-LINK (UNITED STATES)



The post-link B forecast also has the lowest bias plus variance error among the three.

The interest rate movements were forecasted remarkably well by both post-link selections, where the post-link B was the best. The decomposition of the Theil's U statistic also indicates that, the post-link B forecast has the least combination of bias and variance errors. The pre-link forecast on the other hand, was very explosive, missing the mark over the entire twelve months.

The results for the United States indicate that, post-link specifications made a decisive improvement over the pre-link specification. Three out of four variables are forecasted better with the post-link selections. The only inferior forecast to the pre-link selection was the money forecast. Among the two post-link specifications, the post-link B has an edge over the post-link A specifications in all four cases. One could conclude from these results that, international influences should be considered in order to generate better forecasts for United States.

In this chapter, a detailed comparison of the pre-link and the post-link forecast performance for each of the eighteen countries in the LINK-VAR model was presented. A summary of the results and some concluding remarks will constitute the next and the final chapter of this dissertation.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

This dissertation extends the scope of the Vector-Autoregressive model building efforts into the international sphere with the construction of the Multi-country Link Vector Autoregressive Model (LINK-VAR). This LINK-VAR Model is an eighteen country system which combines the novel element in structural international macroeconometric models (i.e., thr linkage mechanisms) with the VAR technique. The national country models in are specified as four variable VAR systems and are linked to one another through a set of link variables which are based on the multilateral trade flows among the countries. Once built, the LINK-VAR Model was used to test the proposition that forecast accuracy of domestic VAR models can be improved by integrating the international influences into these models.

The complete empirical results of this research have been outlined in detail in the previous two chapters. A simplified overall evaluation of all models is presented in Table 8.1. A plus sign indicates a superior forecast and a negative sign indicates an inferior forecast of the post-link specification over the pre-link (closed-economy) specification. The zero sign stands for no significant difference

TABLE 8.1

A SIMPLIFIED SUMMARY OF THE FORECASTING PERFORMANCE OF THE LINK-VAR MODEL

COUNTRY	POST-LINK A					POST-LINK B				
	Y	M	P	R	model	Y	M	P	R	model
Australia	+	O	+	O	+	+	O	+	O	+
Austria	+	+	+	–	+	+	+	+	–	+
Belgium	+	+	–	+	+	+	+	–	+	+
Canada	+	+	+	+	+	+	–	–	+	O
Denmark	O	+	+	+	+	+	–	–	+	O
Finland	O	+	+	na.	+	–	–	+	na.	–
France	+	+	+	+	+	+	+	+	+	+
Germany	+	+	+	–	+	+	+	+	+	+
Ireland	+	–	+	O	+	+	–	+	O	+
Italy	+	+	+	+	+	+	+	+	+	+
Japan	O	–	+	–	–	–	+	+	–	O
Netherlands	+	O	+	–	+	O	–	+	+	+
Norway	–	+	+	+	+	–	–	+	+	O
Spain	O	O	+	na.	O	O	+	+	na.	+
Sweden	O	O	O	+	O	O	+	–	+	+
Switzerland	–	–	–	–	–	–	–	–	–	–
United Kg.	–	+	+	+	+	–	+	+	O	+
U.S.A.	+	–	+	+	+	+	–	+	+	+
TOTALS	10+ 4 – 4 0	10+ 4 – 4 0	15+ 2 – 1 0	9 + 5 – 2 0	14 + 2 – 2 0	10+ 5 – 3 0	9 + 8 – 1 0	13+ 5 – 0 0	10+ 3 – 3 0	12 + 2 – 4 0

between the pre-link and post-link forecasts, as established in Chapter VII.

The forecast performance of the LINK-VAR can be evaluated variable by variable or country by country. A more meaningful assessment would obviously be provided by the latter. It would be of interest to a researcher attempting to forecast the economic activity in these eighteen countries to know whether the closed-economy specification or the open-economy specification for a given country would produce more accurate forecasts. As Table 8.1 indicates, under linkage mechanism A forecast performance has been improved in fourteen out of eighteen countries; it has not changed in two countries; and forecasts have become worse only for two countries. Similarly, under linkage mechanism B, twelve countries had better forecasts, five countries had equally accurate forecasts and only two countries had worse forecasts. The post-link specification was considered superior if at least two variables were forecasted better and at least one forecast was not changed. It should be noted that there is a variable with an inferior forecast in most cases even though the post-link specification is found to be superior over the pre-link specification. A possible reason for this finding could be an over-specification of international linkages in the case of these variables. Another feasible explanation would be that the international influence on some variables might not be as substantial as on some others. Since the comparison is based on the model as a whole, the presence of instances where there is an inferior forecast for one variable cannot undermine the significance of linkages and the overall results.

The results for Switzerland were quite unique and difficult to explain. The forecasts under both linkage mechanisms did not show any improvement over the pre-link forecasts. This result could indicate a possible misrepresentation in terms of the lag structure for this country's model. As demonstrated in Tables 6.2A.16 and 6.2B.16, the post-link specifications produced at least two better forecasts than the pre-link specification for lags of six to twelve and twelve to twenty four periods. These results and those reported would seem to suggest that a re-specification of the lag structures might be fruitful. A possible re-specification considering lag structures that are dispropor- tianate regarding the impact of international fluctuations on each of the variables of the domestic economy might very well improve the forecasting performance even further.

Table 8.1 also shows that the post-link specification improved the forecasts for domestic price levels more than the forecasts of the other three variables. The price predictions were better in fifteen countries under linkage mechanism A and in thirteen countries under linkage mechanism B. The output forecasts were better eleven times under both linkage mechanisms. Under both linkages the improvements in money and interest rate forecasts were less frequent than in the price and output forecasts. The improvement in money forecasts were more substantial under linkage A than linkage B. The opposite was true for the interest rate forecasts.

The overall results prove the intuitive proposition that an open-economy specification, where international fluctuations in economic activity are considered, generates more accurate forecasts than a closed-economy specification with no international linkages among countries. This argument can be made more forcefully when the forecast evaluation is based on a country by country comparison.

The results of this dissertation are very significant considering the four important limitations of the study. Firstly, the international linkages in the LINK-VAR model were based exclusively on trade flows. Under more comprehensive linkages which could incorporate the financial flows along with the trade flows, the forecast performance could probably be improved further. Secondly, in both pre-link and post-link specifications only symmetric lag structures were considered. A more elaborate lag structure, especially for the post-link specifications which would account for the disproportional impacts in the international transmission of economic fluctuations, could lead to a possibly improved international model. Thirdly, in the estimation of the lag structures in country specifications in the model lags were given equal weights. Bayesian restrictions suggested by Litterman (1979), which are based on the researcher's prior beliefs on the lag structures could lead to better forecasts. Imposing such restrictions however, are less straight forward in terms of an international model. In the case of domestic models, it is customarily assumed that earlier lags are more important than latter lags thus more emphasis should be given to sooner lags. In the case of lags on international variables, the same assumption might not be valid. The transmission of the international influence on some countries might be fairly instantaneous, as one might expect as in the case of between Canada and United States, but it would take much longer for some other countries say between Australia and United States. Finally, it is assumed in this study that the coefficient estimates of the LINK-VAR model are time invariant. This assumption would admittedly subjects the results to the Lucas critique. The VAR models with time varying coefficients as suggested in Litterman (1979) and Doan, Litterman, and Sims (1983) might help improve forecast accuracy.

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APPENDIX A[1]

The Linkage Mechanism Through Trade

The simple mathematics of multiplier theory for a single country economy can be derived as follows,

Given the simple Keynesian model:[2]

$$C = a + b\,(Y - T)$$

$$G = G_0$$

$$X = X_0$$

$$M = m\,Y$$

$$T = t\,Y$$

where,

Y is real output. C is real consumption expenditures.

X is real exports. G is real government spending.

M is real imports. T is real tax revenues.

a is autonomous consumption.

b is marginal propensity to consume.

m is marginal propensity to import.

t is the tax rate.

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[1] This example is based on Klein and Peetersen (1973), pp. 150-155.

[2] Real Investment expenditures are not included in the model for simplicity.

The equilibrium solution is,

$$Y = a + b\ (1 - t)\ Y + G_o + X_o - m\ Y$$

the autonomous expenditure multiplier is,

$$\frac{dY}{dG} = \frac{dY}{dX} = \frac{1}{1 - b\ (1 - t) + m}$$

The response of real output to exogenous changes in G or X varies directly with b, inversely with t and inversely with m. It is assumed for stability that,

$$0 < b\ (1 - t) - m < 1$$

In the case of two (look a like) economies, the equilibrium solution is,

$$Y_A = a_A + b_A\ (1 - t_A)\ Y_A + G_{oA} + e_A\ Y_B - e_B\ Y_A$$
$$Y_B = a_B + b_B\ (1 - t_B)\ Y_B + G_{oB} + e_B\ Y_A - e_A\ Y_B$$

where, it is assumed that country A's exports depend on B's output level and that A's imports depend on its own output level and e_A, e_B are marginal propensities to export for the respective countries.

The reduced form equations for the two country model are:

$$Y_A = \frac{1}{1-b_A(1-t_A) + e_B - \dfrac{e_A\ e_B}{1-b_B(1-t_B) + e_A}} \left[G_{oA} + \frac{e_A}{1-b_B(1-t_B) + e_A} G_{oB} \right]$$

$$Y_B = \frac{1}{1-b_B(1-t_B) + e_A - \dfrac{e_A\ e_B}{1-b_A(1-t_A) + e_B}} \left[G_{oB} + \frac{e_B}{1-b_A(1-t_A) + e_B} G_{oA} \right]$$

The government spending multipliers for the two countries are;

$$\frac{dY_A}{dG_{oA}} = \frac{1}{1-b_A(1-t_A) + e_B - \dfrac{e_A\ e_B}{1-b_B(1-t_B) + e_A}}$$

$$\frac{dY_B}{dG_{oB}} = \frac{1}{1-b_B(1-t_B) + e_A - \dfrac{e_A\ e_B}{1-b_A(1-t_A) + e_B}}$$

The comparison of the multipliers in case of a single country model with the two country model indicate that the multiplier has been increased over the single country model by the subtraction of:

$$\frac{e_A \; e_B}{1-b_B \;\; (1-t_B) \; + \; e_A} \qquad \text{for country A}$$

$$\frac{e_A \; e_B}{1-b_A \;\; (1-t_A) \; + \; e_B} \qquad \text{for country B}$$

in the denominator.

In addition, the multiplicand as well as the multiplier can be a reinforcing factor in the two country case. If both country's government spending changes in the same direction the multiplicand changes from;

$$dG_{oA}$$

to

$$dG_{oA} \; + \; \frac{e_A}{1-b_B \;\; (1-t_B) \; + \; e_A} \; G_{oB} \qquad \text{for country A}$$

and

$$dG_{oB}$$

to

$$dG_{oB} \; + \; \frac{e_B}{1-b_A \;\; (1-t_A) \; + \; e_B} \; G_{oA} \qquad \text{for country B}$$

It would be also possible for countries to offset one another if the government spending changes in the opposite direction.

It is evident from this example that the the two country models can be extended without price effects, readily to a general n-country analysis.

APPENDIX B

The Data

AUSTRALIA

Output: Industrial Production: Total, 1980=100, S.A., Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Million Australian Dollars, end of period., S.A., Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, (Quarterly Series converted to monthly through straight line interpolation.) Source: OECD Main Economic Indicators.

Interest Rate: Commercial Bills (90 days), per cent per annum, end of period. Source: OECD Main Economic Indicators.

AUSTRIA

Output: Industrial Production: Total, 1980=100, S.A., Source: OECD Main Economic Indicators.

Money: Money Supply (M1) Billion Schilling, end of period, S.A., Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Treasury Bill Rate (3 Months), (197610-197709 missing, interpolated using regression analysis.) Source: OECD Financial Statistics.

BELGIUM

Output: Industrial Production: Total, 1980=100, S.A., Source: OECD Main Economic Indicators.

Money: Money Supply (M1) Billion Francs, end of period, S.A., (The series is quarterly, interpolated.) Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Treasury Bill Rate (3 months), per cent per annum, end of period, Source: OECD Main Economic Indicators.

CANADA

Output: Domestic Product: Industry, Index of Industrial Production, 1980=100, S.A., Source: OECD Main Economic Indicators.

Money: Money Supply (M1) Billion Canadian Dollars, end of period, S.A., Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Treasury Bill Rate (3 months), per cent per annum, end of period, Source: OECD Main Economic Indicators.

DENMARK

Output: Manufacturing Sales: Total (Volume), 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Kroner, end of period, S.A. Source: OECD Main Economic Indicators

Price: Consumer Prices: All Items, Excluding Indirect Taxes., 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Call Money Rate, per cent per annum, (The data for 1971 are obtained through backcasting usin regression analysis.) Source: IMF., Financial Statistics.

FINLAND

Output: Indicators of Domestic Product: Industry, Index of Industrial Production, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Markaa, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

FRANCE

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Francs, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Call Money Rate, per cent per annum, end of period, Source: OECD Main Economic Indicators.

GERMANY (WEST)

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion D. Marks, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Rate on 3-month Loans (Frankfurt), per cent per annum, end of period, Source: OECD Main Economic Indicators.

IRELAND

Output: Industrial Production: Mining and Manufacturing (Quarterly and interpolated between 1972-1975), S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Million Pounds, end of period, S.A. (197001-197103 and 197606 - 197609 are interpolated using IMF Money supply series.) Source: OECD Main Economic Indicators.

Price: Consumer Prices: Total, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Treasury Bill Rate (3 months), per cent per annum, end of period, Source: OECD Main Economic Indicators.

ITALY

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Lire, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100 Source: OECD Main Economic Indicators.

Interest Rate: Treasury Bill Rate (6 months) per cent per annum, end of period, (missing observations are interpolated) Source: OECD Main Economic Indicators.

JAPAN

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Yen, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, including imputed rent, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Call Money Rate, per cent per annum, end of period, Source: OECD Main Economic Indicators.

NETHERLANDS

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Guilders, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Call Money Rate (Amsterdam), per cent per annum, end of period, Source: OECD Main Economic Indicators.

NORWAY

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Kroner, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Call Money Rate, per cent per annum, Source: IMF., Financial Statistics.

SPAIN

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Pesetas, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

SWEDEN

Output: Industrial Production: Mining and Manufacturing, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1 plus Quasi Money), Billion Kroner, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Call Money Rate, per cent per annum, (197401-197404 backasted using regression analysis) Source: IMF., Financial Statistics.

SWITZERLAND

Output: Industrial Production: Total, 1980=100, (Quarterly, interpolated) S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Francs, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Yield of Confederation Bonds, per cent per annum, end of period, Source: OECD Main Economic Indicators.

UNITED KINGDOM

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Million Pounds, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Treasury Bill Rate (91 Days) Per cent per annum, end of period, Source: OECD Main Economic Indicators.

UNITED STATES

Output: Industrial Production: Total, 1980=100, S.A. Source: OECD Main Economic Indicators.

Money: Money Supply (M1), Billion Dollars, end of period, S.A. Source: OECD Main Economic Indicators.

Price: Consumer Prices: All Items, 1980=100, Source: OECD Main Economic Indicators.

Interest Rate: Treasury Bill Rate (3 months), per cent per annum, end of period, Source: OECD Main Economic Indicators.