

Esko Aurikko

Studies of Exchange Rate Policies and Disequilibria in the Finnish Economy

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PREFACE

The aim of this thesis is to study both theoretically and empirically the effects of exchange rate policies in Finland taking into account various disequilibria in the economy. Related to this an additional aim is to specify and estimate disaggregated dynamic models for imports and exports of goods. The thesis consists of a summary and seven previously published articles:

Exchange Rate Policy and Imported Inflation in a Credit Rationing Economy, *Empirical Economics* 7 (1982), 155 - 173.

Exchange Rate Policies Simulated by Means of an Econometric Disequilibrium Macromodel of the Finnish Economy, *Journal of Policy Modeling* 6 (1984b), 531 - 554.

Active Pegging, Rational Expectations, and Autonomy of Monetary Policy, *Economics Letters* 17 (1985a), 149 - 152.

Testing Disequilibrium Adjustment Models for Finnish Exports of Goods, *Oxford Bulletin of Economics and Statistics* 47 (1985b), 33 - 50.

A Dynamic Disaggregated Model of Finnish Imports of Goods, *Empirical Economics* 10 (1985c), 103 - 120.

Testing the Functional Form of Finnish Aggregate Imports, *Economics Letters* 18 (1985d), 223 - 228.

A Dynamic Analysis of Finnish Export Prices, *the Finnish Journal of Business Economics* 35 (1986), 24 - 38.

The purpose of the introduction is both to survey the research area and to summarize the articles.

The origins and ideas of the research date from the mid-1970s when I was a member of the Model Project Team of the Bank of Finland's Research Department. The first two articles of the thesis were written in the early 1980s while I was working at the Exchange Policy Department. The initial research work for the articles on exports and imports was mostly done in 1983 during a period of full-time research at the Research Department.

I have benefitted greatly from discussions and cooperation with many people while working on the studies. Jouko Paunio was an invaluable source of encouragement during the early stages of the project. Erkki Koskela and Matti Virén have made many useful comments on the work. Several members of the Bank of Finland staff have been very helpful during the project, especially Heikki Koskenkylä, Juhani Hirvonen, Juha Tarkka and Alpo Willman. My official examiners Antti Tanskanen and Pentti Vartia gave detailed comments on the summary.

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Helsinki, January 1986

Esko Aurikko

I INTRODUCTION

1.1 Overview

This summary briefly considers the background, aims, theory and results of the seven previously published articles making up the thesis. The first two articles, Aurikko (1982) and Aurikko (1984b), are concerned with theoretical aspects of disequilibrium models of a small open economy and their econometric estimation. The models are specifically used to assess both theoretically and through simulations the effects of exchange rate policies and imported inflation in various disequilibria regimes of the economy. With the exception of Aurikko (1985a), which deals with theoretical questions relating to active exchange rate policy and monetary autonomy, the other five articles Aurikko (1985a-d, 1986) are primarily empirical and addressed to different estimation and testing issues pertaining to aggregated and disaggregated models of Finnish exports and imports of goods. The empirical results concerning the specification, dynamics, functional form and disaggregation broadly support the use of the particular models of exports and imports in the econometric disequilibrium models in the first two articles.

1.2 General Background

During the Bretton Woods era, the international exchange rate system was characterized by exchange rates which were normally fixed but adjustable in circumstances of "fundamental disequilibrium" in the balance of payments. Exchange rate changes implemented under this system tended to be too late and too large. The institutional setting of Bretton Woods was also reflected in balance of payments theory and econometric models, with emphasis on fixed exchange rates and the policy prescriptions this implied.

The post-Bretton Woods system, with first temporary central rates in 1971 and 1972 and subsequently floating exchange rates for the major currencies, has changed the institutional framework for exchange rate policies considerably. The focus of balance of payments theory has also shifted towards approaches based upon flexible exchange rates. However, despite these changes, there are still many small countries, Finland being one of the first, which have maintained essential elements of the Bretton Woods system by pegging their currencies to a basket in the form of an exchange rate index.¹ In such a setting, the structure of the rates is determined in the international foreign exchange markets while the average level of the rates can be decided by the domestic authorities.

Thus, for many small countries fixed exchange rate models are still relevant, at least in the short-run where the structure of exchange rates determined abroad is replaced by an exchange rate index the level of which can be decided independently. In the current regime of floating exchange rates, however, analysis of policy issues arising from the changing structure of rates requires models which are disaggregated according to different major currencies.

Most macroeconomic models developed in Finland and used to assess, among other things, the effects of exchange rate policies are basically open economy versions of the Keynesian demand-determined macroeconomic model. These models normally include conventional consumption and investment equations, import and export functions through which exchange rate changes are mainly channelled to the domestic economy initially, and equations determining prices, wages and incomes.²

Until recently, inadequate attention was paid to the inclusion of institutional features in the treatment of Finnish financial markets in these models. The most crucial feature is disequilibrium in the bank loan market, which is essentially due to institutionally fixed domestic interest rates and gives rise to credit rationing from time to time.³ Theoretical studies of credit rationing in the Finnish economy have been made by Koskela (1979a,b), Oksanen (1980), Willman

(1981), Kähkönen (1982) and Aurikko (1982). Empirical discussions can be found in Tarkka and Willman (1981) and Aurikko (1984b).⁴

Although disequilibrium phenomena in the Finnish financial markets have lately attracted increased attention, much less attention has been paid to other disequilibria experienced especially since the early 1970s in most industrialized countries, the most obvious examples being the goods and labor markets.

1.3 Aim of the Studies

The aim of the studies is to contribute both theoretically and empirically to the assessment of the effects of exchange rate policies and international inflation in a small open economy with under-developed financial markets, namely Finland. The effects are also considered in cases where other disequilibria are present in the economy. Related to this an important additional aim of the studies is to specify and estimate disaggregated dynamic models of Finnish exports and imports of goods. Since the balance of payments is an important direct channel in the transmission mechanism of exchange rate policies, these models are crucial in the quantitative studies of policies in the first two articles.

The institutional characteristics of the Finnish financial markets suggest the use of the disequilibrium approach with models in which rationing in some markets affects behaviour in other markets. Since the transmission mechanisms of economic policy measures are more varied in disequilibrium models than in conventional specifications, the questions concerning exchange rate policies we address in the studies are quite fundamental in nature. The studies are primarily concerned with questions of the channels and dynamics of effects of exchange rate policies and imported inflation in the different regimes of the models. On this basis, the most relevant considerations for the timing of policies and supporting measures are also briefly discussed.

The above topics are first considered at a theoretical level and then empirically. The theoretical analysis is carried out in two stages. To highlight the channel of exchange rate policy effect stemming from credit rationing, we first consider a theoretical model in which only this disequilibrium element is included. The theoretical framework is then enlarged to include other empirically plausible disequilibrium markets, so that the effects of exchange rate policies can be studied in various regimes of the economy.

In addition and related to the macro-oriented themes in the thesis, specification and estimation issues relating to Finnish exports and imports, together with some specific topics, are also considered. These are primarily empirical questions concerning the properties of the export and import equations in the econometric disequilibrium macromodels in the first two studies.

II THEORETICAL APPROACH

In this Chapter the theoretical approach of the studies is summarized. First, after a brief introductory survey the theoretical framework and results of the disequilibrium approach in Aurikko (1982) and Aurikko (1984b) are discussed. The study in Aurikko (1985a) dealing with somewhat different issues is also summarized here. Secondly, theoretical considerations concerning the specification of the export and import models in the four remaining studies are addressed. The econometric estimation and testing methodology is discussed in Chapter III.

2.1 Introduction

According to Tobin (1980), two different macroanalytical approaches have emerged from the post-Keynesian neoclassical synthesis of the 1960s, both of which stress the need to establish firm micro-economic foundations for macroeconomic theory. The first is the disequilibrium

approach in which prices do not continuously clear all markets. Those agents unable to satisfy their initial notional demands or supplies alter their behaviour in other markets, giving rise to effective demands or supplies. The second approach is the so-called new classical macroeconomics, which is based on rational expectations and continuous market clearing with flexible prices and implies radically different policy implications.

As an introduction the main traditional approaches employed in analysing the effects of exchange rate policies are first briefly reviewed. The derivation and presentation of the disequilibrium approach suitable for a small, open industrialized economy with underdeveloped financial markets is carried out in two stages in the studies. First, a simplified macroeconomic model incorporating only disequilibrium phenomena in the credit market, i.e. credit rationing, is presented in Aurikko (1982). This is motivated by the important role of credit rationing in the transmission of economic policy effects.

Although the model is somewhat analogous to the traditional IS-LM models, it is instructive to study the direct and indirect channels of exchange rate policies in this framework since it also contains the most important elements and economic policy channels of the quarterly econometric model simulated in Aurikko (1982). Secondly, the disequilibria elements in the Finnish economy are studied in greater detail within the framework of a non-Walrasian model for a small open economy in Aurikko (1984b).

Another issue dealt with in the studies is the theoretical discussion and empirical testing and estimation of disaggregated models for imports and exports. Disaggregated models are incorporated in the econometric macromodels to assess empirically the effects of exchange rate policies. This is done in the belief that the institutional and structural characteristics and dynamics of Finnish balance of payments items are captured more reliably in the framework of disaggregated models than in aggregated models.

Traditionally, the effects of exchange rate policies have been assessed first from the viewpoint of various partial approaches and then later within the framework of more integrated macro-economic models. The partial approaches are, in the order of historical origin, the elasticity approach, the Keynesian multiplier approach, the absorption approach, the saving-investment approach and the simplest versions of the monetary approach.⁵

All the partial approaches to devaluation analysis are, in principle, based on various aspects of macroeconomic accounting identities, as noted by Mundell (1968). Even if capital movements are included, all approaches assert identical propositions with different assumptions and interpretations of the economy, and can thus be viewed as reduced-form equations of a larger macroeconomic model.

Starting with the work of Harberger (1950), Laursen and Metzler (1950) and Meade (1952), the partial approaches were gradually integrated into an IS-LM open economy framework capable of treating both income and price effects [see Mundell (1962), Fleming (1962), Mundell (1968) and Shinkai (1975)]. In its simplest form, this standard open economy Keynesian model consists of equilibrium conditions for the output and money markets and a balance of payments equation. With different assumptions concerning prices, output, money supply and the prevailing exchange rate regime, the model can be used to study unemployment and full employment cases, fixed and flexible exchange rate regimes and short-run and long-run effects.⁶

In the 1960s and 1970s, balance of payments theory was elaborated in various directions. One of the extensions was the introduction of tradeables and nontradeables goods in the context of the external and internal balance problem as originated by Salter (1959) and of exposed and sheltered sectors in the Scandinavian model of inflation developed by Aukrust (1970) and Edgren, Faxén and Odhner (1969). Monetary aspects have also been integrated into open economy macroeconomics with the aid of asset market or portfolio balance considerations, together with recognition of budget constraints,

balance sheet identities and equilibrium conditions. Finally, specification of dynamics and expectations formation processes have received increased attention in recent literature on open economy macroeconomics.⁷ One interesting and fruitful research area in recent years has emerged from the various disequilibrium formulations of the conventional IS-LM models.

2.2 Disequilibrium Approach

The persistent disequilibria, especially in the labor market, which emerged in most industrialized countries in the 1970s and the inability of both conventional Walrasian equilibrium models, in which prices clear markets, and Keynesian demand-determined models to fully account for these phenomena has turned attention to non-Walrasian models. In these models, prices in some markets are rigid in the short-run because they are not determined by supply and demand, and markets clear through quantity rationing. Thus short-run price and wage rigidities prevent instantaneous attainment of an equilibrium and lead to temporary equilibrium with markets being cleared through quantity adjustments rather than through price adjustments. In the framework of non-Walrasian models and assuming short-run rigidities, different regimes of the economy can be studied. The models are relevant only in the short-run since no satisfactory theory for rigid prices in the longer run has been established.⁸ Non-Walrasian models were first presented for a closed economy [Barro and Grossman (1971, 1976), Dixit (1976) and Malinvaud (1977)]⁹ and subsequently extended to an open economy framework [Dixit (1978), Neary (1980), Steigum (1980) and Cuddington (1980)].

Most of the literature on non-Walrasian temporary equilibrium models with quantity rationing assumes highly developed financial markets with money normally being the only asset. This specification is not especially suitable in the case of a large group of smaller industrialized countries, including Finland, which lack well-functioning financial markets.

In Finland, domestic interest rates have traditionally been set institutionally, which, in the absence of other equilibrating non-price loan term mechanisms, has resulted in credit rationing from time to time.¹⁰ The financial markets have been dominated by deposit banks and foreign capital movements have been controlled fairly effectively by the central bank. With relatively low domestic interest rates during the past years, excess demand, and thus credit rationing in the domestic credit market, has been an almost permanent phenomenon. In such a framework, the pursuit of an independent domestic monetary policy has generally been possible.

However, the recent trends in the Finnish financial markets in the 1980s towards an enhanced role for market forces are gradually diminishing the importance of credit rationing. In addition, capital mobility has increased reflecting closer integration of domestic and international financial markets. These developments have tended to decrease the autonomy of domestic monetary policy.

Since the degree of capital mobility is inversely related to exchange risk, one policy option to acquire greater monetary autonomy is to increase exchange risk. This issue is studied in Aurikko (1985a) assuming a rule of active pegging, i.e. adjusting the exchange rate index and rational expectations. According to the model, monetary autonomy can be increased with more active pegging but possibly not without limit.¹¹

To study the channels through which exchange rate policies and imported inflation operate in a credit rationing economy, a theoretical macromodel is specified in the first study [Aurikko (1982)].¹² The credit rationing elements in the model are formulated simply by assuming that the credit market is homogeneous with the simultaneous existence of either rationed or unrationed agents, thus allowing separate treatment of credit rationing and no credit rationing regimes. The present theoretical model extends the earlier models notably by specifying price and wage behavior as well as disaggregated foreign trade and balance of payments equations, which are particularly important in studying the channels of exchange rate policy and imported inflation effects in a credit rationing economy.

One conclusion of the comparative statics analysis in Aurikko (1982) that is worth noting is that even a relatively simple macro-economic model with qualitative assumptions about partial responses cannot yield unambiguous short-run total effects for devaluation. This applies especially to the domestic demand and current account effects. Moreover, the quantitative properties of the responses, such as their magnitude and dynamic path, are beyond the scope of a static equilibrium model. These could be studied by specifying explicitly the functions of the model and giving or estimating its parameters numerically [e.g. Nguyen and Turnovsky (1979) and Halttunen (1980)].

As noted earlier, other disequilibrium phenomena in the Finnish economy besides credit rationing are possibly relevant, thereby motivating the need for their explicit treatment. Thus, exchange rate policy effects are also studied theoretically in the framework of an extended model which, in addition to disequilibrium in the financial markets, also allows for possible disequilibria in other markets as well [Aurikko (1984b)].

This non-Walrasian model is specified according to the characteristics of a small open economy with underdeveloped financial markets. The model is in the spirit of the studies by Steigum (1980), Cuddington (1980) and Kähkönen (1982) although the first two models do not specify loan markets. So as to be able to interpret the simulation results of the corresponding macroeconometric model, the present model includes - in contrast to earlier studies - fairly detailed balance of payments equations, notably those for imported final goods, intermediate imports substitutable in domestic production, endogenous exports determined by relative prices and capital movements. Moreover, a variety of other assets besides money is considered. Allowance is also made for the possibility of credit rationing affecting the behavior of households, since loans are introduced in the budget constraint of the households.

The model distinguishes between non-traded and traded goods in the domestic commodities markets and between different varieties of

assets in the asset markets. The sectoral aggregation of the model consists of households, banks, central bank, government sector, foreign sector and two sets of firms producing non-traded and traded goods, respectively.

2.3 Export and Import Equations

In the following, the theoretical framework for specifying the models of the trade balance items is briefly considered.¹³ First, the simultaneous determination of export supply and demand, also taking into account adjustments, is discussed. Secondly, the main theoretical considerations concerning the specification of export prices and import demand in the studies are summarized. Some more specific questions are addressed in Chapter III.

In discussing the modelling of export supply and demand, it is useful to start from two polar cases. In the first case exports are assumed to be completely demand-determined, the price elasticity of export supply thus being infinite. This Keynesian demand-determined model has been widely utilized in econometric studies of foreign trade. In the other polar case, exports are supply-determined, with infinite price elasticity of export demand. This classical determination of exports is incorporated in the Scandinavian model of inflation [see Edgren, Faxén and Odhner (1969)] and the monetary approach to the balance of payments [see Frenkel and Johnson (1976)], where export prices depend on world market prices and exports on domestic supply conditions.

In the study Aurikko (1985b), export supply and demand are specified in an intermediate manner between the polar cases. The simplest case would be to assume an equilibrium model with export prices and quantities adjusting to equilibrium instantaneously. By, moreover, assuming lags in adjustment, "disequilibrium" dynamics is introduced in the model.

As a starting point for the specifications, the simple equilibrium model presented in, for example, Goldstein and Khan (1978) is adopted

$$(1) \quad X^d = X^d(PX/PF, QW)$$

$$(2) \quad X^S = X^S(PX/PD, CU),$$

where export demand (X^d) is a function of the ratio of export prices (PX) to competitors' prices (PF) and of foreign real income or imports (QW). Export supply (X^S) depends on the ratio of export prices to domestic prices (PD) and on domestic capacity utilization (CU).¹⁴ Specification (2) differs somewhat from that in Goldstein and Khan. It is a simple supply function in the framework of imperfect competition in the product and factor markets represented by the variable CU [Aurikko (1975)]. Assuming instantaneous adjustment, the model is completed by the condition $X^d = X^S = X$.

A generalization¹⁵ of the conventional partial adjustment model suggested by Chow (1977) is

$$(3) \quad Y_t - Y_{t-1} = \Lambda(Y_t^* - Y_{t-1}),$$

where $Y_t^* = (\log X_t^e, \log PX_t^e)'$ are unobserved equilibrium values of models (1) and (2), which are assumed to be log-linear, $Y_t = (\log X_t, \log PX_t)'$ are observed values and Λ the adjustment matrix.¹⁶

Particularly in the case of a small open economy, an alternative to (3) is to assume first that export prices are set according to a reduced-form equation obtained from the long-run equality of supply and demand [see Spencer (1975) and Minford (1978)]. Underlying this assumption is essentially the notion that changing prices is costly, so that only intermediate or long-run supply and demand relations in pricing decisions are considered.¹⁷ Secondly, exports are assumed to be realized according to short-run demand and supply.¹⁸ Since the long-run equilibrium prices are not necessarily short-run equilibrium prices, both demand and supply conditions affect exports in the short-run. In this disequilibrium adjustment framework, the supply side of the market is incorporated in export quantity determination.

The assumptions about export quantity adjustment and price setting adjustment can be expressed as

$$(4) \quad \Delta \log X = \lambda_{11}(\log X^d - \log X_{-1}) + \lambda_{12}(\log X^s - \log X_{-1})$$

$$(5) \quad \Delta \log PX = \lambda_{21}(\log X^e - \log X_{-1}) + \lambda_{22}(\log PX^e - \log PX_{-1})$$

with $\lambda_{21} = 0$, λ_{11} , λ_{12} , $\lambda_{22} \geq 0$ and $\lambda_{11} + \lambda_{12} = 1$. The restrictions imply in equation (4) that

$$(6) \quad \log X = (1 - \lambda_{12})\log X^d + \lambda_{12}\log X^s$$

and in (5) that

$$(7) \quad \Delta \log PX = \lambda_{22}(\log PX^e - \log PX_{-1}).$$

According to the above approach, realized exports are determined from both the demand and the supply side, since prices may not be in the short-run equilibrium. First, the short-run export demand is considered. A traditional export demand model is derived from an explicit theory of export demand developed by Armington (1969).¹⁹ The model is then extended to include the supply side effects, which have often have received only a passing and less rigorous treatment in studies of international trade flows.

In this framework, there are many possible models for the determination of exports.²⁰ The most obvious schemes would be

$$(8) \quad X = X^d$$

$$(9) \quad X = X^s$$

$$(10) \quad X = (1-k)X^d + kX^s = X^d + k(X^s - X^d)$$

$$(11) \quad X = \min(X^d, X^s),$$

where X is realized exports, X^d and X^s are export demand and supply, respectively, and k is a fixed weight ($0 < k < 1$). Case (8), implying

zero stockholding costs and substantial foreign waiting costs, and case (9), with costs reversed, are probably too simple. Scheme (10) could be rationalized in terms of markets share adherence behavior as discussed in Kukkonen (1977), Aurikko (1980) and Aurikko (1985b).

The specification (10) for exports of homogeneous or relatively homogeneous products can be written as

$$(12) \quad X = a_1 MF^{b_1} \left(\frac{PX}{PF} \right)^{c_1} (X^S/X^D)^{d_1}, \quad c_1 < 0, \quad 0 < d_1 < 1,$$

where MF is the volume of imports of the most important export markets and X^S/X^D is relative excess supply.²¹

It is simply assumed in the specification of exports in Aurikko (1982) that since X^S/X^D is unobserved it can be approximated by profitability developments, so that when profitability is above (below) the average level of exports increases (decreases). This influence is stronger the more homogeneous exports are.²² By assuming that supply depends on export prices and unit labor costs and specifying demand as in (10), it is seen that X^S/X^D depends positively on export prices and negatively on unit labor costs. The profitability variable is also an increasing function of export prices and a decreasing function of unit labor costs.²³

When applied at the industry level, scheme (11) is too restrictive, implying implausible discontinuities. Estimation of even simple disequilibrium models such as (11) by maximum likelihood methods presents both theoretical and computational difficulties with possible unboundedness of the likelihood function [see Goldfeld and Quandt (1975)]. The dynamics of price behavior is, moreover, a difficult and unsettled issue.²⁴

In the foregoing it was basically assumed that perfect competition prevails in Finnish export markets. However, monopolistic competition might be a more realistic assumption. In the study [Aurikko (1986)] concerning disaggregated export prices the

specification of equilibrium export prices is based on the approach by Deppler and Ripley (1978) and Bruno (1979), according to which a reduced form price equation for a profit maximizing monopolistic firm is of the form

$$(13) \quad PX^e = F(PF, CD, CU).$$

where CD is domestic costs.²⁵ Equation (13) is linearly homogeneous with respect to PF and CD, and for small open countries competitors' prices are relatively important in export price formation.²⁶

Using the terminology of e.g. Calmfors and Herin (1979), a distinction is made in the disaggregated framework in Aurikko (1986) between heterogeneous and homogeneous output. In the former category, which consists of imperfectly substitutable products and has considerable monopoly power in the markets, pricing depends significantly on domestic costs [see Deppler and Ripley (1978)]. In the latter price formation is strongly dominated by competitors' or world market prices.

The specification of long-run equilibrium export prices for relatively homogeneous output implies that export prices closely follow world market prices. The specification also implies that ultimately exchange rate changes are fully passed through to prices expressed in domestic currency.

In specifying import demand equations in Aurikko (1985c) and Aurikko (1985d),²⁷ the theory of Armington (1969) is again utilized and the equations are derived within the framework of general foreign trade theory. This interpretation is possible because of the properties of the assumed CES quantity index of imports.

In the model in Aurikko (1982) disaggregated models of capital movements are also included. The theory of portfolio selection developed by Tobin (1958) and Markowitz (1959) is utilized in the specification of the demand for long-term assets and liabilities and short-term trade credits.²⁸ Other short-term capital flows are

obtained residually as in Tarkka (1983b) when total short-term capital flows (excluding movements in the foreign exchange reserves of the central bank) are explained by the monetary approach. Besides, the factors determining the demand for foreign assets, supply side factors may also exert a considerable influence on capital movements.²⁹ In the case of Finland, with its underdeveloped financial markets, these supply side considerations, mainly in the form of domestic credit rationing and controls on international capital movements, play an important role.

III EMPIRICAL ANALYSIS

In this Chapter the methodology applied in estimating and testing the models for exports and imports of goods in Aurikko (1985b-d, 1986) are described together with the estimation results. Finally, the simulation results for exchange rate policies obtained with the econometric models in Aurikko (1982) and in Aurikko (1984b) are summarized.

3.1 Data and Estimation Methodology

The data utilized in the estimation of the export and import equations are quarterly and seasonally adjusted.³⁰ They cover mainly the period 1962 - 1983 and were obtained from the data base of the quarterly model constructed by the Research Department of the Bank of Finland. The sources and construction of the data are explained in detail in Bank of Finland (1983).

The main estimation issues dealt with in the studies are discrimination between the disequilibrium adjustment models for export supply and demand and determination of the dynamics of the models. More specific questions concern testing for the functional form and disaggregation of the import demand models.

The methodology applied in the estimation and testing of export supply and demand equations in Aurikko (1985b) is as follows: First, the functional form for aggregate data is tested. Secondly, the system (3) is estimated by non-linear least squares, testing different versions of the disequilibrium specification for the elements in the adjustment matrix Λ . Finally, discrimination between models (3), (4) - (5) and (6) - (7), respectively, is discussed.

Disaggregated export price equations are estimated in Aurikko (1986) applying an error correction mechanism, taking into account the dynamic relationships and steady state properties suggested by economic theory. In searching dynamic specifications of the models of export prices and import demand, a dynamic testing procedure as suggested by Mizon (1977) and Harvey (1981) is adopted. In this framework, a general unrestricted dynamic model is taken as the maintained hypothesis, which is simplified systematically in the light of empirical evidence.³¹

The approach differs from that of distributed lags or time series analysis in that it determines the maximal lags and draws a distinction between systematic and error dynamics in the data generation process of the model. The underlying idea is to begin from the most general model and to test sequentially more restricted models. This is an alternative to starting from a simple restricted formulation and trying to assess if it is necessary to adopt a more general dynamic specification arising, for example, from slow adjustment and expectations formation mechanisms which are modelled partially.

The dynamic testing procedure is applicable to autoregressive-distributed lag models.³² The model discrimination problem is accomplished in a two stage testing procedure based on a simplification search in which in the first stage sequential tests for reducing the order of dynamics in the maintained autoregressive-distributed lag model are performed either for all the variables simultaneously or for each variable separately. In the second stage, conditional on the first, it is tested whether there are common factors in the model arrived at in the first stage.³³

3.2 Estimation results

Economic theory seldom offers any guidance as to the choice of the appropriate functional form in specifying and estimating econometric models. This is also the case in international trade theory, where the most commonly used functional forms in supply and demand equations have been linear and log-linear. The choice between this restricted class of functional forms has been made either on grounds of convenience or by some arbitrary statistical criteria.

In the study by Aurikko (1985b), the choice between linear and log-linear forms in simple aggregative export supply and demand equations is tested preliminarily using the Box-Cox (1964) procedure, which involves the specification of a power function.

The Box-Cox analysis of transformations was applied to the equilibrium model (1) - (2) and to its reduced form with X^e and PX^e solved from (1) - (2). However, as there were clear signs of autocorrelation in the residuals the extended method by Savin and White (1978) is used.

To summarize, it can be noted that the tests do not provide convincing support for either the linear or log-linear functional form. In part, this is due to the simple specifications studied, simultaneity of the model and aggregative data. Thus, the conventional log-linear form is used in estimating export supply and demand systems.³⁴

The empirical validity of the assumption of disequilibrium as against the equilibrium specification of the adjustment matrix Λ in (3) is first tested in Aurikko (1985b) in the case where X^e and PX^e are in reduced form. Secondly, restrictions on Λ are tested when X^e and PX^e are entered into (3) in structural form. Thirdly, discrimination between models based on adjustment mechanisms in (3) and in (4) and (5) is assessed and again tests of restrictions in the framework of the latter model are performed. Logarithmic models and aggregative data are used throughout.

In the aggregative framework with reduced-form models for X^e and PX^e , the adjustment mechanism which is data admissible implies that export volumes are determined by demand and supply considerations and that export prices adjust slowly to the long-term equilibrium price.

Secondly, the restrictions on Λ in (3) are tested where X^e and PX^e are reduced forms expressed in terms of the structural parameters of (1) and (2) written in the log-linear form. Even in this case the general adjustment mechanism ($\lambda_{21} = 0$, $\lambda_{22} \neq 1$) is supported by empirical considerations.

Next, the disequilibrium adjustment model (4) and (5) is considered. Testing the empirical validity of this model and the model above where export quantities are also adjusted with respect to the equilibrium values is less straightforward since the models are non-nested. In this context, the discrimination between the two models is assessed first by the Akaike Information Criterion (AIC) [Akaike (1978)],³⁵ which suggests that model (4) and (5) might be marginally selected. As the AIC rule is not especially powerful in discriminating between the models,³⁶ the non-nested procedure suggested by Pesaran and Deaton (1978) for testing systems of nonlinear equations is utilized. The tests also support the latter hypothesis, i.e. that in the aggregate framework the adjustment process is not symmetric in the case of export volumes and prices.

Finally, test results of the adjustment matrix Λ in model (4) and (5) suggest that there is empirical support for model (4) and (5), but that the adjustment mechanism in this framework is possibly more complicated than that implying models (6) and (7).

Since, however, the tests are conducted using aggregative data and simple models which implicitly assume that the adjustment mechanisms of export volumes and prices do not differ between different export categories, the evidence is not unduly against using model (4) and (5) with restrictions as in model (6) and (7) as a basic framework for estimation even in the case of disaggregated models of export volumes and prices as in Aurikko (1982).

The economic implications of the estimation results in Aurikko (1985b) are that nearly half of the changes in competitors' prices or exchange rates are transmitted to export prices in domestic currency, the adjustment lag being about four quarters. In this simultaneous model based on perfect competition the dependency of export prices on competitors' prices is considerably weaker than in most aggregative export price models. In Vartia (1972, 1974), Tanskanen (1976), Korkman (1980b), Halttunen (1980), Vartia and Salmi (1981) and Tarkka (1983a) export prices are affected mostly by competitors' prices and exchange rates, with domestic costs having a relatively minor influence.

The assumption of perfect competition in Finnish exports markets is not realistic, at least in the short-run. Moreover with disaggregated models a distinction between heterogeneous and homogeneous output can be made. In the former class pricing depends significantly on domestic costs while in the latter price formation is dominated by competitors' or world market prices.

It was assumed in the framework of monopolistic competition in Aurikko (1986) that the export price equation is linearly homogeneous with respect to competitors' prices and domestic costs. Together with the dynamics reflecting the slow adjustment and expectations formation mechanisms, this suggests the use of a simple error correction mechanism. The tests suggest that price setting is homogeneous in the export prices of the wood and paper industry products and heterogeneous in the case of metal and other industrial products.

Next, we follow Mizon and Hendry (1980) and, instead of imposing the restrictions untested as is often done in econometric work, we test whether the error correction mechanism is in fact a correct specification. The testing proceeds by applying joint F-tests on the restrictions, implying the error correction mechanism from a general dynamic model. The restrictions cannot be rejected for the export prices of wood industry products while in the model for export prices of paper industry products separate F-tests show that not all restrictions are data admissible.

In summary, it can be noted that the estimation results for the disaggregated export prices are statistically acceptable and the parameter estimates are reasonably stable. Moreover, imposing restrictions on the dynamics in the form of the error correction mechanism is not always data admissible and must be tested. The results also indicate strong dependency of Finnish export prices on competitors' prices and exchange rates. This dependency is considerably smaller in the case of a corresponding aggregative model in Aurikko (1986). In the recent study by Sukselainen (1984) disaggregated export prices depend more clearly on domestic costs.

In most empirical studies of the import demand model, the linear or log-linear functional form is assumed. For example, in the studies of Finnish imports of goods the log-linear or relative difference form is used in Vartia (1974), Aurikko (1975, 1984a), Korkman (1979) and Mannermaa and Kaski (1980). This assumption is not based on any theoretical considerations, so that the choice between the linear and log-linear forms is first tested in Aurikko (1985c). The testing is carried out both in the framework of an aggregate import demand equation and also in disaggregated models.³⁷

Again in the case of aggregate imports, since the Durbin - Watson statistics indicate the existence of positive autocorrelation in the residuals, at least in the static models, the method suggested by Savin and White (1978) is used. The test statistics imply that the log-linear form is clearly acceptable in both static and dynamic cases. This result is in line with results obtained elsewhere [see Khan and Ross (1977), Boylan, Cuddy and O'Muircheartaigh (1980) and Gandolfo and Petit (1983)].³⁸

In the literature there do not seem to be any studies which test the functional form for disaggregated import demand models. The tests with the disaggregated models also give strong support for the log-linear specification, especially in the models for imports of raw materials and fuels and lubricants, which account for about 70 per cent of total imports of goods. However, the disaggregated models were used without there being any empirical reasons for doing

so. Testing the aggregated versus the disaggregated specification is therefore necessary.

In the framework of the linear system the obvious way is to test the equality of the parameter estimates of the activity and relative price variables. Since, however, these variables do not sum to the corresponding aggregates the test would not be relevant. Thus, the decision on the desirability of disaggregation is based on the classical proposition by Orcutt (1950) of possible downward bias in estimated aggregate elasticities.

Accordingly, the testing is performed in Aurikko (1985c) by applying to the system of log-linear disaggregated models the seemingly unrelated regression equations (SURE) [Zellner (1963)] estimation method. The SURE estimation method is particularly suitable here because the disturbances in the models can be expected to be contemporaneously correlated and therefore a potential gain in the efficiency of the parameter estimates may be obtained. Moreover, in the SURE estimation framework constraints across different equations are effectively tested.

The test results give strong support for the rejection of the hypothesis of equality of the values of the coefficients of activity variables and relative prices in the static loglinear system. In the corresponding dynamic specification the different test alternatives point to the same conclusion.

While lately the choice between linear, log-linear and the general Box - Cox functional forms has been assessed in several studies, other plausible and interesting functional forms could be considered. The functional form issue in the case of Finnish aggregate import demand is examined in Aurikko (1985d). The alternative functional forms, which are log-linear, logit and exponential forms, are tested using nested and non-nested test procedures. The evidence provided by the logit and exponential alternatives cast some doubt on the empirical validity of the popular log-linear specification for Finnish aggregate imports. From the point of view of policy

appraisals the specifications give quite different results concerning, for example, the effects of exchange rate policies.

In estimating disaggregated import demand models the dynamic sequential testing procedure is again utilized. Summarizing the results, it can be noted that the estimated dynamic import demand models are fairly satisfactory with stable and plausible parameter estimates. The dynamic properties of the models do not appear to be too complicated and suggest that static specifications might be a suitable approximation for dynamic specifications.

Disaggregated dynamic models for long-term items in the capital account are estimated on the basis of the portfolio approach in the econometric model in Aurikko (1982). For the short-term capital account a specification according to the monetary approach is used. This implies that the short-term capital account is a function of the excess demand for money, where the demand for money depends on the value of production and the interest differential and the supply of money is obtained from a consolidated balance sheet of the banking sector.³⁹ The stocks of short-term trade credits are estimated according to the portfolio theory approach.

3.3 Simulation Results

As a potentially useful aid in policy planning, it is important to try to assess empirically the effects of foreign exchange policies and imported inflation. Two econometric models are utilized in this task in Aurikko (1982) and (1984b).⁴⁰ The first model is a disaggregated version of the quarterly model constructed by the Research Department of the Bank of Finland (BOF3D model).⁴¹ The specifications of the disaggregated models for the balance of payments items are similar to those discussed above. The second model is a more aggregated annual disequilibrium econometric macromodel of the Finnish economy.⁴²

The most important questions examined in the studies concerning exchange rate policies are: i) the dynamics of effects of devaluation

Studies of Exchange Rate Policies and Disequilibria in the Finnish Economy

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Academic dissertation to be publicly discussed, by permission of the Faculty of Social Sciences of the University of Helsinki, in Auditorium III, Porthania, Hallituskatu 11—13, on May 10, 1986, at 12 o'clock.

Helsinki 1986

and international inflation on domestic prices, real variables and balance of payments, ii) the optimal timing of the policy and iii) tentative conclusions concerning other policy measures taken to support exchange policies although these are not considered explicitly. Of course, the effects of devaluation depend crucially on the monetary policies adopted in connection with the devaluation [see Krugman and Taylor (1978)]. Other stabilization measures actually taken, e.g. in 1967 abolition of indexation, wage agreements, price controls and tax policy, will not be considered either so that the devaluation simulations cannot be interpreted as an analysis of the exchange rate policies conducted in Finland. Moreover, it is beyond the task of the studies to examine the assignment problem, policy norms or the question of accommodating domestic policy measures.

Traditionally, the effects of exchange rate policies have often been assessed within the framework of various partial approaches. A short empirical discussion of the elasticities approach is particularly useful here as an introduction to the empirical properties of the foreign trade block of the quarterly model with credit rationing. In the elasticity approach, the direct substitution effects of foreign exchange policy on the trade balance are considered. As a background to the assessment of the substitution effects, the foreign trade equations of the BOF3D model containing disaggregated equations for export prices, export demand and import demand are first briefly summarized.

The long-run price elasticity of total imports of goods in the BOF3D model in Aurikko (1982) aggregated by 1978 shares is -0.68 and that for exports -1.24 .⁴³ Since no domestic repercussions of the devaluation are taken into account in the partial simulation, aggregate export prices expressed in foreign currency fall somewhat. This causes growth in the aggregate export volume. Exogenous import prices in domestic currency are assumed to increase by about 9 per cent immediately after a 10 per cent devaluation⁴⁴ so that import volumes decrease quite sharply. As a consequence of these developments the trade balance improves markedly.

In the partial analysis of the effects of devaluation, domestic prices, wages and monetary variables were assumed to be constants throughout. The BOF3D macroeconometric model used in the first simulations to assess quantitative effects of exchange rate policy and imported inflation has Keynesian properties in the short-run and neoclassical properties in the long-run. In the model, production, income, labour, price and wage blocks are disaggregated into two open sector industries (forestry and manufacturing) and two closed sector industries (services and agriculture). This disaggregation utilizes the basic framework and ideas of the Scandinavian model of inflation, implying that in the long-run inflation will be equal to the rate of change in foreign prices and the exchange rate of the Finnish markka.

The disequilibrium element in the BOF3D model results from the assumption of financial disequilibrium. As there is no equilibrating interest rate mechanism in the Finnish loan market, equations for the demand for and supply of loans have been included in the financial sector of the model and estimated by means of a disequilibrium method. The maximum of the logarithmic ratio between these and zero is used as a credit rationing variable, which is the main channel of transmission of monetary effects in the model. Because of the lack of an equilibrating interest rate mechanism, possible disequilibrium in the credit market (credit rationing) has spillover effects in the expenditure equations and in short-term capital movements, as discussed above.

In connection with the simulations, no assumptions about accommodating domestic economic policy measures are made, implying in the case of monetary policy that the monetary effects of the balance of payments are not neutralized. As regards other exogenous changes in the model, it is assumed that the pass-through of exchange rate changes to aggregate imports prices in domestic currency is approximately 90 per cent.

The results of the simulations with the BOF3D model are in line with the qualitative conclusions made with the simplified theoretical

model in Aurikko (1982). In particular, the credit market effects of devaluation on domestic investment demand are dominant and, apart from an initial expansive effect, aggregate domestic demand contracts for a large part of the simulation period according to the econometric model. As policy simulations depend crucially upon the prevailing credit market regime and upon switching between the two regimes, it would be desirable to develop a version of the model based on heterogeneous credit markets which would permit smoother switching between the two regimes. Devaluation simulations associated with various domestic monetary measures are also important as a means of determining the sensitivity of the model with respect to these policies and in order to find optimal policy measures.

According to the simulations, the BOF3D model is fairly sensitive to the credit market conditions prevailing at the time the policies are implemented and to a possible change in credit market regime or tightness in the credit rationing regime. This has implications both for the timing of the policy measures and for the supporting monetary policy undertaken in order to dampen possible cyclical movements in domestic demand. An additional complicating factor is that the model is not linear with respect to the magnitude of the shock.

Finally, exchange rate policy simulations with the second multimarket disequilibrium model in Aurikko (1984b) are summarized. Compared with single market disequilibrium models, the estimation problems are more complex in the case of multimarket disequilibrium models. In these models, the multiplicity of the integrals in the likelihood functions depends on the number of interrelated markets, thus creating difficult computational problems in estimation.⁴⁵ Despite these pitfalls there have been several attempts to estimate multimarket disequilibrium models. The most notable are by Artus et al. (1984), Kooiman and Kloek (1985), Sneessens (1981) and Vilares (1981) [for a recent survey, see Laffont (1985)]. The first and second models, both two-market disequilibrium models, are estimated by the maximum likelihood method, while the other two models, being basically recursive, are estimated using single equation estimation techniques.

Besides estimation problems, most econometric work on multimarket disequilibrium models has been confined to the goods and labor markets. For some small countries with underdeveloped financial markets, such as Finland, an explicit treatment of disequilibrium in these markets would be highly desirable. Since the spillover effect in such models from the goods market to the financial market is relatively weak, the model is approximately recursive and can be estimated by single equation methods, thus avoiding difficulties still encountered in full-information methods.

The estimated disequilibrium model is specified on the basis of the theoretical model summarized above and in Aurikko (1984b). Annual data for the years 1960 - 80 are mainly adapted and aggregated from the data base of the quarterly econometric model constructed at the Bank of Finland (BOF3 model).⁴⁶

Since the effects of economic policies in a disequilibrium model are highly dependent on the regimes prevailing in the economy, this issue is studied in the framework of various exchange rate policy simulations. In the simulations, devaluations are assumed to be carried out at the beginning of, alternatively, 1965, 1971 or 1975. The timing of the devaluations is set so as to coincide with the different unemployment regimes in the economy. On the basis of the estimation results there was excess supply in the traded goods market without credit rationing in 1965 - 1969, excess demand without credit rationing in 1970 - 1973 and excess supply with credit rationing in 1975 - 1979.

According to the simulations, the devaluation effects are very sensitive, especially to the credit market conditions prevailing at the time the policies are implemented and to a possible change in the credit market regime or excess demand for credit in the credit rationing regime. The policy effects are not affected so much by the conditions prevailing in the goods market, assuming moderate policy shocks, although some cyclical oscillations are discernible.

In summary, it can be concluded that the beneficial effects of devaluation are best obtained by implementing the policy measure in

conditions of excess supply in the traded goods market, implying underutilization of resources with no credit rationing, or by easing the credit market through appropriate monetary policies in order to ensure rapid export expansion with relatively minor economic fluctuations. Thus, disequilibria in the credit and goods markets seem to have clear implications both for the timing of policy measures and for the supporting monetary and fiscal policies undertaken in order to dampen possible cyclical movements in domestic demand.

IV CONCLUDING REMARKS

The present studies have examined the effects of exchange rate policies in different disequilibria regimes of the economy. Since the trade balance is an important direct channel in the transmission of policy effects, theoretical and empirical issues concerning exports and imports of goods are also investigated in the studies.

According to the theoretical analysis and simulations with the two disequilibrium models, the effects of exchange rate policies are very sensitive, especially to the credit market regime prevailing at the time the policies are implemented. There is clearly less sensitivity in this respect in the case of the goods market. However, recent trends in the Finnish financial markets towards an enhanced role for interest rates in equilibrating the markets is diminishing the significance of credit rationing. In addition, the growing international integration of Finnish financial markets and increased sensitivity of foreign capital flows to interest rate differentials and exchange rate expectations points to the need to model expectations in a satisfactory way.

On the basis of the aggregated and disaggregated analysis of the models for exports and imports of goods there seems to be scope for some further research in this area. In this connection it might be

useful to study the models for exports and imports in the light of various estimation periods using rigorous dynamic econometric methods. Assuming different theoretical approaches and testing them using appropriate testing procedures would also be an important task. Finally, disaggregating exports and imports by goods and areas might provide fruitful insights.

FOOTNOTES:

- 1 In Finland, this was first accomplished unofficially in the early 1970s and officially in 1977.
- 2 For a concise survey of model building in Finland in the 1970s, see Halttunen (1980).
- 3 Lately, unregulated credit markets have emerged where loans are contracted at market rates conforming closely to the call money rate set by the central bank. Models incorporating these developments are beginning to appear; see e.g. Kähkönen (1984) and Bank of Finland (1985).
- 4 The studies of exchange rate policies in Halttunen (1980) and Halttunen and Korkman (1981) do not incorporate disequilibrium in the bank loan market.
- 5 See Robinson (1944), Kindleberger (1968), Alexander (1952), Black (1959). For surveys, see Stern (1973) and Johnson (1975 and 1977).
- 6 For a review and detailed discussions, see Kyle (1976) and Korkman (1980a).
- 7 See Dornbusch (1980) and Handbook of International Economics (1985).
- 8 For a discussion, see Cuddington, Johansson and Löfgren (1984).
- 9 The initial impetus to these models was given by Patinkin (1965), Clower (1965) and Leijonhufvud (1968).
- 10 Rigidity of non-price loan terms can be rationalized by existing agreements, costs of changing the terms [see Koskela (1976) and Baltensperger (1980)] and adverse changes in the loan portfolios of the banks [see Stiglitz and Weiss (1981)].
- 11 An empirical analysis of the extent of monetary autonomy in Finland can be found in Rajakangas and Johansson (1984).
- 12 Earlier attempts at specifying credit rationing models for the Finnish economy have been made by Koskela (1979a,b), Oksanen (1980), Willman (1981) and Kähkönen (1982).
- 13 This discussion refers to the studies in Aurikko (1985b-d, 1986) but, as noted earlier, it also has relevance for the foreign trade equations in Aurikko (1982) and Aurikko (1984b).
- 14 It is assumed that $\partial X^d / \partial (PX/PF) < 0$, $\partial X^d / \partial QW > 0$ and $\partial X^S / \partial (PX/PD)$, $\partial X^S / \partial CU > 0$.
- 15 A even more general specification is discussed in Aurikko (1985b).

- 16 It would seem that specification (3) violates the principle of voluntary exchange, i.e. $X = \min(X^d, X^s)$. As Chow (1977) argues, the principle is valid only for equilibrium situations with actual demand or supply exceeding equilibrium demand or supply because of costs or some other rigidities associated with demand or supply changes. Alternatively, buyers and sellers might not have equal market power [Rosen and Quandt (1978)].
- 17 For one of the first theoretical treatments of this subject, see Barro (1972). For a recent dynamic intertemporal study, see Rotemberg (1982). Empirical support for the proposition that in the short-run quantities tend to be more flexible than prices in the adjustment behaviour of firms is given by Kawasaki, McMillan and Zimmerman (1982).
- 18 Some plausible schemes are presented in equations (8) - (11).
- 19 The framework is discussed in Aurikko (1975).
- 20 See Minford (1978).
- 21 The model includes the cases of demand-determined exports ($d_1 = 0$) and supply-determined exports ($d_1 = 1$).
- 22 The long-run effects of changes in profitability, which are especially relevant in capital intensive production, are not specified in (12).
- 23 This can be seen by writing profitability (gross profits) as $(PX \cdot X - W \cdot L) / PX \cdot X = 1 - ULC / PX$, where W is the wage rate, L employment and ULC unit labor costs.
- 24 Accordingly, it might be more realistic to accept (11) at the firm level and to aggregate to the industry level on the assumption that there exist simultaneously firms facing excess demand and excess supply, so that the markets are heterogeneous. Assume, according to Muellbauer (1978), that for firms with excess supply $X^s + \varepsilon_j \geq X^d + \eta_j$ and that for firms with excess demand $X^s + \varepsilon_j < X^d + \eta_j$, where ε_j and η_j are stochastic variables with a continuous cumulative distribution function $F(\varepsilon, \eta)$. Mean exports are given by

$$X = \int_{\theta > Z} (X^d + \eta) dF + \int_{\theta < Z} (X^s + \varepsilon) dF = X^d - V(Z),$$

where the average state of excess demand is denoted by

$Z = X^d - X^s$, mean excess demand by V and $\theta = \varepsilon_j - \eta_j$. The expression is similar to (12) except that $X < \min(X^d, X^s)$ and V is a non-linear function of Z , the form of which depends on the specification of the distribution F . As noted by Laffont (1985), no satisfactory theoretical basis exists for

modelling F , so that this approach is comparable to a formulation in which the realized quantity is a non-linear and thus approximately linear function of supply and demand.

- 25 Since the variable CU in (13) is the ratio of actual output to potential output, it approximates the positive scale variable effect from the demand function and the negative productivity effect from the production function. Alternatively, the variable CU might reflect less than perfect competition in the markets for inputs [Evans and Klein (1967)].
- 26 Empirical support is provided in Amano (1974). For empirical evidence in the Finnish case, see Aurikko (1980), Korkman (1980b), Halttunen (1980), Vartia and Salmi (1981) and Sukselainen (1984). For an extensive study in the Swedish case, see Calmfors and Herin (1979).
- 27 It is assumed that import prices (supply) are exogenous in the model. This assumption is based on the fact that Finnish imports make up only a small share of total world trade and therefore have only a marginal influence on world prices. In the same way, it can be assumed that the supply of Finnish imports is very elastic at the prevailing world market price.
- 28 See Aurikko (1976).
- 29 Among the first to stress this was Spittäler (1971).
- 30 For the possible pitfalls of using seasonally adjusted data in dynamic models, see Davidson, Hendry, Srba and Yeo (1978).
- 31 An optimal sequential testing procedure exists only for naturally ordered nested hypotheses. The complexity of the testing increases when the hypotheses are not naturally ordered.
- 32 These models are of the form

$$(i) \quad \theta(L)'X_t = w_t,$$

where $\theta(L)$ is a vector of $(k+1)$ polynomials in the lag operator L with orders m_0, m_1, \dots, m_k and with $\theta_0(L)$ operating on the normalized dependent variable. The orders of polynomials determining the systematic dynamics of the model (i) are taken to be sufficiently large to ensure that the error term w_t is white noise.

- 33 Denoting this model by $AD(\tilde{m}_0, \tilde{m}_1, \dots, \tilde{m}_k)$ with $\theta_{\tilde{m}}(L)$ being the vector of polynomials in L , the determination of the error dynamics of the model $AD(\tilde{m}_0, \tilde{m}_1, \dots, \tilde{m}_k)$ in the form of the number of common factors extractable from the model consists of testing the sequence of hypotheses

$$(i) \quad \rho_r(L) \alpha_{\tilde{m}-r}(L) = \theta_{\tilde{m}}(L)$$

for $r = 0, 1, \dots, \underline{m}$, where $\underline{m} = \min(m_i)$. Thus the first test is for one common factor. If this test is not rejected, a test for two common factors is conducted and so on. The procedure is continued as long as the hypotheses are accepted.

The common factor test procedure is illustrated by the following simple model with the common factor restriction removed

$$(ii) \quad Y_t = a + bX_t + cZ_t + u_t,$$

where $u_t = \rho u_{t-1} + \varepsilon_t$, with ε_t representing white noise. The common-factor transformed model is obtained by subtracting from (ii) its lagged form multiplied by ρ :

$$(iii) \quad Y_t = (a - \rho a) + \rho Y_{t-1} + bX_t - \rho bX_{t-1} + cZ_t - \rho cZ_{t-1} + \varepsilon_t$$

The corresponding unrestricted model is

$$(iv) \quad Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 X_t + \alpha_3 X_{t-1} + \alpha_4 Z_t + \alpha_5 Z_{t-1} + w_t.$$

Comparing (iii) and (iv) it is seen that in the former model there are four parameters to be estimated while in the latter there are six. When the common factor restriction is valid the statistical efficiency of the parameter estimates is improved. Testing the validity of common factor restrictions could be based on Wald tests, so that estimation of only the unrestricted model is needed [see Harvey (1981)]. However, the constraint between coefficients of more dynamic models than (iii) and (iv) would be complicated. Thus, we use the LR-test, where the transformed structure, i.e. equation (iii), is estimated by a non-linear maximum likelihood algorithm.

- 34 There seem to be no studies in the literature on the appropriate functional form for export demand and supply models. However, in many studies on import demand the appropriate functional form is found to be log-linear [see e.g. Khan and Ross (1977) and Boylan, Cuddy and O'Muircheartaigh (1980)].
- 35 According to the AIC, the decision rule is to select the model for which $AIC = -2L + 2n$ is the minimum, where n is the number of parameters estimated. On the relative power of this test procedure, see e.g. Judge et al. (1980).
- 36 A more satisfactory related test would be Schwarz' Bayesian Information Criterion [Schwarz (1978)]. See the discussion in Teräsvirta and Luukkonen (1983).
- 37 The specification of the disaggregated models is discussed in Aurikko (1984a, 1985c).

- 38 It is somewhat restrictive to compare only linear and log-linear models. Recently developed LM tests could be used to assess the adequacy of the specifications against the general Box-Cox specification [see Godfrey and Wickens (1981), Ghosh, Gilbert and Hughes Hallet (1983) and Tse (1984)].
- 39 See Tarkka (1983b).
- 40 Both models are subject to the Lucas (1976) critique of econometric policy evaluation. For a somewhat different view and discussion, see Sims (1982).
- 41 For a more detailed presentation of the BOF3 model, see Tarkka and Willman (1981) and Bank of Finland (1985). A description of an earlier version of the model can be found in Bank of Finland Quarterly Model (1972) and Koskenkylä (1972), Halttunen (1972), Lahtinen (1972), Aurikko (1973), Pohjola (1974), Hirvonen (1975) and Willman (1976).
- 42 In the corresponding theoretical model above rigid prices were assumed, thus restricting the analysis to the short-run. In the econometric model in Aurikko (1984b) prices are endogenized.
- 43 The absolute values of the short-run price elasticities are considerably smaller.
- 44 See the discussion in Aurikko (1982).
- 45 Besides computational problems in the numerical optimization of the likelihood function, there is also a possibility of multiple maxima.
- 46 Bank of Finland (1983) and Tarkka and Willman (1981). The non-traded and traded sectors correspond to the aggregated closed and open sectors in the BOF3 model. The specification of some equations also resembles that of the BOF3 model, except for the spillover terms. Of the four disequilibrium markets in the model, in only two, i.e. the loan and traded goods markets, are transactions assumed to be determined either by demand or supply, whereas the nontraded goods market and the labor market are always demand-determined. In view of the size of the overall model and anticipating insurmountable computational problems, the loan and traded goods markets are written as an approximation in the form

$$(i) \quad Z_1 = \min(Z_1^d, Z_1^s) + \varepsilon_1$$

$$(ii) \quad Z_2 = \min[Z_2^d - \alpha_2(Z_1^d - Z_1), Z_2^s] + \varepsilon_2,$$

where Z_i , Z_i^d and Z_i^s are the observed quantities, unobserved demands and supplies in the loan ($i=1$) and traded goods markets

($i=2$), respectively, α_2 is a parameter and ε_2 and ε_2 are normally and independently distributed error terms with zero means. In the credit rationing regime, the spillover term $Z_1^d - Z_1$ is positive and it can be shown [Ito (1980)] that in the case of Cobb-Douglas utility functions the deviation of the rationed agents' effective demand from their notional unconstrained demand is a linear function of the degree of excess demand. In the regime without credit rationing (excess loan supply), $Z_1^d - Z_1 = 0$ and the spillover effect is absent. The system (i) - (ii) is recursive and can be estimated sequentially by single equation estimation methods. Although the system is nonlinear, maximum likelihood estimation and nonlinear least squares estimation are equivalent because of the additive error specification.

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Exchange Rate Policy and Imported Inflation in a Credit Rationing Economy¹⁾

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Abstract: The paper assesses the effects of exchange rate policies and imported inflation in the case of Finland, which is a small open economy with underdeveloped financial markets. Under such circumstances interest rates do not necessarily equilibrate the credit market, so that a simplified theoretical disequilibrium model with credit rationing is first presented. In the second part of the paper the Bank of Finland quarterly econometric model for the Finnish economy is simulated. The most important conclusion to emerge from the simulations with the quarterly model is that the effects are highly dependent on the credit market conditions.

1. Introduction

The aim of this paper is to simulate the effects of exchange rate policies and imported inflation in the case of Finland, which is a small open economy with underdeveloped financial markets. Domestic interest rates in these markets have traditionally been set institutionally, which, in the absence of other equilibrating mechanisms, has resulted from time to time in credit rationing. As other financial institutions and the securities market play only a minor role, the markets have been dominated by deposit banks and firms have had to resort mainly to domestic and foreign bank lending for investment finance. Moreover, foreign capital movements have been controlled fairly effectively by the central bank. With relatively low domestic interest rates during the past years, excess demand, and thus credit rationing in the domestic credit market, has been an almost permanent phenomenon. In such a framework, the pursuit of an independent domestic monetary policy has, in general, been possible, and as the banks have been dependent on central bank borrowing the main monetary instruments have been the terms and cost of central bank credit. [For a review of Finnish financial markets see *Bingham et al.*]

To study the channels through which exchange rate policies and imported inflation operate in a credit rationing economy a simplified theoretical macromodel is first spec-

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ified in Section 2. The credit rationing elements in the model are formulated by assuming that the credit market is heterogeneous, thus simply allowing the treatment of credit rationing as a permanent phenomenon. Section 3 is devoted to simulations using the Bank of Finland quarterly econometric model for the Finnish economy. Finally, there is a brief concluding section.

2. The Channels of Exchange Rate Policy Effects in a Simplified Macroeconomic Model with Credit Rationing

2.1 Introduction

In simulating the effects of economic policy with large macroeconomic model it is instructive first to study the effects with the aid of a simplified theoretical model containing the most important elements and economic policy channels of the econometric model. The simplified model is used for an analysis of the direct and indirect channels of foreign exchange policy and imported inflation in order to be able to interpret the simulation results of the macroeconomic model and to assess their plausibility and logical consistency.

2.2 The Model

For an overall view of the model, Table 1 presents a simplified flow-of-funds framework with a foreign sector, private sector, private banks, central bank and government sector. Summing horizontally and vertically gives market and budget constraints, respectively. Subscripts *d* and *s* indicate demand and supply, respectively. Positive entries denote sources of finance and negative entries uses of finance.

The model is based on a short-run open economy extension of the traditional Keynesian model [*Meade; Mundell*].³⁾ It is assumed that the economy produces a single homogeneous commodity either for domestic demand or for export. Two commodities are imported: a final good and an intermediate good [cf. *Korkman*, 1980].

The former is substitutable for the domestic commodity while the latter is used as an input in domestic production in a proportion depending on relative prices. The equilibrium condition for the goods market is⁴⁾

³⁾ To explore longer-run implications, the model incorporates dynamics stemming from changes in stocks of financial assets working through the balance of payments and the government budget constraint together with price adjustment. However, exchange rate expectations and, in the long-run, important changes in stocks of real assets are ignored in the model.

⁴⁾ To simplify the specification of demand and import functions, the demand variables are written so as to include imports. In particular, because of their minor importance, terms-of-trade effects [see *Laursen/ Metzler*] on *EP* are assumed away. These variables also have their natural empirical counterparts in the econometric model.

	Foreign sector	Private sector	Private banks	Central bank	Government	Total
Gross income	YF	YPG			YGG	YV
- taxes		$-TA$			TA	
+ transfers		TR			$-TR$	
= Disposable income	YF	YP			YG	YV
- absorption		$-EPV$			$-EGV$	$-EV$
+ imports	MV					MV
- exports	$-XV$					$-XV$
= Financial deficit	$-BC$	BCP			BCG	0
Δ currency		$-\Delta S^d$		ΔS^s		0
Δ deposits		$-\Delta D^d$	ΔD^s			0
Δ central bank debt			ΔH^d	$-\Delta H^s$		0
Δ loans		ΔL^d	$-\Delta L^s$			0
Δ bonds		$-\Delta B^d$			ΔB^s	0
Δ foreign capital	$-\Delta KF^s$	ΔKFP^d			ΔKFG^d	0
Δ foreign exchange (central bank)	ΔGCB^s			$-\Delta GCB^d$		0
	0	0	0	0	0	

Tab. 1: Simplified Flow-of-Funds Framework

$$Y = \frac{P}{PD} EP \left(\overset{+}{Y}, \overset{-}{T}, \overset{-}{RL}, \frac{\overset{-}{Z}}{P}, \frac{\overset{+}{V_{-1}}}{P} \right) + \frac{PP}{PD} G + \frac{PP}{PD} X \left(\frac{\overset{-}{PP}}{ePF} \right) \quad (2.1)$$

$$- \frac{ePMF}{PD} MF \left(\overset{+}{EP}, \frac{\overset{-}{ePMF}}{PP} \right) - \frac{ePMR}{PD} MR \left(\overset{+}{Y}, \frac{\overset{-}{ePMR}}{PD} \right),$$

where

- Y = real domestic output (income)
 EP = real private domestic consumption and investment demand (private absorption)
 G = exogenous real government demand (government absorption)
 Z = rate of credit rationing
 X = volume of exports
 MF = volume of final imports
 MR = volume of intermediate imports
 PD = domestic output deflator
 PP = price level of domestic commodity
 P = overall domestic price level
 PF = exogenous foreign price level in foreign currency
 PMF = exogenous price level of final imports in foreign currency
 PMR = exogenous price level of intermediate imports in foreign currency
 e = exchange rate.

In (2.1) private absorption depends conventionally on real income Y , exogenous real taxes T , the loan rate RL and lagged real wealth V_{-1}/P . The signs above the variables refer to the assumed signs of the partial effects. In addition spill-over effects from credit rationing are captured by the inclusion of the variable Z/P in (2.1).⁵ On empirical grounds, as discussed above, and for analytical convenience only the case where Z is nonnegative is examined, i.e. the case of excess loan supply (no credit rationing) is ruled out. This is based on the assumption that the credit market is an aggregate of heterogeneous submarkets with the simultaneous occurrence of both rationed and unrationed customers, so that credit rationing is in effect all the time with only the degree of credit rationing varying. Further it can be shown [Ito] that in the case of Cobb-Douglas utility functions the deviation of the rationed customers' effective demand from their notional unconstrained demand is a linear function of the degree of excess demand. Aggregating over submarkets gives (2.1) [see Muellbauer], assuming that there are no direct spill-over effects from private demand to the credit market.

Export demand X depends on relative prices, foreign demand not being explicitly included because it can be assumed to be given exogenously in the case of a small country. According to the import demand function MF , total domestic absorption is allocated between domestic and foreign sources depending on relative prices. Similarly, the proportion of imported intermediate inputs used in production is based on relative prices.

The current account in terms of domestic prices is

$$BC = PP \cdot X - ePMF \cdot MF - ePMR \cdot MR - YF \quad (2.2)$$

where

$YF = RF_{-1} \cdot e(KFP_{-1} + KFG_{-1})$, i.e. net interest payments abroad

$RF =$ exogenous foreign interest rate level

$KFP =$ net stock of the short- and long-term foreign debt of the private sector in terms of foreign currency

$KFG =$ net stock of the foreign debt of the government in terms of foreign currency.

In the short-run KFP is the only endogenous component of total foreign debt and it is written simply

$$eKFP = KFP^d = KFP^d (RF, RL, Z). \quad (2.3)$$

This specification is based essentially on portfolio theory containing, however, no wealth variables [see Aurikko, 1976]. The credit rationing variable Z captures the spill-over effect from the credit market, as capital movements, and especially short-term capital flows, are not totally controlled by the central bank. In the equilibrium condition (2.3), foreign supply is assumed perfectly elastic and demand-determined. This implies that exchange rate changes lead to proportional changes in the net stock of foreign debt expressed in terms of foreign currency.

⁵ Z is the difference between loan demand and supply, see equation (2.17).

From the central bank balance sheet (see Table 1)

$$S = H + GCB \quad (2.4)$$

the supply of central bank credit to the private banks H^s is derived residually, as the foreign exchange reserves of the central bank GCB are obtained from the overall balance of the balance of payments

$$\Delta GCB = BC + \Delta KFP^d + \Delta eKFG \quad (2.5)$$

and the supply of currency S^s is assumed to be determined by demand given as

$$S^s = S^d (PD^+ \cdot Y, RD, V_{-1}^+). \quad (2.6)$$

The specification of the remaining assets and liabilities of the model starts from the balance sheet of the private banks (see Table 1).

$$L = D + H, \quad (2.7)$$

where L is loans granted to the private sector, D domestic deposits and H central bank credit. All items in (2.7) are denominated in domestic currency, because it is assumed that the banks only act as intermediaries for loans denominated in foreign currency, i.e. their foreign exchange position is closed.

The banks are assumed to determine individually their supply of loans by maximising their profit and regarding deposits as well as interest rates as exogenously given. The supply of loans is thus

$$L^s = L^s (RL, R), \quad (2.8)$$

where R is the marginal cost of central bank credit defined as

$$R = R(H). \quad (2.9)$$

Finally, the stock of government bonds in the portfolio of the private sector is supply-determined because it is assumed that the government fixes their terms so as to make them sufficiently attractive. The supply of government bonds follows from the government budget constraint⁸⁾

$$\Delta eKFG + \Delta B = PP(G - T) + RF_{-1} \cdot eKFG_{-1} + RB_{-1} \cdot B_{-1}. \quad (2.10)$$

The price and wage block of the model contains equations and definitions for domestic prices, a Phillips curve and a simple expectations formation mechanism. In the case

⁶⁾ In (2.6) RD is the exogenous deposit rate.

⁷⁾ The equation should also include the exogenous basic discount rate together with monetary policy parameters determining the marginal cost of central bank credit. Although being the most important monetary instruments of the central bank, they are not included in (2.9) because they are subsequently treated as constants.

⁸⁾ In the constraint, RB is the exogenous tax-free bond rate.

of a small open economy like Finland, domestic prices are strongly influenced by world market prices although costs and demand pressures have some influence as well [for empirical evidence, see *Aurikko*, 1980; *Vartia/Salmi*]. A hat over a variable denotes proportionate change, e.g. $\hat{PD} = \Delta PD/PD_{-1}$. Assuming all prices and the exchange rate in the previous period to be equal to one, we get $PD = PD_{-1} (1 + \hat{PD}) = 1 + \hat{PD}$. Thus

$$\begin{aligned} \hat{PD} &= a_1 + a_2 \hat{W} + a_3 (Y - \bar{Y}) + a_4 [e (1 + \hat{PF}) - 1] \\ 0 < a_2 < 1, a_3 > 0, 0 < a_4 \leq 1, \end{aligned} \quad (2.11)$$

where \bar{Y} is capacity output.

Wages are determined as

$$\hat{W} = b_1 + b_2 \hat{P} + b_3 (Y - \bar{Y}), \quad 0 < b_2 \leq 1, b_3 > 0. \quad (2.12)$$

Equation (2.12) is a conventional expectations-augmented Phillips curve for wages with price expectations formed according to the perfect foresight hypothesis and equivalent to rational expectations in a deterministic model, and the unemployment level approximated according to "Okun's law" by the capacity output gap $Y - \bar{Y}$.⁹

Prices PP and P are defined as¹⁰)

$$\hat{PD} = k_1 \hat{PD} + (1 - k_1) [e (1 + \hat{PMR}) - 1], \quad 0 < k_1 < 1 \quad (2.13)$$

$$\hat{P} = k_2 \hat{P} + (1 - k_2) [e (1 + \hat{PMF}) - 1], \quad 0 < k_2 < 1. \quad (2.14)$$

Equations (2.11)–(2.14) can be reduced to

$$\begin{aligned} \hat{P} &= c_1 + c_2 (Y - \bar{Y}) + c_3 [e (1 + \hat{PMR}) - 1] \\ &+ c_4 [e (1 + \hat{PMF}) - 1] + c_5 [e (1 + \hat{PF}) - 1]. \end{aligned} \quad (2.15)$$

With the above restrictions $c_2, c_3, c_4, c_5 > 0$.¹¹)

2.3 Effects of Exchange Rate Policy and Imported Inflation

This subsection analyses the short-run effects and longer-run implications of exchange rate policy and imported inflation on domestic output, credit rationing, the current account and domestic inflation in the macromodel outlined in the preceding subsection.

⁹) Possible direct credit rationing effects on the supply side of the model are assumed negligible and are thus ignored.

¹⁰) The price levels are geometric averages with fixed weights. In the short-run this is not a serious limitation.

¹¹) It is easily seen that in the long-run when $Y = \bar{Y}$ a sufficient condition for the domestic inflation rate to equal world inflation or exchange rate depreciation is that (2.11) and (2.12) are linearly homogeneous with $a_2 + a_4 = 1$ and $b_2 = 1$.

The model is as follows:

$$\begin{aligned}
 Y = \frac{1 + \hat{P}}{1 + \hat{P}\hat{D}} EP \left[Y, T, RL, \frac{Z}{1 + \hat{P}}, \frac{(L^s + GCB + B)_{-1}}{1 + \hat{P}} \right] \\
 + \frac{1 + \hat{P}\hat{P}}{1 + \hat{P}\hat{D}} G + \frac{1 + \hat{P}\hat{P}}{1 + \hat{P}\hat{D}} X \left[\frac{1 + \hat{P}\hat{P}}{e(1 + \hat{P}\hat{F})} \right] \\
 - \frac{e(1 + \hat{P}\hat{M}\hat{F})}{1 + \hat{P}\hat{D}} MF \left[EP, \frac{e(1 + \hat{P}\hat{M}\hat{F})}{1 + \hat{P}\hat{P}} \right] \\
 - \frac{e(1 + \hat{P}\hat{M}\hat{R})}{1 + \hat{P}\hat{D}} MR \left[Y, \frac{e(1 + \hat{P}\hat{M}\hat{R})}{1 + \hat{P}\hat{D}} \right]
 \end{aligned} \quad (2.16)$$

$$Z = L^d [(1 + \hat{P}\hat{D}) Y, RL] - L^s [(1 + \hat{P}\hat{D}) Y, RL, RD, (L^s + GCB + B)_{-1}, GCB]^{12} \quad (2.17)$$

$$\begin{aligned}
 BC = (1 + \hat{P}\hat{P}) X - e(1 + \hat{P}\hat{M}\hat{F}) MF - e(1 + \hat{P}\hat{M}\hat{R}) MR \\
 - eRF_{-1} (KFP_{-1}^d + KFG_{-1})
 \end{aligned} \quad (2.18)$$

$$\begin{aligned}
 \hat{P} = c_1 + c_2 (Y - \bar{Y}) + c_3 [e(1 + \hat{P}\hat{M}\hat{R}) - 1] + c_4 [e(1 + \hat{P}\hat{M}\hat{F}) - 1] \\
 + c_5 [e(1 + \hat{P}\hat{F}) - 1]
 \end{aligned} \quad (2.19)$$

$$\Delta GCB = BC + \Delta KFP^d + \Delta eKFG \quad (2.20)$$

$$\Delta eKFG + \Delta B = (1 + \hat{P}\hat{P}) (G - T) + RF_{-1} \cdot eKFG_{-1} + RB_{-1} \cdot B_{-1} \quad (2.21)$$

The first four equations of the model determine the short-run static flow equilibrium and the last two equations the intermediate-run dynamic stock equilibrium. The distinctive feature of the model as compared with IS-LM models is that the conventional equilibrating endogenous interest rate mechanism of IS-LM models is replaced by credit rationing and its spill-over effects to other markets.¹³) The crucial monetary policy instruments are the terms and cost of the private banks' central bank credit. In the present model the equilibrium condition (2.16) defines the IS curve of the commodity market and equation (2.17) the LM curve of the loan market with respect to Y and Z .

Before analyzing the model by comparative statics it is first necessary to see whether the static part of the model can be solved uniquely. The Jacobian (J) of the static

¹²) In (2.17) the expression for L^s is obtained by inserting (2.9) into (2.8) and solving H from (2.4).

¹³) Earlier attempts at specifying an IS-LM analogy for the Finnish economy have been made by Koskela [1979], Oksanen [1980] and Willman [1981].

part of the model (2.16)–(2.19), where $F^i = (2, i)$, $i = 16, \dots, 19$, is

$$F_Y^{16} - F_Z^{16} F_Y^{17} + F_Z^{16} F_P^{17} F_Y^{19} - F_P^{16} F_Y^{19}. \tag{2.22}$$

Sufficient conditions for (2.22) to be positive follow from the assumptions about the signs of the partial derivatives of the model. In addition it is required that F_Y^{16} , F_Z^{16} and F_P^{16} are all positive. The first is true if $EP_1 < 1$, the second if $MF_1 < 1$ and the third if the partial price effect on demand is negative. Thus a unique solution for the model exists locally with respect to the endogenous variables as a function of the exogenous variables and parameters.

In studying the comparative statics properties of the model it is illuminating to treat the direct and indirect channels of causation separately.¹⁴⁾ In the case of exchange rate policy there are four direct channels, i.e. $\partial Y(e)/\partial e$, $\partial Z(e)/\partial e$, $\partial BC(e)/\partial e$ and $\partial \hat{P}(e)/\partial e$, which are positive according to the assumptions made above. In particular, $\partial BC(e)/\partial e = -F_e^{18} > 0$ provided the Marshall-Lerner condition is met.¹⁵⁾ Thus, for example, according to the model devaluation directly increases domestic demand and credit rationing, i.e. tightens the domestic credit market, improves the current account in terms of domestic currency and raises the domestic rate of inflation.

The total effect of devaluation can be obtained from equations

$$\begin{pmatrix} \partial Y/\partial e \\ \partial Z/\partial e \\ \partial BC/\partial e \\ \partial \hat{P}/\partial e \end{pmatrix} = \frac{1}{J} \begin{pmatrix} J_{11} & J_{21} & J_{31} & J_{41} \\ J_{12} & J_{22} & J_{32} & J_{42} \\ J_{13} & J_{23} & J_{33} & J_{43} \\ J_{14} & J_{24} & J_{34} & J_{44} \end{pmatrix} \begin{pmatrix} \partial Y(e)/\partial e \\ \partial Z(e)/\partial e \\ \partial BC(e)/\partial e \\ \partial \hat{P}(e)/\partial e \end{pmatrix}$$

where the indirect multiplier terms J_{ij} are cofactors of the Jacobian matrix with signs as shown in Table 2.

	Direct demand effect	Direct credit rationing effect	Direct current account effect	Direct domestic price effect
Y	+	-	0	-
Z	+	+	0	(+)
BC	(-)	+	+	(-)
\hat{P}	+	-	0	+

Tab. 2: Indirect effects of devaluation originating from

It can be seen from the first column of Table 2 that, according to the model, devaluation also increases domestic demand indirectly. Similarly, it tightens credit markets and accelerates inflation. However, the indirect demand effect on the current account is ambiguous, but possibly negative provided that the partial price and demand effects

¹⁴⁾ A similar approach is used in *Turnovsky* [1977].

¹⁵⁾ In fact, the Marshall-Lerner condition is possibly more stringent than necessary in the present model, because export prices in domestic currency rise according to equations (2.11) and (2.13). However, net interest payments also increase with unitary elasticity.

on credit rationing and the credit rationing effects on the current account are dominated by the partial price and demand effects on the current account, implying that the Marshall-Lerner condition is met.

The second column shows that a direct increase in credit rationing tends to reinforce itself indirectly, but reduce demand and inflation; the current account is improved indirectly. According to the third column the initial current account improvement is magnified indirectly. There are no other indirect effects because the variable BC in the model does not appear in equations (2.16), (2.17) and (2.19). The last column shows that domestic inflation reinforces itself indirectly. On the other hand, the indirect credit rationing effect is ambiguous but presumably positive. The indirect negative effect of inflation on the current account presupposes similar conditions as in the case of the indirect demand effect on the current account.

The sign of the overall effect of devaluation on the endogenous variables of the model is ambiguous, with the exception of the positive credit rationing effect, because according to Table 2 the indirect effects, the sum of which gives the total effect, are different in sign and therefore offsetting. For example, of the four channels making up the overall effect of devaluation on the current account two are positive and two negative: the indirect current account and credit rationing effects are positive while the demand and price effects are assumed to be negative. If the negative effects are relatively small, then the short-run impact of devaluation on the current account is positive. The total effect of devaluation on domestic demand and prices is also ambiguous, but probably positive. For this to be so requires, in particular, that the credit market effects of devaluation on demand and prices are quite small.

As a conclusion it can be noted that even a relatively simple macroeconomic model with qualitative assumptions about the partial responses cannot yield unambiguous short-run total effects for devaluation. This applies especially to the domestic demand and current account effects. Moreover, the quantitative properties of the responses, such as their magnitude and dynamic path, are outside the sphere of a static equilibrium model. Therefore it is desirable to study them in the framework of an econometric model.

Using the above results, the effects of imported inflation in the form of an increase in the prices of intermediate imports and overall foreign inflation are briefly discussed. The direct effects of an increase in the prices of intermediate imports (e.g. energy) are positive, except that $\partial Z(P\hat{M}R)/\partial P\hat{M}R = 0$. The positive direct demand and current account responses presuppose that the absolute value of the price elasticity of intermediate imports is large enough to compensate for the offsetting effects in final imports and exports caused by rising domestic prices. According to Table 2 the total effect is positive on inflation and possibly negative on the current account. Demand and credit market affects are uncertain.¹⁶⁾

¹⁶⁾ The above price elasticity assumption might be unrealistic, as substitution of raw material imports in domestic production is difficult, at least in the short-run. Consequently, the absolute value of price elasticity could be small so that the direct demand and current account effects may be negative. In this case the total effect on demand and credit markets is also negative, while that on the current account and inflation is ambiguous, but presumably negative on the former and positive on the latter.

As foreign prices and the exchange rate enter the model almost symmetrically, the effects of an increase in international inflation ($d\hat{P}\hat{M}R = d\hat{P}\hat{M}F = d\hat{P}\hat{F}$) are almost identical to those of exchange rate policy. Because, in addition, e is included in net interest payments in equation (2.18), the total short-run effect of devaluation on the current account is weaker than the effect of a corresponding increase in international inflation. Thus, provided the Marshall-Lerner condition holds, international inflation has more favourable balance of payments effects than devaluation.

To simplify the dynamic analysis of the model, it is assumed that V_{-1} does not enter equation (2.17). It is also assumed that B is an exogenous policy parameter of the government and that $\Delta B = 0$. Moreover, the exogenous foreign prices and exchange rate are set equal to one and the dynamics of domestic prices and wages are assumed to be stable with stationary values equal to one.

The dynamics of the model are determined by equations

$$Y - EP [Y, Y_{-1}, GCB, GCB_{-1}] + MF(EP) + MR(Y) = 0 \quad (2.23)$$

$$\Delta GCB + MF(EP) + MR(Y) - KFP^d + (1 + RF_{-1}) KFP_{-1}^d = 0 \quad (2.24)$$

obtained by inserting equation (2.17) into (2.16) and (2.21) into (2.20). Linearization of the system gives

$$Y + aY_{-1} + bGCB + cGCB_{-1} = K \quad (2.25)$$

$$Y + dY_{-1} + eGCB + fGCB_{-1} = K' \quad (2.26)$$

where K and K' are constants and the signs above the parameters have been derived using previous results and assumptions.

The stability conditions for (2.25) and (2.26) [see *Gandolfo*] suggest that the system might be stable provided that $d > 0$, i.e. the wealth effects of Y_{-1} via L_{-1}^s on EP are dominated by the credit rationing effects of Y_{-1} on KFP_{-1}^d . Thus the stability of (2.25) and (2.26), and hence local stability of (2.23) and (2.24), is not easily determined. However, assuming that the system is dynamically stable in the sense that all prices, wages and nominal variables grow at the rate determined by international inflation and all real variables are constant, suggests that devaluation is transmitted in full to domestic prices in the long-run. Domestic inflation can be kept lower than international inflation only by continuous revaluation.

The existence of a long-run dynamic equilibrium characterised by constant inflation implies the conventional result of monetary analysis that the real equations of the model are homogeneous of degree zero and nominal equations of degree one. A once-and-for-all devaluation or international inflation shock does not affect the stationary real variables of the model. So there are no current account effects except during a temporary adjustment period.

3. Effects of Exchange Rate Policy in a Macroeconomic Model of the Finnish Economy

3.1 A Partial Approach

Traditionally, the effects of exchange rate policies have often been assessed within the framework of various partial approaches. A short empirical discussion of the elasticities approach is particularly useful here as an introduction to the empirical properties of the foreign trade block of the model.

In the elasticity approach the direct substitution effects of foreign exchange policy on the trade balance are considered in the case where domestic incomes, wages and prices are taken as constants. In order to assess the substitution effects implied by the elasticities approach the foreign trade equations of the Bank of Finland quarterly model containing disaggregated equations for export prices, export demand and import demand are briefly reviewed [these are discussed in *Aurikko*, 1975, 1980].

The specification for export prices in the case of relatively homogeneous products is

$$PXUS = aPCOUS^b (CDUS/CFUS)^c, \quad (3.1)$$

where $PXUS$ is export prices, $PCOUS$ world market prices and $CDUS/CFUS$ relative costs in the home country and competitor countries, all measured in US dollars. The specification implies that ultimately exchange rate changes are fully passed through to the prices expressed in domestic currency. Export prices of more heterogeneous, imperfectly substitutable products also reflect the effects of prices of other inputs and capacity utilization pressures.

As Finnish export prices are highly dependent on world market prices, export volumes are also assumed to be determined from the supply side as well as by relative prices and demand, so that exporters adjust deliveries according to profitability developments: i.e., exports are determined as

$$X = a'MFO^{b'} (PXUS/PCOUS)^{c'} K^{d'}, \quad c' < 0, d' > 0, \quad (3.2)$$

where MFO is the volume of imports of the most important export markets and K is a profitability variable (gross profits). It is postulated that when profitability is above (below) the average level exports increase (decrease). This influence is stronger the more homogeneous exports are.

Import prices are exogenous in the model. It is also assumed that the supply of Finnish imports is very elastic at exogenously determined world market prices. Disaggregated import demand equations are specified in the standard way as

$$M = a''D^{b''} (PM/PD)^{c''} Q^{d''}, \quad b'' > 0, c'' < 0, \quad (3.3)$$

where D is the relevant demand variable, PM/PD relative prices of imports and demand D in domestic currency and Q other variables.

The long-run price elasticity for total imports of goods aggregated by 1978 shares was -0.68 and that for exports -1.24 .¹⁷⁾ As the foreign trade equations approximately fulfill the requirements for application of the Marshall-Lerner condition,¹⁸⁾ it is conceivable that devaluation would, according to this criterion, improve the Finnish trade balance. However, for a preliminary appraisal of the workings and dynamics of the foreign trade block of the model, the following simulation is presented.

	1971	1972	1973	1974	1978
Export prices	8.0	8.3	8.1	8.0	8.0
Volume of exports	1.1	1.2	2.1	2.3	2.3
Value of exports	9.2	9.9	10.4	10.5	10.4
Import prices	9.0	9.0	9.0	9.5	9.3
Volume of imports	-4.0	-5.2	-5.2	-5.4	-5.2
Value of imports	4.6	3.3	3.3	3.7	3.6
Trade balance	0.3	0.7	0.9	1.2	2.4

Tab. 3: Partial substitution (elasticities) effects of devaluation¹⁾

¹⁾ A 10 per cent devaluation of the Finnish mark from 1971. I onwards. Except for the trade balance, which is in billions of marks, multipliers are expressed as $100(XD_t - XC_t)/XC_t$ where

XC = control solution of variable X

XD = disturbed solution of variable X (exchange rates only are increased 10 per cent permanently from 1971.I).

As no domestic repercussions of the devaluation are taken account, aggregate export prices expressed in foreign currency fall somewhat. This causes growth in the aggregate export volume even disregarding the positive effects from increased profitability. Exogenous import prices in domestic currency are assumed to increase over 9 per cent immediately after devaluation so that import volumes decrease quite sharply. As a consequence of these developments the trade balance improves markedly.

In the partial analysis of the effects of devaluation discussed so far in this section, domestic prices, wages and for the most part monetary influences were assumed to be constants throughout. The rest of the paper deals with the quantitative effects of devaluation based on simulations of the macroeconomic model of the Finnish economy.

3.2 The Model

The macroeconometric model used in simulations is a quarterly model constructed at the Bank of Finland (BOF model) [for details see *Tarkka/Willman*]. It is basically a Keynesian demand-determined model in which production, income, labour, price and wage blocks have been disaggregated into two open sector industries (forestry and

¹⁷⁾ The absolute values of the short-run price elasticities are considerably smaller, as distributed lag schemes are extensively used in the foreign trade equations.

¹⁸⁾ As Finland is to a large extent a price-taker in her export markets, export prices in terms of foreign currency remain practically unchanged after devaluation. Exports tend to increase through the profitability channel after devaluation.

manufacturing) and two closed sector industries (services and agriculture). This disaggregation utilizes the basic framework and ideas of the Scandinavian model of inflation [see *Edgren/Faxén/Odhner*] implying that in the long-run inflation will be equal to the rate of change in foreign prices and the exchange rate of the Finnish mark.

As there is no equilibrating interest rate mechanism in the Finnish loan market, equations for the demand for and supply of loans have been included in the financial sector of the BOF model and estimated by means of a disequilibrium method. The maximum of the logarithmic ratio between these and zero is used as a credit rationing variable which is the main channel of transmission of monetary effects in the model. Thus, unlike the theoretical model, the BOF model assumes a homogeneous credit market in which either excess demand (credit rationing) or excess supply (no credit rationing) is possible.

3.3 The Simulations

In this section the BOF model is simulated for the effects of exchange rate policy and imported inflation. In the simulations, use is made of the control solution of the model, which is a simultaneous solution of the model utilizing actual values of lagged endogenous variables at the start of the simulation period and actual values of the exogenous variables throughout the simulation period. The results of the simulation experiments are expressed as dynamic multipliers of the form $100 \cdot (XD_t - XC_t)/XC_t$, where XC is the control solution of variable X and XD the disturbed (simulated) solution of variable X .¹⁹⁾

In the exchange rate policy simulation a 10 per cent permanent devaluation is assumed to be carried out at the beginning of 1971. The devaluation is timed to coincide with a downturn of the business cycle. This is to avoid excessive overheating of the economy in the form of capacity constraints and accelerated inflation, thus providing scope in the model for export expansion via increased profitability and import substitution.

In connection with the devaluation simulation, assumptions about accommodating domestic economic policy measures and other exogenous changes in the model must be made. The former are simply assumed away.²⁰⁾ Of the latter, changes in exogenous import prices in terms of domestic currency are of importance. They can be shown to increase by the full amount of the devaluation as long as no other countries alter their exchange rates, the price elasticity of the supply of imports is infinite and foreign exporters do not alter their supply prices in terms of dollars [*Goldstein*]. In the case of a small open economy the first two conditions are obviously met. However, using evidence from empirical estimates of past Finnish devaluations,²¹⁾ it is assumed here that

¹⁹⁾ In Figures 3 and 4 absolute differences $XD_t - XC_t$ are used.

²⁰⁾ In the case of monetary policy this simply means that the discount policy of the central bank is passive as in the theoretical model, implying that the monetary effects of the balance of payments are not neutralized.

²¹⁾ These results are available from the author upon request.

20 per cent of the devaluation is absorbed by foreign exporters so that import prices of final goods (consumer and investment goods) in terms of domestic currency increase by only 80 per cent of the devaluation. While this assumption is based on competitive considerations, it is clear that the devaluation is entirely and instantly passed through to the import prices of intermediate imports (raw materials and fuels) in terms of domestic currency, i.e. the pass-through rate is 100 per cent.

In the other two simulation experiments – international inflation and an increase in the prices of imported energy – the relevant prices are increased permanently by 10 per cent as from the beginning of 1971. In the former simulation foreign interest rates are also increased by 10 percentage points in the first quarter of 1971.

Results of the devaluation simulations are presented in Figures 1–4. According to the BOF model the volume of imports decreases immediately after the devaluation but less than in the partial simulation in Table 2. This is because the solution also includes the effects of the devaluation on domestic prices, production and credit markets. Later on, imports stay at a lower level than in the control solution, mainly in response to developments in domestic consumption and investment.

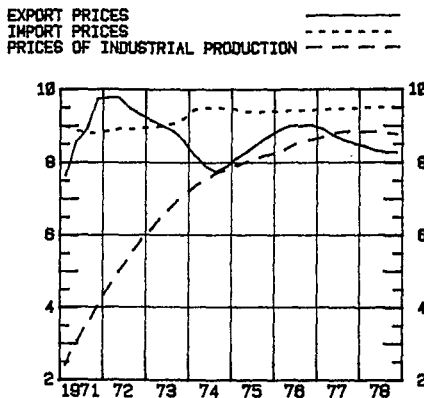


Fig. 1: Effects of Devaluation

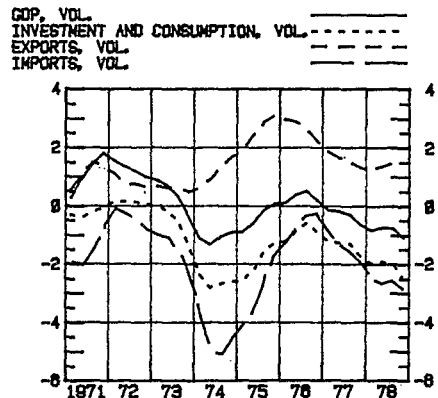


Fig. 2: Effects of Devaluation

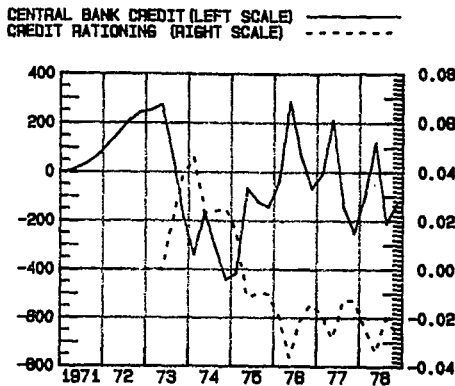


Fig. 3: Effects of Devaluation

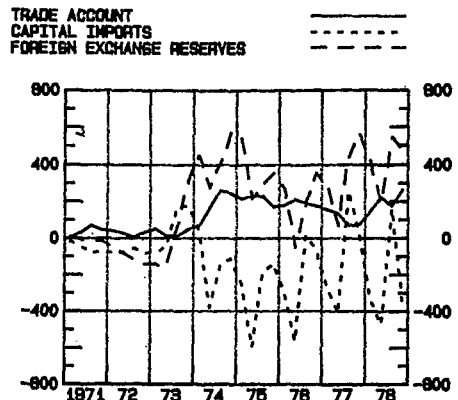


Fig. 4: Effects of Devaluation

Export prices rise rapidly by nearly the full amount of the devaluation, but stabilize subsequently at a level about 8 per cent higher. In spite of increased domestic costs, the volume of exports responds positively to the devaluation throughout the simulation period because of favourable profitability developments. Accordingly, the trade account does not improve markedly until three years after the devaluation. This prolonged *J*-curve effect derives from terms-of-trade changes and the different dynamics of export and import volumes.

The current account improves approximately in line with the trade account because the change in exchange rates has relatively little effect on imports and exports of services and investment income. Imports of long-term capital increase slightly throughout almost the entire simulation period while short-term capital imports are for the most part markedly lower than in the control solution, a reflection mainly of the improvement in the current account. All in all, these changes result in an increase in the foreign exchange reserves of the central bank.

The effects of foreign exchange policy on domestic demand are expansive immediately after the devaluation, but soon both investment and consumption begin to contract, the former mainly because of the credit rationing effect and the latter because of slower growth in disposable income. However, at the beginning of the fifth year following the devaluation, tightness in the credit market eases and this has a positive effect on domestic demand.²²⁾

Credit rationing is thus an important element in the BOF model. In contrast to the assumption of a heterogeneous credit market in the theoretical model of Section 2, where excess demand was a persistent phenomenon, the BOF model is based on the assumption of a homogeneous credit market, i.e., the minimum of the demand for and supply of credit is realized. This allows for the possibility of excess supply or demand regimes in the model. In the former regime monetary effects are of a minor importance, while in the credit rationing regime monetary effects are overwhelmingly important. In the case of the devaluation simulation with passive domestic monetary policy, the credit market switches into an excess demand (credit rationing) regime in the third year after the devaluation, while in the control solution the excess supply (no

²²⁾ Some implications for the long-run effects of devaluation can be inferred from Figures 1–4. The dynamic multipliers at the end of the simulation period suggest that the model is approximately neutral with respect to price developments, whereas the real variables oscillate, although the amplitude of the oscillations are dampened over time mainly because of changes in the credit market conditions and profitability. The simulation results together with rough estimations of the effects of stabilization measures possibly undertaken in connection with the devaluation do not contradict the so-called devaluation cycle hypothesis based on theoretical and empirical findings on Finnish devaluations carried out at intervals of ten years [see *Korkman*, 1978]. According to the hypothesis during the first years after devaluation domestic demand increases, unemployment falls and the relative share of profits increases. This process is reversed in the latter part of the cycle until a new devaluation is undertaken.

credit rationing) regime prevails until the beginning of 1974 exerting a contractive effect on domestic demand.²³⁾

Because of this feature of the model, the effects of policy simulations are highly sensitive to the timing of the simulations. A similar devaluation simulation starting from the beginning of 1974 with credit rationing prevailing shows that the initial contractive effect of the tightening of the credit markets on domestic demand is stronger and faster than in the devaluation simulation in Figures 1–4.

Although based on different credit market assumptions, the results of the devaluation simulation are in line with the qualitative conclusions made with the simplified theoretical model of Section 2. In particular the credit market effects of devaluation on domestic investment demand are dominant and apart from an initial expansive effect aggregate domestic demand contracts for a large part of the simulation period according to the econometric model. As policy simulations with the BOF model depend crucially upon the prevailing credit market regime and upon switching between the two regimes it would be desirable to develop a version of the model based on heterogeneous credit markets which would permit smoother switching between the two regimes. Devaluation simulations associated with various domestic monetary measures are also important as a means of determining the sensitivity of the model with respect to these policies and in order to find optimal policy measures.

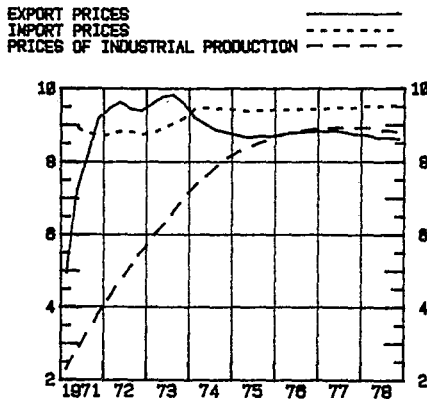


Fig. 5: Effects of International Inflation

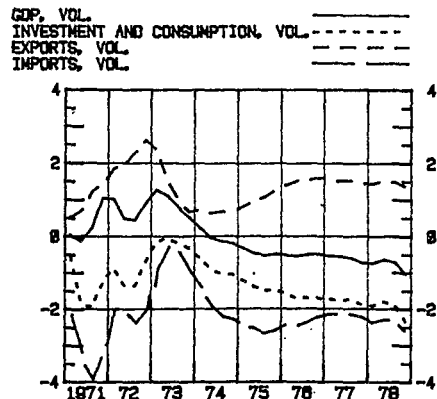


Fig. 6: Effects of International Inflation

In Figures 5 and 6 the effects of international inflation on prices and demand are roughly comparable to those of foreign exchange policy. This follows from the fact that exchange rates and foreign prices enter the model almost symmetrically. How-

²³⁾ In Figure 3 the credit rationing effect is measured as the difference between the simulated and control values of the credit rationing variable. The control solution is zero (no credit rationing) until the first quarter of 1974 and positive (credit rationing) thereafter. The simulated solution is zero in the first nine quarters of the simulation period and positive thereafter. During the period 1973–1975, it is greater than the control solution and in 1976–1978 smaller, implying tighter credit market conditions in 1973–1975 and easier conditions later on.

ever, because of lags, export prices react more slowly than in the devaluation simulation causing only modest export and domestic demand expansion immediately after the price shock. Even with a considerable drop in the volume of imports, the current account deteriorates, demonstrating the *J*-curve effect in the first half of 1971. With foreign interest rates temporarily increased, capital imports are depressed and the foreign exchange reserves of the central bank are lower during the first two quarters as compared with the control solution. Because of the assumption of unchanged monetary policy, the credit market switches into a credit rationing regime during 1971–1972. In 1973 there is no credit rationing and domestic demand increases.

Thus differences in the effects of international inflation and devaluation in the BOF model stem mainly from different lag schemes in the foreign trade equations with respect to exchange rates and foreign prices and from the assumption about foreign interest rates.

Finally, the effects of a 10 per cent increase in the prices of imported energy are presented in Figures 7 and 8. The effects are inflationary and expansive. The current account effect is negative and the credit rationing effect marginally positive throughout the simulation period.²⁴⁾

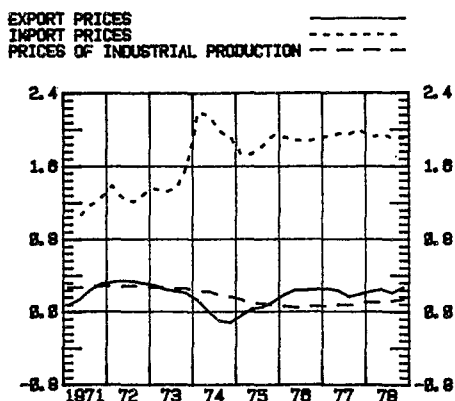


Fig. 7: Effects of Increase in the Prices of Imported Energy

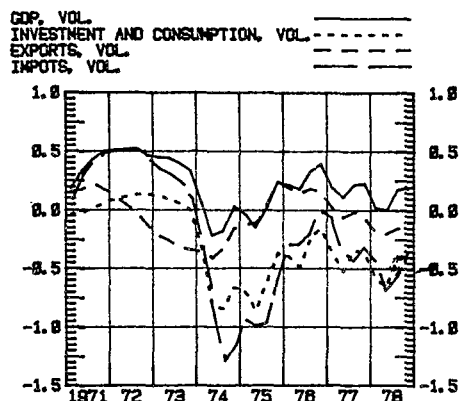


Fig. 8: Effects of Increase in the Prices of Imported Energy

²⁴⁾ The effect on domestic demand is contractive only temporarily mainly because a shock of only 10 per cent does not trigger any fundamental change in the credit market conditions. An experiment with a 100 per cent shock showed a highly contractive response with considerable tightening in the credit market. However, a complicating factor in this case is that, with a sizeable increase in energy prices, some increase in other international prices should also be assumed.

4. Conclusions

In this paper the effects of devaluation and imported inflation are studied in the framework of a macroeconomic model specified for a small open economy with underdeveloped financial markets. The policy effects and their channels are first analyzed with the aid of a simplified macroeconomic model containing credit rationing elements. According to the simulations the present version of the BOF model is fairly sensitive to the credit market conditions prevailing at the time the policies are implemented and to a possible change in credit market regime or tightness in the credit rationing regime. This has implications both for the timing of the policy measures and for the supporting monetary policy undertaken in order to dampen possible cyclical movements in domestic demand. An additional complicating factor is that the model is not linear with respect to the magnitude of the shock.

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Exchange Rate Policies Simulated by Means of a Disequilibrium Model of the Finnish Economy

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In this paper a model for the Finnish economy with disequilibrium in the goods and financial markets is specified and estimated by single equation methods. The transmission mechanisms of the model are studied in the framework of various devaluation simulations. The model is very sensitive, especially with respect to the prevailing credit market regime and possible regime changes. Policy effects are not so much affected by conditions in the goods market, assuming moderate policy shocks. These considerations suggest the importance in policy planning of identifying the regimes prevailing in the markets.

1. INTRODUCTION

With the recent interest in theoretical disequilibrium models, in which short-run price and wage rigidities prevent instantaneous attainment of an equilibrium leading to temporary equilibrium with markets clearing by quantity rather than by price adjustments,¹ econometric work on these models has also been extensive. Estimation of fix-price disequilibrium models for a single market with a demand function, supply function, and a min condition, mostly by the maximum likelihood method, has been accomplished in several studies since the derivation of the density function for the model by Maddala and Nelson (1974).² The main econometric complication is the possibility of unboundedness of the likelihood functions.

The estimation problems are more complex in the case of multimarket disequilibrium models. In these models the multiplicity of the integrals in the likelihood functions depends on the number of interrelated markets, thus creating difficult computational problems in estimation.³ Despite

¹Disequilibrium models were first presented for a closed economy (Barro and Grossman, 1976, and Malinvaud, 1977) and subsequently extended to an open economy framework (Dixit, 1978; Steigum, 1980; and Cuddington, 1980).

²For a review of the models and econometric methods, see Quandt (1982).

³Besides computational problems in the numerical optimization of the likelihood function there is a possibility of multiple maxima.

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these pitfalls there have been several attempts to estimate multimarket disequilibrium models. The most notable are by Artus et al. (1984), Kooiman and Kloek (1980), Sneessens (1981), and Vilares (1981) (for a recent survey, see Laffont, 1983). The first and second models, both two-market disequilibrium models, are estimated by the maximum likelihood method, while the last two models, being basically recursive, are estimated using single-equation estimation techniques.

Besides estimation problems, this first wave of econometric work on multimarket disequilibrium models has been confined to the goods and labor markets. For some small countries with underdeveloped financial markets, such as Finland, an explicit treatment of disequilibrium in these markets would be highly desirable.⁴ As the spillover effect in such models from the goods market to the financial market is relatively weak, the model is approximately recursive and can be estimated by single-equation methods, thus avoiding difficulties still encountered in full-information methods.

The aim of this paper is, first, to specify and estimate a disequilibrium macromodel for the Finnish economy and, second, to examine the transmission mechanisms of the model in the light of various devaluation simulations. In Section 2 the institutional characteristics of the Finnish economy and the specification of the model are discussed. Estimation results are presented in Section 3. The properties of the model in the different disequilibrium regimes are examined in Section 4 in the framework of devaluation simulations.

2. SPECIFICATION OF THE MODEL⁵

Most of the literature on disequilibrium models assumes highly developed financial markets with money normally being the only asset. This specification is not especially suitable in the case of a large group of smaller industrialized countries, such as Finland, which lack well-functioning financial markets. In Finland domestic interest rates are set institutionally, which, in the absence of other equilibrating nonprice loan terms mechanisms, has resulted from time to time in credit rationing.⁶

As other financial institutions and the securities market are relatively unimportant, the financial markets have been dominated by deposit banks

⁴Theoretical disequilibrium models with emphasis on financial markets are developed in Kähkönen (1982), Aurikko (1982b), and Cuddington (1983).

⁵The model is discussed in detail in Aurikko (1982b).

⁶Rigidity of nonprice loan terms can also be rationalized by existing agreements, costs of changing the terms (see Koskela, 1976, and Baltensperger, 1978) and adverse changes in the loan portfolios of the banks (see Stiglitz and Weiss, 1981).

and firms have had to resort mainly to domestic and foreign bank lending for investment finance. Moreover, foreign capital movements have been controlled fairly effectively by the central bank. With relatively low domestic interest rates during the past years, excess demand, and thus credit rationing in the domestic credit market, has occurred.

The model distinguishes in the domestic commodities markets between nontraded and traded goods and in the asset markets between different varieties of assets. There are altogether five commodities in the model: nontraded goods (Q_1), traded goods exported and used domestically for consumption or investment (Q_2), imported final goods (MF) substitutable for the domestic traded goods in consumption (MFH) and investment (MFI), intermediate imports (MRF) used as inputs in domestic production in a proportion depending on relative prices, and labor (L). The assets in the model are currency (S), deposits (D), loans (LO), central bank credit (H), foreign capital (KF), and the foreign exchange reserves of the central bank (GCB). The sectoral aggregation of the model consists of households, banks, the central bank, the government sector, the foreign sector, and two sets of firms producing nontraded and traded goods, respectively.

Households demand the domestic nontraded (C_1) and traded goods (C_2) as well as imported final goods (MFH). They supply labor, assumed to be determined exogenously. This implies that unemployment causes only income effects with no substitution effects. Firms supply nontraded and traded goods to households, government, and the foreign sector. Firms demand labor, intermediate imports, investment goods, and domestic and foreign finance.

The domestic economy is connected with the foreign sector (rest of the world) through imports of intermediate and final goods, exports of traded goods, and capital movements. Thus the overall balance of the balance of payments (change in the foreign exchange reserves of the central bank, GCB) is $\Delta GCB = BC + \Delta eKFP + \Delta eKFG$, where BC is the current account and KFP (KFG) is the net stock of the foreign debt of the firms (government) in terms of foreign currency and e is the exchange rate.

The balance sheet of the central bank being defined as $S = H + GCB$, the supply of central bank credit to the private banks H^s is determined residually because the foreign exchange reserves of the central bank GCB are determined endogenously and it is assumed that the supply of currency S^s is determined by the demands of households.

Banks grant loans (LO) to households and firms that are financed by deposits from households (DH) and central bank credit (H), i.e., $LOH + LO_1 + LO_2 = LO = DH + H$, where all items are denominated in domestic currency because it is assumed that the banks' foreign

exchange position is closed. The banks are assumed to behave⁷ so that the supply of loans is $LO^s = LO^s(\overset{+}{R}L, \bar{R})$, where R is the marginal cost of central bank credit determined as $R = R(\overset{+}{H})$.

The real government absorption (G) is composed of purchases of traded and nontraded goods, which, together with taxes (T), are exogenous in the model. Also, as the main interest is in exchange rate policies, the model abstracts from government bonds and bank lending. Finally, the supply of deposits is derived residually from the balance sheet of the private banks.

Because the model describes a small open economy with underdeveloped financial markets it is assumed that of the eleven markets of the model only four are rationed and of them labor and nontraded goods markets are always in excess supply. So the model generates, depending on the prevailing level of prices, wages, and interest rates, four kinds of unemployment disequilibria, which can be classified as a Keynesian unemployment regime with excess supply and a classical unemployment regime with excess demand in the traded goods market. Both regimes contain two regimes, one with and one without credit rationing. To discuss the effective demands and supplies it is illuminating to consider the budget constraints facing the various sectors in the model.

In Table 1 subscripts d and s indicate demand and supply and all prices and exchange rates are, for simplicity, normalized to be equal to one. Uses of finance are written on the left-hand side and sources on the right-hand side. In the household budget constraint π stands for the contemporary dividends of firms, which are assumed to be distributed to the households. It is also assumed that the banks' profits accrue to the households and the central banks profits to the government. Summing the sectoral budget constraints gives the aggregate budget constraint.

The transactions in the four disequilibrium markets are determined by the short side of the market, which by assumption is always the demand side in the nontraded goods market and labor market. With the markets clearing by quantity rather than by price adjustment, there will be spillover effects from demand or supply failures to the other markets. These effects arise from demand failure in the labor and nontraded goods markets as well as from possible rationing in the traded goods and credit markets. The spillover effects of unemployment appear only in household income as the labor supply is fixed. Excess supply of nontraded goods influences the demands of firms producing nontraded goods. Rationing of traded goods

⁷See Aurikko (1982a). The signs above the variables refer to the assumed signs of the partial effects.

Table 1. Budget Constraints of the Model

Households	$C1^d + C2^d + MFH^d + \Delta SH^d + \Delta DH^d = L1^s + L2^s + \Pi - T$ $+ \Delta LOH^d - R \cdot H$
Firms	$I2D^d + MFI^d = \Delta L01^d + \Delta L02^d + \Delta KFP^d$
Central bank	$\Delta H^s + \Delta GCB^d = \Delta S^s$
Banks	$\Delta LO^s = \Delta DH^s + \Delta H^d$
Government	$G1^d + G2^d + RF \cdot KFG = \Delta KFG^d + T + R \cdot H$
Foreign sector	$X^d - M^s - RF \cdot KF + \Delta KF^s = \Delta GCB^s$
Total	$(C1^d + G1^d - Q1^s) + (C2^d + X^d + G2^d + I2D^d - Q2^s)$ $+ (L1^d + L2^d - L1^s - L2^s) + (LO^s - LOH^d - LO1^d$ $- LO2^d) = 0.$

demand in the classical regime has spillover effects on the trade offers of households. By assumption, firms are never rationed in the labor market. However, they are constrained in the traded goods market in the Keynesian regime. Moreover, possible credit rationing has spillover effects on the behavior of both households and firms.

3. ESTIMATION

The model estimated in this section is specified on the basis of the theoretical model discussed in the previous section. The annual data for the years 1960–80 are mainly adapted and aggregated from the data base of the quarterly econometric model constructed at the Bank of Finland (BOF3 model).⁸

Of the four disequilibrium markets in the model, in only two—viz., the loan and traded goods markets—are transactions assumed to be determined either by demand or by supply, whereas nontraded goods market and labor market are always demand-determined. In view of the size of the whole model and anticipating insurmountable computational problems as

⁸Bank of Finland (1983) and Tarkka and Willman (1981). The nontraded and traded sectors correspond to the aggregated closed and open sectors in the BOF3 model. Also, the specification of some equations resembles, except for the spillover terms, that of the BOF3 model. The variables are listed in the Appendix. The data and list of equations of the model are available from the author upon request.

discussed in Section 1, the statistical model of the loan and traded goods markets is written as an approximation in the form

$$Z_1 = \min(Z_1^d, Z_1^s) + \varepsilon_1, \quad (1)$$

$$Z_2 = \min[Z_2^d - \alpha_2(Z_1^d - Z_1), Z_2^s] + \varepsilon_2, \quad (2)$$

where Z_i , Z_i^d , and Z_i^s , are the observed quantities, unobserved demands, and supplies in the loan ($i=1$) and traded goods markets ($i=2$), respectively, α_2 is a parameter, and ε_1 and ε_2 are normally and independently distributed error terms with zero means.⁹ In the credit rationing regime the spillover term $Z_1^d - Z_1$ is positive, and it can be shown (Ito, 1980) that in the case of Cobb–Douglas utility functions the deviation of the rationed agents' effective demand from their notational unconstrained demand is a linear function of the degree of excess demand. In the regime without credit rationing (excess loan supply) $Z_1^d - Z_1 = 0$ and the spillover effect is absent. The system (1), (2) is recursive and can be estimated sequentially by single-equation estimation methods. Although the system is nonlinear because of the additive error specification, maximum likelihood estimation and nonlinear least-squares estimation are equivalent. Thus (1) is estimated with a nonlinear algorithm as

$$\log(\text{LO}^s/\text{LO}_{-1}) = 0.302 - 0.006\text{TIME} + \sum_0^2 a_i(R - \text{RL})_{-i}, \quad (3)$$

(188.7) (1.7)

$$\log(\text{LO}^d/\text{LO}_{-1}) = -0.455 + 0.611 \log(QV/\text{LO}_{-1}) \quad (4)$$

(5.9) (12.2)

$$+ 0.382 \log(W/P) - 0.009\text{TIME},$$

(3.8) (1.2)

$$a_0 = -0.002, \quad a_1 = -0.005, \quad a_2 = -0.004, \quad \sum a_i = -0.011,$$

(1.7) (1.7) (1.7) (1.7)

$$\text{LO} = \min(\text{LO}^s, \text{LO}^d), \quad (5)$$

$$\bar{R}^2 = 0.754, \quad \text{DW} = 1.871, \quad \text{SE} = 0.021.$$

Equation (3) is specified according to the discussion in Section 2 and equation (4) is a simple version of loan demand determined by the value of aggregate income (QV), Walrasian real wages (W/P), and a time trend (TIME).¹⁰ Nonsignificant interest rates are omitted. Models (3) and (4)

⁹For the conceptual and econometric issues connected with specifying error terms in the min condition, see Quandt (1982) and Laffont (1983).

¹⁰In the estimated equations the t -statistics are written in parentheses below the coefficients; \bar{R}^2 is the coefficient of determination adjusted for degrees of freedom, DW is the Durbin–Watson statistic, and SE is the standard error of estimate.

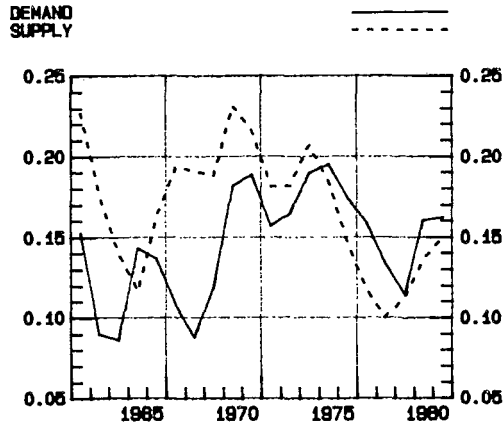


Figure 1. Loan market.

resemble those of the BOF3 model and indicate (Figure 1) the existence of credit rationing in 1964 and in 1974–80.¹¹

In the estimation of the disequilibrium model (2) for traded goods, credit rationing effects are captured in the relevant equations by the variable RHOE defined as

$$\text{RHOE} = \max[\log(\text{LO}^d/\text{LO}^s), 0]. \quad (6)$$

Because of the relatively low number of degrees of freedom the components of $Q2^d$ were first estimated separately with the fitted values inserted in (2):

$$\log Q2^s = -6.040 + 1.420 \log K - 0.468 \log(\text{PMRF}/P2), \quad (7)$$

(120.8) (23.3) (2.9)

$$\log Q2^d = 0.071 + 0.933 \log[\tilde{C}2 + \tilde{X} + (\text{PI}/P2)\tilde{\text{IM}} - (\text{PMF}/P2)\tilde{\text{MFI}} + G2], \quad (8)$$

(0.17) (36.7)

$$Q2 = \min(Q2^s, Q2^d), \quad (9)$$

$$\bar{R}^2 = 0.992, \quad \text{DW} = 1.552, \quad \text{SE} = 0.026.$$

In the traded goods supply model (7) it is assumed in a traditional way that in the short run the capital stock (K) is a fixed factor and consequently enters, together with relative prices, as an explaining

¹¹In the quarterly BOF3 model credit rationing is observed in 1962–64 and in 1974–78.

variable in (7).¹² In the equation (8) PI is the price index of total investment IM, G_2 is exogenous while \bar{C}_2 , \bar{X} , \bar{IM} , and \bar{MFI} are the computed values from

$$\begin{aligned} \log C_2 = & -4.035 + 1.022 \log(YD_{-1}/P2_{-1}) + 0.484 \log(PMF/P2) \\ & (5.0) \quad (16.0) \quad (3.0) \quad (10) \\ & + 0.499 \log(P2_{-1}/P2_{-2}) - 1.166 \text{RHOE}_{-1} - 0.768 \text{RHOE}_{-2}, \\ & (2.3) \quad (1.8) \quad (1.2) \end{aligned}$$

$$\bar{R}^2 = 0.950, \quad DW = 1.728, \quad SE = 0.058;$$

$$\begin{aligned} \log X = & 5.016 + 0.895 \log MFO - 0.648 \log[P2/(FXUS \cdot PMFO)], \\ & (15.8) \quad (18.8) \quad (2.0) \quad (11) \end{aligned}$$

$$\bar{R}^2 = 0.973, \quad DW = 1.169, \quad SE = 0.055;$$

$$\begin{aligned} \text{IM}/K_{-1} = & 0.110 - 0.064 \log(W/P2) - 0.029 \log(\text{RF}/\text{RL}) \\ & (0.04) \quad (2.8) \quad (3.2) \end{aligned}$$

$$\begin{aligned} & + 0.434 \log Q1 - 0.395 \log K_{-1} + \sum_3^5 a_i \text{RHOE}_{-i}, \\ & (7.9) \quad (7.8) \quad (12) \end{aligned}$$

$$\begin{aligned} a_3 = & -0.089, & a_4 = & -0.119, & a_5 = & -0.089, \\ & (1.10) & & (1.10) & & (1.10) \end{aligned}$$

$$\sum a_i = -0.297,$$

$$\bar{R}^2 = .863, \quad DW = 1.752, \quad SE = 0.006;$$

$$\begin{aligned} \log \text{MFI} = & 2.649 + 2.008 \text{DS63} + 0.588 \log \text{IM} - 0.880 \log(\text{PMF}/P2) \\ & (3.2) \quad (1.5) \quad (6.8) \quad (2.2) \quad (13) \\ & - 0.402 \log(\text{PMF}_{-1}/P2_{-1}), \\ & (1.1) \end{aligned}$$

$$\bar{R}^2 = 0.858, \quad DW = 1.181, \quad SE = 0.075.$$

In (10) the lag in real disposable income ($YD/P2$) was chosen to reduce simultaneity and ensure convergence of the model. The credit rationing variable is also included in (10). To capture the effects of inflation on the consumption variable, $\log(P2_{-1}/P2_{-2})$ has added. In the aggregated exports (X) model in (11) the explanatory variables are foreign imports MFO and a ratio of traded goods prices to prices of foreign imports, both in USD. The model of total investment in (12) includes an adjustment mechanism and is log-linear and aggregated, i.e., $K/K_{-1} = (K^d/K_{-1})^\alpha \text{RHOE}^\beta$, where the approximation $\log(K/K_{-1}) \approx \text{IM}/K_{-1}$ is used. Also, production $Q1$ is used rather than Q on empirical grounds.¹³

¹²In (7) and subsequently import prices are given in terms of domestic currency. In (7) PMRF is the price index of intermediate imports MRF.

¹³The correct variable should have been PII as defined in (14).

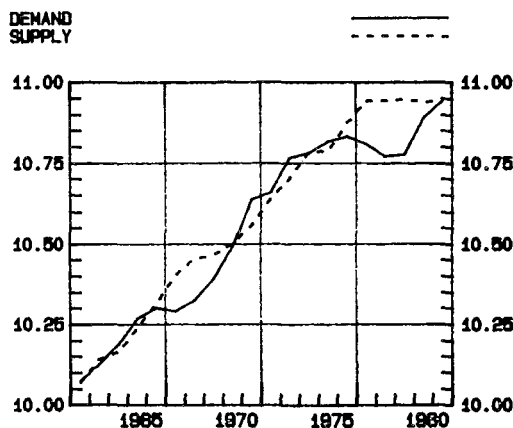


Figure 2. Traded goods market.

According to the model the years 1963–64 and 1969–74 are fairly plausibly supply-determined and the years 1975–79 demand-determined. In the other years, supply of and demand for the traded goods are approximately in balance (Figure 2).

Spillover variable in the traded goods market similar to that in the loan market is defined as

$$PII = \max[\log(Q2^s/Q2^d), 0]. \quad (14)$$

Separate equations for effective labor demands in the nontraded and traded sectors were estimated:

$$\log(L1/Q1) = -1.531 - 0.469 \log(W/P1) - 0.075 \log(PMRF/P1) \quad (15)$$

(3.8) (2.6) (1.7)

$$+ 0.564 \log(L1_{-1}/Q1) - 0.008 \text{TIME},$$

(5.3) (3.1)

$$\bar{R}^2 = 0.999, \quad DW = 1.660, \quad SE = 0.008;$$

$$\log L2 = 3.984 - 0.082 \log(W/P2) - 0.176 PII - 0.286 PII_{-1} \quad (16)$$

(3.3) (1.0) (1.5) (1.6)

$$+ 0.364 \log L2_{-1} + 0.007 \text{TIME},$$

(1.9) (2.5)

$$\bar{R}^2 = 0.858, \quad DW = 1.942, \quad SE = 0.017.$$

In (15) the lagged dependent variable represents an adjustment process in the labor markets with the long-run output elasticity of labor demand constrained to unity. The trend variable TIME is included to account for the diminished amount of labor relative to output in the nontraded goods

sector. In equation (16) for labor demand in the traded goods sector, the variable PII defined in (14) captures the spillover effect from the goods markets to the labor markets in the Keynesian regimes. Again, a simple adjustment mechanism is included as well as the trend variable.

Effective demand for nontraded goods was estimated in the same way as for traded goods in (10), but with the lagged stock of assets added¹⁴

$$\begin{aligned} \log C1 &= 0.437 + 0.910 \log(YD_{-1}/P1_{-1}) \\ &\quad (.5) \quad (8.8) \\ &\quad + 0.237 \log[(DH_{-1} + S_{-1} + B_{-1})/YD_{-1}] \\ &\quad (1.8) \quad (17) \\ &\quad + 0.058 \log(FCGH/P1) - 0.325 \text{ DTR66} \\ &\quad (2.8) \quad (3.9) \\ &\quad + 0.264 \log(P1_{-1}/P1_{-2}) - 0.922 \text{ RHOE}_{-1}, \\ &\quad (2.6) \quad (1.7) \\ \bar{R}^2 &= 0.989, \quad DW = 1.989, \quad SE = 0.023. \end{aligned}$$

The models of the two remaining import components were estimated as

$$\begin{aligned} \log MFR &= -7.164 - 0.422 \log(\text{PMRF}/P2) + 1.524 \log Q1 \\ &\quad (6.3) \quad (4.0) \quad (14.8) \\ &\quad + 1.397 \text{ DS63} - 0.155 \text{ DF69} - 0.829 \text{ PII}, \\ &\quad (2.2) \quad (4.0) \quad (14.8) \quad (18) \\ \bar{R}^2 &= 0.993, \quad DW = 2.068, \quad SE = 0.035; \end{aligned}$$

$$\begin{aligned} \log MFH &= -11.45 + 1.804 \log(YD/P2) - 1.165 \log(\text{PMF}/P2) \\ &\quad (8.5) \quad (14.5) \quad (5.8) \\ &\quad + 0.926 \text{ DS63} + 0.185 \text{ DF69} - 0.062 \text{ DMCP} \\ &\quad (1.3) \quad (4.5) \quad (2.2) \\ &\quad + \sum_0^3 a_i \text{ RHOE}_{-i}, \quad (19) \end{aligned}$$

$$\begin{aligned} a_0 &= -0.582, & a_1 &= -0.874, & a_2 &= -0.874, & a_3 &= -0.582, \\ &\quad (2.1) & &\quad (2.1) & &\quad (2.1) & &\quad (2.1) \end{aligned}$$

$$\sum a_i = -2.912,$$

$$\bar{R}^2 = 0.978, \quad DW = 1.782, \quad SE = 0.042,$$

¹⁴Because C1 includes investment in housing, variables FCGH (exogenous state loans for housing) and DTR66 (a dummy variable for tax reliefs in housing in 1966) were used.

where

DF69 = dummy variable for the revision of foreign trade statistics in 1969,

DMCP = cash payment dummy variable.

Model (18) for intermediate imports (MFR) and model (19) for households' final imports (MFH) are fairly standard with plausible demand and price elasticities except that spillover effects from the disequilibrium markets are present.

Demand for currency (S) was simply estimated as

$$\log S = 3.669 - 0.517 \log[(DH_{-1} + S_{-1} + B_{-1})/P_{-1}] + 0.834 \log QV \\ (2.9) \quad (2.9) \quad (14.9) \\ + 1.699 \text{ RHOE}, \quad (20) \\ (1.3)$$

$$\bar{R}^2 = 0.987, \quad DW = 1.163, \quad SE = 0.062,$$

and net imports of private foreign capital (FFP) as

$$\text{FFP} = 305.7 - 629.0 \Delta(\text{RF} - \text{RL}) + 0.202 \Delta Q1V - 0.105 \Delta(Q \cdot \text{PII})_{-1}, \\ (0.6) \quad (5.1) \quad (3.6) \quad (1.8) \quad (21)$$

$$\bar{R}^2 = 0.728, \quad DW = 1.475, \quad SE = 1190.1.$$

The marginal cost of central bank credit (R) to the private banks as an increasing function of the amount of the credit (H) is determined from

$$R = \text{RDI} + (\text{HV}/\text{HQ}) \cdot H \cdot \text{IND}(H - \text{HQ}), \quad (22)$$

where

RDI = exogenous basic discount rate of the central bank credit,

HV = exogenous sensitivity parameter of the cost of central bank credit with respect to the amount of the credit (H),

HQ = exogenous quota of central bank credit.

In (22) $\text{IND}(H - \text{HQ}) = 1$, if $H \geq \text{HQ}$, and = 0 otherwise, so that the marginal cost of central bank credit to the private banks equals the basic discount rate when actual central bank credit is lower than the quota. The marginal cost increases according to the sensitivity parameter when $H \geq \text{HQ}$. The sensitivity parameter was calculated using the marginal cost data in Tarkka (1981).

Non-Walrasian models have been studied mostly by assuming rigid prices. This has restricted the analysis to the short run. In the longer run the assumption of fixed prices is clearly not tenable. There exist some theoretical attempts to endogenize prices in non-Walrasian models. In

these models the prices are assumed to be either set by the agents or determined by some auctioneer mechanisms.¹⁵ In this study it is assumed that prices and wages are responding at least partly to the latter, somewhat ad hoc, mechanism, i.e., prices and wages react to excess demands. However, the reaction is not assumed to be complete in the sense of equilibrating the markets in the short run. Thus quantities adjust in the first place resulting in an equilibrium with rationing, while prices and wages respond only gradually and in the longer run to excess demands or supplies.

The endogenous prices in the model are nontraded ($P1$) and traded goods prices ($P2$) and aggregate wages (W). All import prices in terms of foreign currency and world market prices are assumed exogenous. The specification of the price-wage block includes the determination of domestic prices, a Phillips curve, and an expectations formation mechanism. In the case of a small open economy like Finland, domestic prices are strongly influenced by world market prices, although costs and demand pressures have some influence too.¹⁶

As the model is disaggregated into nontraded and traded goods, the wage-price model is formulated along the lines of the Scandinavian inflation model¹⁷ and the nontradeable-tradeable approach.¹⁸ According to these approaches nontraded goods prices are determined by unit labor costs and traded goods prices as well as by demand pressures in the traded goods sector, which are assumed to be symmetric and temporary. Traded goods prices depend on world market prices and permanently on demand pressures with a fairly long lag:

$$\begin{aligned} \Delta \log P1 = & 0.013 + 0.616 \Delta \log[(W \cdot L1)/Q1] + 0.381 \Delta \log P2 \\ & (2.7) \quad (8.4) \quad (8.0) \\ & + 0.118 \Delta \log(Q2^d/Q2^s), \quad (23) \\ & (2.8) \end{aligned}$$

$$\bar{R}^2 = 0.950, \quad DW = 2.808, \quad SE = 0.010;$$

$$\begin{aligned} \Delta \log P2 = & 0.673 \Delta \log(FXUS \cdot PMFO) - 0.007 \text{DINP} \\ & (9.8) \quad (4) \\ & + 0.123 \log(Q2^d_{-2}/Q2^s_{-2}) + 0.243 \Delta \log P2_{-1}, \quad (24) \\ & (1.5) \quad (2.7) \end{aligned}$$

$$\bar{R}^2 = 0.874, \quad DW = 2.407, \quad SE = 0.026.$$

¹⁵See, e.g., Honkapohja (1979) and Green and Laffont (1981). Stability in dynamic disequilibrium models is analyzed in Honkapohja and Ito (1983).

¹⁶Empirical evidence is given in Vartia and Salmi (1981) and Aurikko (1984).

¹⁷Edgren et al. (1969).

¹⁸See, e.g., Dornbusch (1973).

In accordance with the expectations-augmented Phillips curve, wages are postulated to depend on price expectations formed with perfect foresight and on unemployment. However, the latter dependence is assumed to be of a transitory nature only so as to maintain long-run parity with domestic and foreign inflation.¹⁹ Also, as it is assumed that the wage share is constant in the long run, the coefficients of traded goods prices and productivity are constrained to be equal, i.e., the variable $(P2 \cdot Q2)/L2$ was used.²⁰ Thus

$$\Delta \log W = +0.314 \Delta \log[(P2 \cdot Q2)/L2] + 0.427 \Delta \log[(P2 \cdot Q2)_{-1}/L2_{-1}] \quad (3.9) \quad (4.6)$$

$$- 0.091 \Delta \log U_{-2} - 0.014 \text{DINP} + 0.225 \Delta \log W_{-1}, \quad (25)$$

$$(4.1) \quad (0.9) \quad (1.7)$$

$$\bar{R}^2 = 0.760, \quad DW = 2.451, \quad SE = 0.019,$$

where

U = unemployment rate,

DINP = dummy variable for incomes policies in 1969–70.

The dynamics of the wage-price submodel is in accordance with the Scandinavian inflation model of the small open economy. International inflation and changes in the exchange rate are transmitted in full to domestic prices and wages in the long run. So domestic inflation can be kept lower than international inflation only by continuous revaluation.

4. SIMULATIONS

As the effects of economic policies in a disequilibrium model are highly dependent on the regimes prevailing in the economy, this issue is studied in the framework of various exchange rate policy simulations. Other illustrative policies in this context would have been demand management, monetary, or price (wage) policies. An additional motivation for the examination of policy simulations is that this issue has not yet been adequately explored in the multimarket econometric disequilibrium models. In the simulations, use is made of the control solution of the model, which is a simultaneous solution of the model utilizing actual values of lagged endogenous variables at the start of the simulation period and actual values of the exogenous variables throughout the simulation

¹⁹Ettlin (1979).

²⁰In (23) and (25), for simplicity, the number of persons employed, $L1$ or $L2$, has been used instead of hours worked, which would have been a more correct variable.

period.²¹ The results of the simulation experiments are expressed as dynamic multipliers of the form $100 \cdot (ZD_t - ZC_t)/ZC_t$ or $(ZD_t - ZC_t)$, where ZC is the control solution and ZD the disturbed (simulated) solution of variables Z .

In the simulations a 10 percent permanent devaluation is assumed to be carried out at the beginning of, alternatively, 1965, 1971, or 1975. The timing of the devaluations is set so as to coincide with the different regimes in the economy. According to Figures 1 and 2 the economy was in the Keynesian regime without credit rationing in 1965–69, in the classical regime without credit rationing in 1970–73, and in the Keynesian regime with credit rationing in 1975–79. In this context, assumptions about accommodating domestic economic policy measures and other exogenous changes in the model must be made. The former are simply assumed away.²² As regards the latter, changes in exogenous import prices in terms of domestic currency are of importance. It is assumed that import prices of final goods (consumption and investment goods) in terms of domestic currency increase by only 80 percent of the devaluation and that the devaluation is entirely and instantly passed through to the import prices of intermediate imports (raw materials and fuels) in terms of domestic currency, i.e., the pass-through rate is 100 percent.²³

Results of the devaluation simulations are presented in Figures 3–12. The 1965 and 1971 devaluation runs are, for ease of comparison, set to coincide with the 1975 devaluation. According to the adopted Scandinavian inflation model the domestic price level increases quite rapidly in all simulations. In the third year after the devaluation it has risen by the full amount of the devaluation and actually overshoots in two cases mainly because the credit market stays in the no credit rationing regime with demand for traded goods increasing relatively fast. Subsequently, the price level multiplier diminishes, reflecting tightening of credit market conditions.

Because of the rapid increase in domestic prices, the volume of exports responds markedly only for two or three years after the devaluation. In later years, the export multiplier is about 0.5 percent.

²¹According to the dynamic ex post solution (not reported here) the model works satisfactorily.

²²In the case of monetary policy this simply means that the discount policy of the central bank is passive, implying that the monetary effects of the balance of payments are not neutralized.

²³See a discussion in Aurikko (1982a). Exogenous imports and exports of services, investment income, nominal taxes, and other incomes were also increased in the simulations by the same percentage as the devaluation.

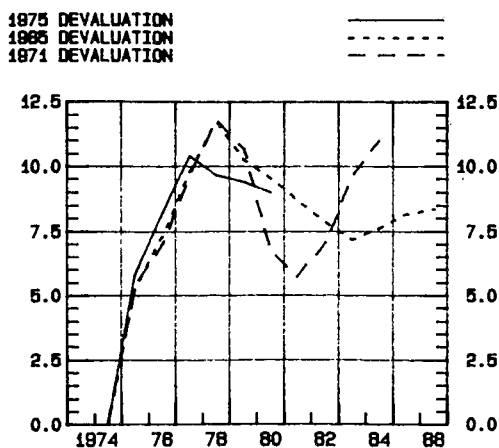


Figure 3. Domestic price level (percent).

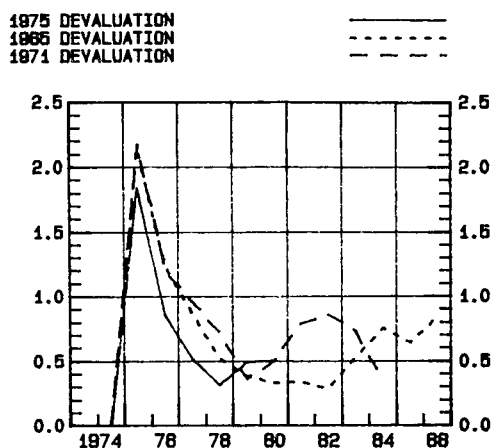


Figure 4. Exports (percent).

There are considerable differences in GDP (Q) developments in the three cases. In the 1965 devaluation the GDP effect is mostly positive, reflecting easy credit market conditions, while in the other two cases there is a contractive effect shortly after the devaluation as the credit market switches into the credit rationing regime. Because of the strong and subsequently positive effect on exports, developments in the traded goods

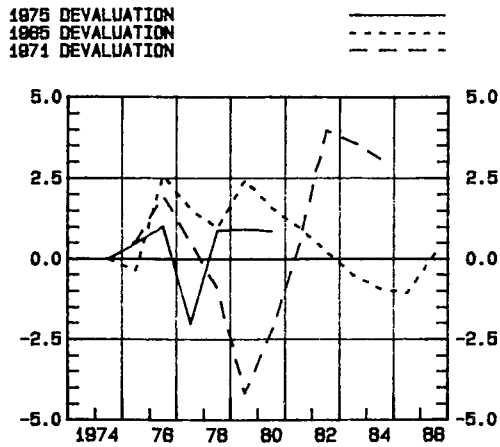


Figure 5. GDP (percent).

sector are on balance more favorable than in the nontraded goods sector (Figures 6 and 7).

The devaluation responses in the traded goods market are summarized in the variable PII in Figure 8. In the case of the 1965 devaluation in the Keynesian unemployment regime without credit rationing, PII is mostly at a lower level than in the control solution, implying higher employment and imports. In the other two cases, the response oscillates around the control solution, giving rise to cycles of about five years' duration in employment

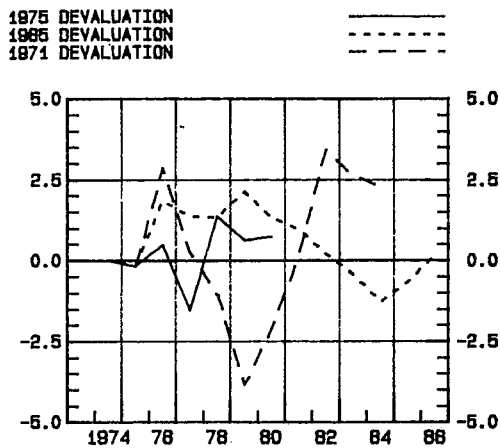


Figure 6. Nontraded goods, Q1 (percent).

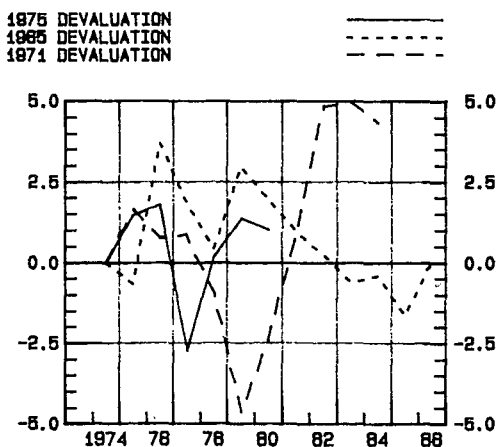


Figure 7. Traded goods, Q2 (percent).

in the traded goods sector and in intermediate imports. The former cycle is not discernible in the aggregate unemployment rate because of its small share (Figure 9). The latter cycle, however, clearly reinforces the swings in total imports in Figure 10 since intermediate imports are a major component in total imports.

Because the multiplier for the value of export demand is roughly equal in all three cases, the differences in current account developments (Figure 11) derive from the developments of the multipliers for the volume of

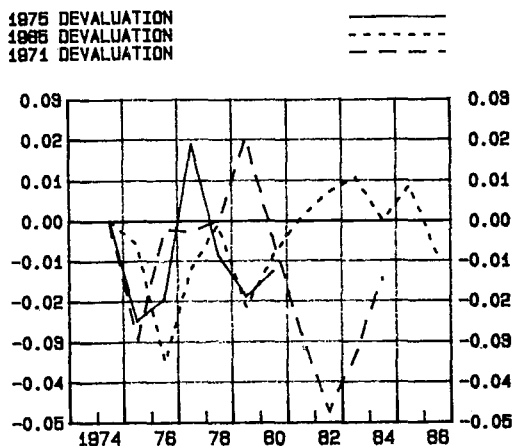


Figure 8. Variable PII (difference).

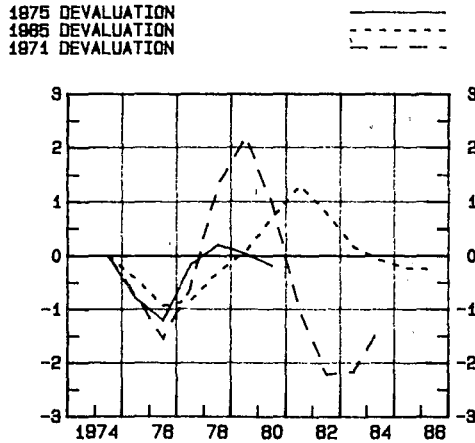


Figure 9. Unemployment (difference).

imports and the prevailing regime in the traded goods sector. In the 1965 devaluation, the total effect of these developments is to leave the current account at approximately the same level as in the control solution. In the other two cases, there is an initial *J*-curve effect followed by a deterioration in later years as imports increase. These unexpectedly pessimistic results are due to three reasons. First, domestic prices rise fairly rapidly after the devaluation and by an equivalent amount.

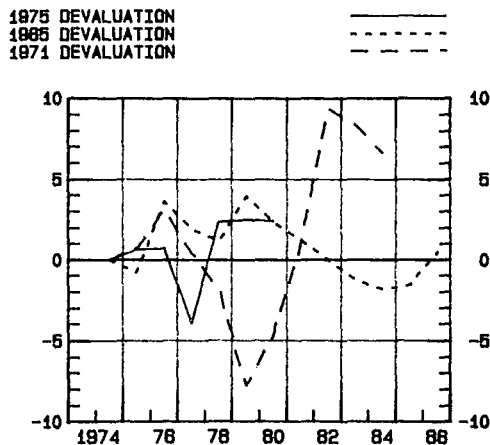


Figure 10. Imports (percent).

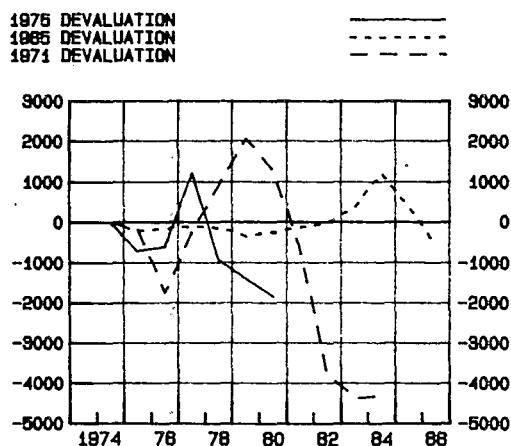


Figure 11. Current account (difference).

Secondly, supply-side effects are taken into account through the variable PII. Thirdly, and most importantly, the current amount improves but not permanently because the contractive effect on domestic demand and imports of possible credit rationing is only temporary.

Credit rationing is thus a vital element in the model. The model is based on the assumption of a homogeneous credit market, i.e., the minimum of the demand for and supply of credit is realized. This allows for the possibility of excess supply or demand regimes in the model. In the former regime, monetary effects are of a minor importance, while in the credit rationing regime monetary effects are overwhelmingly important. In the devaluation simulations with passive domestic monetary policy, credit market developments are determined besides loan demand by loan supply via the balance sheet of the central bank and the equation determining the marginal cost of central bank credit to the private banks. The credit market effects of the simulations are summarized in Figure 12. It is seen that the effects are very sensitive to the timing of the simulations. In the simulation starting in 1965 the credit market stays in the no-credit-rationing regime nearly throughout the simulation period. In the 1971 simulation the credit market switches into the credit-rationing regime during the third year after the devaluation, while in the case of the devaluation simulation in 1975, with credit rationing already prevailing, there occurs an immediate increase in credit rationing. In both the two last-mentioned cases, the credit market swings sharply in the opposite direction shortly after the tightening.

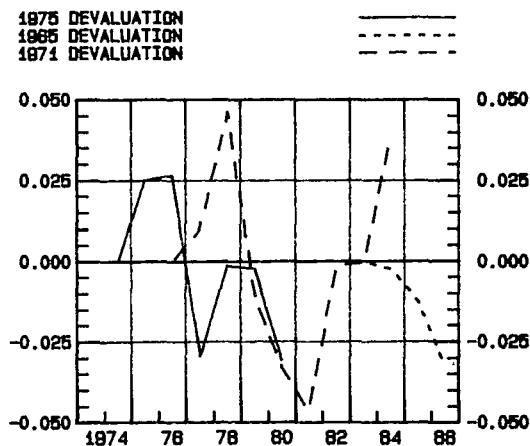


Figure 12. Variable RHOE (difference).

As a summary of the devaluation simulations in the different regimes, it can be concluded that the beneficial effects of devaluation are best secured by implementing the policy in the Keynesian unemployment regime with no credit rationing or easing the credit market with appropriate monetary policies to ensure a rapid expansion in exports with relatively minor economic fluctuations. An implication of the model is that devaluation would not be the ideal policy to restore lost international price competitiveness.²⁴

5. SUMMARY AND CONCLUSIONS

In this paper a disequilibrium model for the Finnish economy is specified and estimated with annual data. The estimation method is fairly simple, thus avoiding the complexities inherent in more sophisticated methods. Nevertheless, the results are plausible and satisfactory. As the transmission mechanisms of economic policy measures are more varied in disequilibrium models than in equilibrium models, the properties of the model were examined in the framework of exchange rate policy simulations. According to the simulations, the policy effects are very sensitive, especially to the credit market conditions prevailing at the time the policies are implemented and to a possible change in the credit market

²⁴ According to a revaluation simulation starting in 1971, revaluation would be successful in curbing domestic inflation and would have no adverse balance of payments effect. On the other hand, revaluation would depress domestic demand and increase unemployment considerably.

regime or excess demand for credit in the credit rationing regime. The policy effects are not so much affected by the conditions prevailing in the goods market, assuming moderate policy shocks, although some cyclical oscillations are discernible according to the model. In summary, it can be concluded that the beneficial effects of devaluation are best obtained by implementing the policy measure in the Keynesian unemployment regime with no credit rationing in order to ensure fast export expansion with relatively minor economic fluctuations. Moreover, disequilibria in the credit and goods markets seem to have clear implications both for the timing of the policy measures and for the supporting monetary and fiscal policies undertaken in order to dampen possible cyclical movements in domestic demand.

APPENDIX: VARIABLES OF THE MODEL

Endogenous Variables

- CA = current account
- C1 = volume of consumption of nontraded goods
- C2 = volume of consumption of traded goods
- DH = deposits of the public in the banks
- FFP = net imports of private foreign capital
- GCB = foreign exchange reserves of the central bank
- H = central bank debt of the banks
- IM = volume of investment of the firms
- K = net stock of capital of the firms
- LE = total employment
- LO = loans of the banks to the public
- LO^d = demand of bank loans
- LO^s = supply of bank loans
- L1 = employment in the nontraded goods sector
- L2 = employment in the traded goods sector
- MFH = volume of imports of final goods (consumer goods)
- MFI = volume of imports of final goods (investment goods)
- MRF = volume of imports of intermediate goods (raw materials and fuels)
- P = price index of total output
- PII = excess supply of traded goods
- P1 = price index of nontraded goods output
- P2 = price index of traded goods output
- Q = volume of gross output
- Q1 = volume of gross output of nontraded goods
- Q2 = volume of gross output of traded goods
- Q2^d = demand for traded goods
- Q2^s = supply of traded goods

- R = marginal cost of central bank credit
 $RHOE$ = excess demand for bank loans
 S = currency (notes and coins in circulation)
 TB = trade balance
 U = unemployment rate
 X = volume of exports
 YD = real disposable income
 W = wage rate

Exogenous Variables

- B = government bonds
 $DF69$ = dummy variable for the revision of foreign trade statistics in 1969
 $DMCP$ = cash payment dummy variable
 $DINP$ = dummy variable for incomes policies in 1969–70
 $DTR66$ = dummy variable for tax reliefs in housing in 1966
 $FCGH$ = state loans for housing
 FFG = net imports of foreign capital by the government sector
 $FXUS$ = FIM/USD exchange rate
 $G1$ = government sector expenditure on nontraded goods
 $G2$ = government sector expenditure on traded goods
 HQ = quotas of central bank credit
 HV = sensitivity parameter of the cost of central bank with respect to the amount of credit
 L = supply of labor
 MFO = weighted volume of imports in the countries most important for Finland's exports
 MSV = value of imports of services
 PMF = unit value index of imported final goods
 $PMFO$ = price index of MFO
 $PMFR$ = unit value index of imported intermediate goods
 RDI = basic discount rate on the central bank credit
 RF = foreign interest rate level (3-month eurodollar rate in London)
 RL = interest rate level of domestic bank loans
 $TIME$ = time trend
 XSV = value of exports of services
 $YFTF$ = net investment income and transfers in the balance of payments

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ACTIVE PEGGING, RATIONAL EXPECTATIONS, AND AUTONOMY OF MONETARY POLICY

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A simple stochastic model of an open economy is used to analyze the effects of exchange rate policies and variability in the money supply process on monetary autonomy. With deterministic exchange rate policies (active pegging), and assuming serially uncorrelated expectations monetary autonomy can be increased although not without limit.

1. Introduction

Many recent stochastic models of the open economy assume that the exchange rate is perfectly flexible and that expectations are formed rationally. One of the questions addressed in the framework of these models is the variability of the exchange rate with respect to various stochastic shocks and the degree of capital mobility.¹ However, these models are not suitable for analyzing those especially small economies pegging their currencies either to a major currency or to a basket of currencies.

Under completely fixed exchange rates and perfect capital mobility, a small country cannot conduct an independent monetary policy. With the presence of exchange rate risk and risk aversion, capital mobility is less than perfect and monetary policy gains autonomy. The exchange risk can arise from discrete adjustments of the domestic currency or from active pegging. Since the degree of capital mobility is inversely related to exchange rate risk, one policy option to acquire greater monetary autonomy is to increase exchange risk.

The aim of this paper is to examine the effects of domestic exchange rate policies on exchange risk and the autonomy of domestic monetary policy. Section 2 presents a simple stochastic model of the monetary sector of an open economy with fixed but adjustable exchange rates, rational expectations and exogenous exchange rate risk. In section 3 the concept of consistent exchange rate risk is introduced.

2. The model

The model is a simple version of the monetary model developed by Kouri and Porter (1974). It is assumed that domestic agents can allocate their wealth between domestic money and one-period

¹ For recently contributions, see Barro (1978), Driskill and McCafferty (1980a,b), Turnovsky and Bhandari (1982) and Eaton and Turnovsky (1984).

domestic and foreign bonds, while foreigners hold neither domestic money nor bonds. For simplicity, income and prices are assumed to be exogenous. With demand for money defined as $M^d = M(r)$, $M_r < 0$, where r is domestic interest rate, the equilibrium condition in the domestic money market is

$$M(r) = M_r \Delta r = \Delta L - \Delta F + X. \quad (1)$$

The right-hand side of (1), the money supply, is derived from the consolidated balance sheet of the banking sector, L being domestic credit creation, F the stock of foreign securities and X the current account.

Assuming only exchange rate risk and risk aversion, the net demand for foreign securities is derived in the mean-variance framework [Dornbusch (1983)] as

$$F = (1/\delta^2 A)(r^f + \tilde{e} - r), \quad (2)$$

where r^f is the foreign interest rate, A ($A > 0$) is a measure of absolute risk aversion, \tilde{e} is the difference between the currently expected and current exchange rate expressed in logarithmic form being a first order approximation of the expected relative exchange rate change, and δ^2 is the variance of the one-period exchange rate forecast. In the case of perfect capital mobility with either risk neutrality or absence of exchange risk uncovered interest parity prevails.

Taking the difference of (2) and solving with (1), the following reduced form is obtained [Tarkka (1984)]:

$$\Delta F = \alpha [-M_r \Delta r^f + \Delta L + X - M_r \Delta \tilde{e}], \quad (3)$$

$$\Delta r = \alpha [\Delta r^f + \delta^2 A (-\Delta L - X) + \Delta \tilde{e}]. \quad (4)$$

In the model (3)–(4) α is the offset coefficient expressed in terms of the structural parameters as $\alpha = 1/(1 - \delta^2 A M_r)$ with $0 \leq \alpha \leq 1$. In the following it is assumed that both risk aversion A and the interest rate response of money demand M_r are constants. The offset coefficient is equal to unity in the absence of exchange rate risk and there is no monetary autonomy. In the other polar case $\alpha = 0$ when $\delta^2 \rightarrow \infty$ and monetary autonomy is complete.

The offset coefficient in the model is thus an important parameter determining the degree of monetary autonomy. Clearly, with a completely fixed exchange rate $\alpha = 1$ and the issue is then whether the monetary authority can increase policy autonomy by active pegging. To address this question the following policy rule is added to the model:

$$e_t - e_{t-1} = a \Delta F, \quad a > 0. \quad (5)$$

The rational expectations solution of the model is obtained by substituting (3) into (5) and applying conditional expectations held at time $t-1$. Thus

$$b [E_{t-1} e_{t+1} - ((2b-1)/b) E_{t-1} e_t + ((b-1)/b) e_{t-1}] = a \alpha E_{t-1} J_t, \quad (6)$$

where $b = a \alpha M_r < 0$ and $J_t = \Delta L_t + X_t$ and it is assumed that $\Delta r_t^f = 0$ and $E_{t-1} e_{t-1} = e_{t-1}$.

Eq. (6) can be written as a stochastic second order difference equation

$$b [1 - ((2b-1)/b) B + ((b-1)/b) B^2] E_{t-1} e_t = a \alpha E_{t-1} J_{t-1}, \quad (7)$$

where the operator B is defined as $BE_t e_{t+1} = E_t e_t$.

Eq. (7) is factorized as

$$b(1 - \lambda_1 B)(1 - \lambda_2 B)E_{t-1}e_t = a\alpha E_{t-1}J_{t-1}, \quad (8)$$

where $\lambda_1 = 1$ and $\lambda_2 = (b-1)/b > 1$ are the characteristic roots. To satisfy the transversality condition eq. (8) is solved by dividing by the unstable factor $1 - \lambda_2 B$ [see Sargent (1979)]. Thus

$$E_{t-1}e_t = e_{t-1} + \frac{1}{1-b} \sum_{i=0}^{\infty} \left(\frac{b}{b-1}\right)^i a\alpha E_{t-1}J_{t+i}. \quad (9)$$

Leading (9) one period forwards it can be seen that the conditional expectation of the exchange rate in period t for $t+1$ depends on future expectations held at t of the process J_{t+1+i} , $i=0, 1, \dots$. For example, expectations of future cuts in domestic credit creation or of deficits in the current account induce expectations of revaluation.²

Next, monetary autonomy is considered in the case of some simple expectations mechanisms assuming that exchange risk is evaluated independently of expectations. If expectations are uniform so that $E_t L_{t+1+i} = 0$, for all t and i , the offset coefficient calculated from (3) is $\alpha_0 = \alpha/(1-b)$ since $\Delta \tilde{e} = [a\alpha/(b-1)]\Delta L_t$. In this case monetary autonomy can be strengthened by increasing the coefficient a .

If expectations are uniform with $E_t J_{t+1+i} = \Delta L_{t+1}$, $i=0$ and $E_t J_{t+1+i} = 0$, $i=1, 2, \dots$, the coefficients for the periods t and $t+1$ are $\alpha_t^1 = \alpha_0$ and $\alpha_{t+1}^1 = \alpha(-b)/(1-b) = \alpha_0(-b)$. As a limiting case consider $E_t J_{t+1+i} = \Delta L_{t+1}$, $i=0, 1, \dots$, giving $\alpha_t^2 = \alpha(1+b)$ and $\alpha_{t+1}^2 = \alpha(-b)$.

Thus in the last two cases it can be seen that with increasingly forward looking expectations, monetary autonomy in period t also decreases. However, the total offset coefficients for periods t and $t+1$ are constant and equal to α , implying a corresponding increase in autonomy in period $t+1$ for sufficient active pegging.

3. Consistent exchange rate risk

Above it was assumed that in spite of rational expectations exchange rate risk was parametrically given. Since the exchange rate risk is not policy invariant according to model (9), it is now assumed that agents' expectations of exchange rate risk are consistent with the full model solution.

The rational expectations equilibrium solution of the model is obtained by substituting (9) into (5) and assuming that the process J_{t+1+i} is serially uncorrelated with zero mean and finite variance δ_e^2 . This gives

$$e_{t+1} = e_t + (a\alpha/(1-b))\Delta L_{t+1} = e_t + H_{t+1}. \quad (10)$$

² This result is due to the simple policy rule (5). Alternatively, assuming a rule of the form

$$e_t - e_{t-1} = a'\Delta R = a'(X - \Delta F), \quad a' < 0, \quad (5')$$

where R is the foreign exchange reserves of the central bank, expectations of current account deficits, assuming $0 < \alpha < 1$, would induce expectations of devaluation. In this case, the direct effect of the deficit expectation dominates the indirect effect of capital imports increasing reserves. For simplicity, the general propositions of the paper are derived only in the case of rule (5). Analogous results could be derived using rule (5').

From (10) consistent exchange rate risk is obtained as a conditional one-period variance of e_{t+1} , $\delta^2 = \text{var}(e_{t+1}) = \text{var}(H_{t+1})$. The solution is ³

$$\delta^2 = (a\alpha/(1-b))^2 \delta_\epsilon^2 = (a^2/(1+a+\delta^2)^2) \delta_\epsilon^2. \quad (11)$$

In the last expression it is assumed that $A = 1$ and $M_r = -1$. It can be seen that δ^2 depends on a and δ_ϵ^2 but since eq. (11) is third degree in δ^2 it cannot be solved explicitly. However, as the right-hand side of (11) is a decreasing function of δ^2 for $\delta^2 \geq 0$, there exists exactly one positive solution: $\delta^2 = \delta^2(a, \delta_\epsilon^2)$. It is easily seen that $\partial\delta^2/\partial a > 0$. Thus, with more active pegging the monetary authority can increase monetary autonomy. In the case where $a = 0$, also $\delta^2 = 0$ and autonomy cannot be increased without limit since the right-hand side of (11) is bounded for all δ^2 , $a \geq 0$. This is due to deterministic pegging. Obviously with a stochastic pegging rule the limit disappears. Also, $\partial\delta^2/\partial\delta_\epsilon^2 > 0$ and $\delta^2 = 0$, when $\delta_\epsilon^2 = 0$. In this case, however, more uncertainty in expectations, i.e., a rise in δ_ϵ^2 , increases monetary autonomy without limit. ⁴

As a conclusion it can be noted that, according to the model, monetary policy is more autonomous the more active exchange rate policies are pursued and/or the more variability there is in expectations concerning the money supply process and the less these expectations are discounted to the present. With deterministic exchange rate policies (5) or (5') and assuming serially uncorrelated expectations, monetary autonomy can be increased only in a limited way. If expectations are serially corrected or if the exchange rate policy rule is stochastic, autonomy can be further enhanced.

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³ Note that because $\lambda_1 = 1$ in (9) the asymptotic variance of the exchange rate is unbounded.

⁴ Assuming more generally that J_{t+1+i} is a Markov process, $E_{t+1}J_{t+1+i} = \mu^i \Phi_{t+1}$, $|\mu| < (b-1)/b$, gives

$$\delta^2 = a^2 \delta_\phi^2 / [1 + (1-\mu)a + \delta^2]^2. \quad (11')$$

Again it is seen that $\partial\delta^2/\partial a, \partial\delta^2/\partial\delta_\phi^2 > 0$. In this case, however, monetary autonomy can be increased without limit by setting $\mu = 1$.

TESTING DISEQUILIBRIUM ADJUSTMENT MODELS FOR FINNISH EXPORTS OF GOODS

*Esko Aurikko**

I. INTRODUCTION

Conventional formulations of foreign trade equations are usually based on some demand theoretical framework. In the case of a small country, it is normally assumed that the supply of imports is infinitely elastic, making possible the use of OLS in the estimation of import demand models and thus of price and income elasticities (see e.g. Houthakker and Magee, 1969). Even in export models for a small country, however, the simplifying assumption of infinite price elasticity of either export supply or demand is not always realistic, so that it is necessary to consider simultaneous demand and supply systems. Simultaneous estimation of export demand and supply models has been accomplished in some recent studies (Goldstein and Khan, 1978; Lundborg, 1981). In the former study even an adjustment mechanism, and thus a disequilibrium specification, is estimated.

The notion that in some markets disequilibrium, i.e. demand does not equal supply, prevails, either because of temporarily fixed prices reflecting, for example, institutional circumstances or because of sluggish price and quantity adjustments, has suggested different types of disequilibrium models. The former case leads to fixed price disequilibrium models in which the transacted quantities are the minima of the quantities demanded and supplied (for recent surveys, see Quandt, 1982; Laffont, 1983). The latter case, emphasizing disequilibrium as an adjustment process, results in general simultaneous disequilibrium adjustment formulations as suggested by Spencer (1975), Chow (1977) and Orsi (1982).

The purpose of this paper is to test different disequilibrium adjustment models in the framework of the demand for and supply of exports of Finnish goods. The basic model with the various adjustment mechanisms is discussed in Section II. In Section III the simultaneous disequilibrium adjustment export model is estimated with quarterly data and the adjustment mechanisms are tested using nested and non-nested methods. Section IV concludes.

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II. THEORETICAL MODELS

In discussing modelling of export supply and demand, two simple polar cases can be distinguished. In the first case exports are assumed to be completely demand-determined, price elasticity of export supply thus being infinite. This Keynesian demand-determined model has been widely utilized in econometric studies of foreign trade. The assumption of infinite price elasticity of supply is especially relevant when productive capacity is underutilized in the export industries or when production is subject to constant or increasing returns to scale. In the other polar case exports are supply-determined with infinite price elasticity of export demand. This classical determination of exports is incorporated in the Scandinavian model of inflation (Edgren, Faxén and Odhner, 1969) and the monetary approach to the balance of payments (Frenkel and Johnson, 1976), in which export prices depend on world market prices and exports on domestic supply conditions.

In this paper export supply and demand are specified in a manner intermediate between the polar cases. The simplest case would be to assume an equilibrium model with export prices and quantities adjusting to the equilibrium instantaneously. The simple equilibrium model presented, for example, in Goldstein and Khan (1978) is:

$$XG^d = XG^d(PX/PF, QW) \quad (1)$$

$$XG^s = XG^s(PX/PD, CU) \quad (2)$$

where export demand (XG^d) is a function of the ratio of export prices (PX) to competitors' prices (PF) and of foreign real activity (QW). Export supply (XG^s) depends on the ratio of export prices to domestic prices (PD) and on domestic capacity utilization (CU).¹ The partial derivatives of XG^d and XG^s are assumed to be:

$$XG^d_{PX/PF} < 0, XG^d_{QW} > 0, XG^s_{PX/PD} > 0, XG^s_{CU} > 0$$

Assuming instantaneous adjustment the model is completed by the condition:

$$XG^d = XG^s = XG \quad (3)$$

The approach based on equilibrium in the supply of and demand for exports might be too restrictive. Complete and instantaneous equilibrium in markets with uncertainty and various frictions such as binding contracts, adjustment and information costs, imperfect information, inventories and rationing seem to imply rigidities in the adjustment of prices and quantities and thus to generate possible disequilibria.

¹ Specification (2) differs somewhat from that in Goldstein and Khan. It is a simple supply function in the framework of imperfect competition in the product and factor markets represented by the variable CU (Aurikko, 1975).

With lags in adjustment, the following conventional adjustment mechanism can be incorporated in the equilibrium model (1)–(3):

$$\Delta xg_t = \gamma(xg_t^e - xg_{t-1}) \quad (4)$$

$$\Delta px_t = \lambda(px_t^e - px_{t-1}) \quad (5)$$

where the adjustment coefficients γ and λ are positive and adjustment is with respect to the equilibrium values xg^e and px^e . Above lower case letters denote logs of corresponding capitals and $\Delta z_t = z_t - z_{t-1}$. It is thus assumed that export volume and price are determined both in the demand and supply side of the market. With $\gamma = 1$ and consequently $XG = XG^e$, equations (4) and (5) collapse to a process resembling the traditional Walrasian adjustment process.

A generalization of the partial adjustment model (4) and (5) suggested by Chow (1977) is:

$$\Delta y_t = \Lambda(y_t^* - y_{t-1}) \quad (6)$$

where $y_t^* = (xg_t^e, px_t^e)'$ are unobserved equilibrium values of the model (1)–(3) assumed to be log-linear, $y_t = (xg_t, px_t)'$ are observed values and Λ the adjustment matrix.

A still more general adjustment mechanism, which does not impose arbitrary skewed lags, is the following error correction model:

$$\Delta y_t = \Lambda \Delta y_t^* + \Gamma(y_{t-1}^* - y_{t-1}) \quad (7)$$

Model (7) incorporates derivative control $\Lambda \Delta y_t^*$ and proportional control $\Gamma(y_{t-1}^* - y_{t-1})$, i.e., an error correction mechanism, implying that for $\Gamma \neq 0$ in the steady state $y = y^*$ (Hendry and Richard, 1983). Model (7) nests model (6) as well as models (4)–(5) and (1)–(3).²

Specifications of the form (6) and (7) have been derived in the theory of portfolio selection by minimizing costs of being out of equilibrium together with adjustment costs subject to the balance sheet constraint (Sharpe, 1973). In the theory of interrelated factor demand decisions, general dynamic factor demand models are generated by cost minimization and duality considerations (Epstein and Denny, 1983). Partial price and quantity adjustment models can be derived assuming monopolistic competition and cost of adjustment (Rotemberg, 1982). A natural generalization would be to assume that there exist both price and quantity adjustment costs. Assuming, moreover, that the price and quantity (output) are fixed simultaneously and independently, thus implying the existence of inventories and rationing, the dynamic optimization problem would result in a system of difference equations. The solution of the system minimizes the expected present value of total costs, consisting of costs of being out of equilibrium and costs of

² Model (7) allows for a more orthogonal choice of explanatory variables than model (6), but also falls consistently short of constantly growing equilibrium values (see Salmon, 1982).

price and quantity adjustment. However, the above approach is not realistic in assuming that prices and quantities are set independently without taking into account their dependency via the demand function. Allowing for this there would be no obvious way to rationalize the cross effects in (6) and (7).

Thus a general objection to the above models based on simple equilibrium or general disequilibrium adjustment dynamics is that they are either too restrictive or too general. Moreover, they lack firm theoretical foundations, and are consequently not altogether satisfactory specifications for econometric analysis.³

An alternative, especially in the case of a small open economy, is to assume, first, that export prices are set according to a reduced form equation obtained from the long-run equality of supply and demand (Minford, 1978). This assumption is based on the notion that changing prices is costly. Secondly, exports are assumed to be realized according to short-run demand and supply (Spencer, 1975). Since the long-run equilibrium prices are not necessarily equal to short-run equilibrium prices, both demand and supply conditions affect exports in the short-run. In this disequilibrium framework the supply side of the market is incorporated in export quantity determination. These two assumptions are briefly discussed below.

Recently, it has been widely recognized that it is costly to change prices, especially in foreign markets, because of both administrative costs and the implicit costs arising from the possible reaction of customers, particularly in the case of large price changes.⁴ Another possible reason for the failure of prices to adjust continuously to clear markets is the monopolistic power of exporters.

Since the market clearing models might perhaps require substantial price changes in response to often volatile supply or demand changes in domestic or international markets, it is assumed that market clearing takes place through the adjustment of quantities rather than through the costly adjustment of prices. Adjustment of quantities is assumed to occur with respect to the short-run demand and supply, export prices being kept relatively stable in the long-run equilibrium.

This mode of adjustment might be rationalized in terms of simple market shares adherence behaviour. Above it was assumed that export

³ It would seem that the specifications (6) and (7) violate the principle of voluntary exchange, i.e. $XG = \min(XG^d, XG^s)$. As Chow (1977) argues, the principle is valid only for equilibrium situations in which actual demand or supply exceed equilibrium demand or supply because of costs or some other rigidities associated with demand or supply changes. Alternatively, buyers and sellers might not have equal market power (Rosen and Quandt, 1978). Specification (6) can also be defended since the min formulation would imply wide oscillations and overshooting in the adjustment (Chow, 1977).

⁴ For one of the first theoretical treatments of this subject, see Barro (1972). For a recent intertemporal study, see Rotemberg (1982). Empirical support for the proposition that in the short-run quantities tend to be more flexible than prices in firms' adjustment behaviour is given by Kawasaki, McMillan and Zimmerman (1982).

prices are set at a long-run equilibrium and thus follow fairly closely world market prices, which are determined exogenously for a small country. Thus the prices are not necessarily those that equilibrate supply and demand in the country.

Moreover, it is assumed that the total world demand in the short-run is approximately constant and that equation (1) is of the form:

$$XG^d = a_0(PX/PF)^{-\delta} QW \quad (1')$$

where, given $PX = PF$, a_0 is the market share.⁵ If the realized export price is relatively low at $PX = PF$, revenues and profits are relatively low and the hypothesis is that especially unprofitable exports are curtailed. However, a central assumption is that exporters try to keep their market shares roughly constant (i.e. $XG = XG^d$), even maintaining unprofitable production to some extent because regaining lost market shares later would be both costly and time consuming. With relatively high export prices and revenues, it is assumed that market shares are gained in both old and new markets by increased export efforts. An alternative rationalization would be that there exist some non-price variables which adjust so that the market clears.

The above assumptions concerning export quantity determination and the price setting adjustment can be expressed as:

$$\Delta xg_t = \lambda_{11}(xg_t^d - xg_{t-1}) + \lambda_{12}(xg_t^s - xg_{t-1}) \quad (8)$$

$$\Delta px_t = \lambda_{21}(xg_t^e - xg_{t-1}) + \lambda_{22}(px_t^e - px_{t-1}) \quad (9)$$

where $\lambda_{21} = 0$, λ_{11} , λ_{12} , $\lambda_{22} \geq 0$ and $\lambda_{11} + \lambda_{12} = 1$. In equation (8) the restrictions imply that:

$$xg_t = (1 - \lambda_{12}) xg_t^d + \lambda_{12} xg_t^s \quad (10)$$

i.e. xg is a convex combination of demand and supply, and in (9) that:

$$\Delta px_t = \lambda_{22}(px_t^e - px_{t-1}) \quad (11)$$

In equation (10) the weights are assumed to be constants, being a special case of the specification of Spencer (1975), in which the weights are variable and the model asymptotically reduces to the $\min(XG^d, XG^s)$ model.

III. EMPIRICAL RESULTS

The data utilized in the estimation of the export model are quarterly and seasonally adjusted and cover the period 1962–81. They are derived from the data base of the quarterly model constructed in the Research Department of the Bank of Finland.⁶ A description of the data can be found in the Appendix.

⁵ An analogous form is assumed for equation (2).

⁶ Bank of Finland (1983).

The estimation of export supply and demand systems begins by estimating the systems (7) and (6) using a non-linear maximum likelihood method and then testing the two models. Next, different versions of the disequilibrium specification (6) are tested in respect to the elements in the adjustment matrix Λ . Finally, discrimination between the models (6) and (8)–(9), respectively, is discussed.

In the theoretical discussion of export supply and demand it was argued that observed export volumes and prices are adjusted according to long-run values as in (6) and (7).

Alternatively, it was assumed that export prices are adjusted with respect to long-run equilibrium prices, with export volumes determined both from the demand and supply side, i.e. with respect to xg^d and xg^s as in (8).

The empirical validity of the assumption of disequilibrium as against the equilibrium specification of the adjustment matrix Λ in (6) is first tested in the case where xg^e and px^e are in unconstrained reduced form. Next, restrictions on Λ are tested when xg^e and px^e are included in (6) in the reduced form expressed in terms of the structural parameters. Finally, discrimination between models based on adjustment mechanisms in (6) and (8)–(9) is assessed and again tests on restrictions in the framework of the latter model are performed. Logarithmic models⁷ and, for simplicity, aggregative data are used throughout.

(i) *Models (7) and (6): xg^e and px^e in Unconstrained Reduced Form*

The unrestricted form of (7) with xg^e and px^e in the unconstrained reduced form is:

$$\Delta xg_t = \lambda_{11}(xg_t^e - xg_{t-1}^e) + \lambda_{12}(px_t^e - px_{t-1}^e) + \gamma_{11}(xg_{t-1}^e - xg_{t-1}) + \gamma_{12}(px_{t-1}^e - px_{t-1}) + u_1 \quad (12)$$

$$\Delta px_t = \lambda_{21}(xg_t^e - xg_{t-1}^e) + \lambda_{22}(px_t^e - px_{t-1}^e) + \gamma_{21}(xg_{t-1}^e - xg_{t-1}) + \gamma_{22}(px_{t-1}^e - px_{t-1}) + u_2 \quad (13)$$

where xg_t^e and px_t^e are given, with variables PF , PD , MF and CU assumed exogenous, as:

$$xg_t^e = a_0 + a_1 pf_t + a_2 pd_t + a_3 mf_t + a_4 cu_t \quad (14)$$

$$px_t^e = b_0 + b_1 pf_t + b_2 pd_t + b_3 mf_t + b_4 cu_t \quad (15)$$

⁷ There seem to be no studies in the literature on the appropriate functional form for export demand and supply models. However, in many studies on import demand the appropriate functional form is found to be log-linear (see e.g. Khan and Ross, 1977; Boylan, Cuddy and O'Muircheartaigh, 1980). Box-Cox tests for functional form for the equilibrium model (1)–(3) with aggregative data proved to be inconclusive. The test results are available from the author upon request.

where the disturbances u_i , in (12)–(13), $i = 1, 2$, are serially independent and distributed normally as $N(0, U)$ and

XG = volume of exports to market economies

PX = unit value index of XG

MF = weighted volume of imports of most important market economies

PF = price index of MF

PD = prices of production in manufacturing industry

CU = capacity utilization rate of the Finnish economy.

The system (12)–(13) (model (7)) as well as the restricted model (6) were estimated with a nonlinear maximum likelihood algorithm with the following results:

	Model 7		Model 6	
	Coefficient	Asymptotic standard error	Coefficient	Asymptotic standard error
a_0	3.58	0.41	3.79	0.29
a_1	0.55	0.16	0.67	0.27
a_2	-0.61	0.26	-0.76	0.33
a_3	1.13	0.19	1.10	0.14
a_4	0.70	0.27	0.72	0.57
b_0	-0.32	0.24	-0.41	0.15
b_1	0.60	0.09	0.53	0.14
b_2	0.41	0.14	0.51	0.16
b_3	0.03	0.10	0.03	0.07
b_4	-0.18	0.13	-0.13	0.31
λ_{11}	0.84	0.24	0.71	0.11
λ_{12}	0.48	0.28	0.44	0.16
λ_{21}	0.02	0.11	0.07	0.04
λ_{22}	1.06	0.12	0.58	0.07
γ_{11}	0.82	0.11		
γ_{12}	1.12	0.20		
γ_{21}	0.00	0.04		
γ_{22}	0.78	0.27		

The reduced form coefficient estimates are of the same order of magnitude in the two models. Also in model (7) the coefficient estimates for the elements in the matrices Λ and Γ are rather similar. The signs are as expected according to the assumed partial effects in (1) and (2) (see Goldstein and Khan (1978)), although some of the coefficients are not significant according to the asymptotically valid t -test. The estimated coefficients of the adjustment matrices Λ and Γ in model (7) are plausible and, with exception of λ_{21} and γ_{21} , significant. The logarithm of the value of the maximized likelihood function of the

model is $L = 300.7$. In the restricted model (6) the estimated adjustment coefficients are also plausible and $L_0 = 294.2$. According to the asymptotically valid likelihood ratio test the restriction $\Lambda = \Gamma$ implying that model (7) reduces to model (6), is not rejected at the 1 per cent significance level⁸ as the LR test statistic under $\Lambda = \Gamma$ distributed as χ^2_4 is 13.0.⁹

Next, some plausible adjustment mechanisms in the framework of model (6) are tested. As the tests are conditional on the validity of model (6), it is necessary to first consider this issue. According to the values (-2.49 and 3.19) of the Durbin h -test statistics for model (6), the residuals might be autocorrelated. However, as the model is non-linear the distribution of the h -statistic is unknown. In order to assess the validity of (6), a linear version of the system is estimated by ordinary least squares with independent variables as in (14) and (15) together with lagged dependent variables. The test statistics are:

$$xg: \bar{R}^2 = 0.970 \text{ SEE} = 0.065 \text{ LM1} = 0.92 \text{ LM4} = 0.23 \text{ LMH} = 3.34 \\ \phantom{\bar{R}^2} \\ \phantom{\bar{R}^2} $$

$$C_f = 0.83 \text{ } C_b = 0.54 \text{ } C_f^2 = 0.09 \text{ } C_b^2 = 0.25 \\ (0.95) \quad (0.95) \quad (0.18) \quad (0.18)$$

$$px: \bar{R}^2 = 0.998 \text{ SEE} = 0.028 \text{ LM1} = 2.17 \text{ LM4} = 1.11 \text{ LMH} = 0.24 \\ \phantom{\bar{R}^2} \\ \phantom{\bar{R}^2} $$

$$C_f = 0.84 \text{ } C_b = 1.01 \text{ } C_f^2 = 0.29 \text{ } C_b^2 = 0.20 \\ (0.95) \quad (0.95) \quad (0.18) \quad (0.18)$$

Above \bar{R}^2 is the adjusted coefficient of determination, SEE is the residual standard error, LM1 and LM4 are test statistics for first and fourth order autocorrelation distributed as $N(0, 1)$ (Breusch and Pagan, 1980), and LMH is a test statistic for heteroscedasticity distributed as χ^2_1 (Pagan, Hall and Trivedi, 1983). In addition, C_f , C_b , C_f^2 and C_b^2 are Cusum and Cusum Squares test statistics for parameter stability where the recursive residuals are computed forwards (f) and backwards (b). The 5 per cent critical values are shown in parentheses.

As indicated by the test statistics (cf. also Figures 1 and 2), the linear model corresponding to (6) is reasonably stable with no severe autocorrelations. On this evidence it is assumed that the non-linear model (6) is also adequately valid.

The first test in the framework of model (6) is as suggested by the above estimates $\lambda_{21} = 0$, i.e.:

⁸ The asymptotic validity of the test calls for a degrees of freedom correction in small samples (Mizon, 1977). The selected high significance level offsets the failure to know which correction to use.

⁹ In model (7), the restrictions $\lambda_{21} = \gamma_{21} = 0$, $\lambda_{22} = 1$ and $\lambda_{21} = \gamma_{21} = 0$, $\lambda_{22} = \gamma_{22}$ are both not rejected, implying in the former case instantaneous and in the latter case gradual adjustment of export prices.

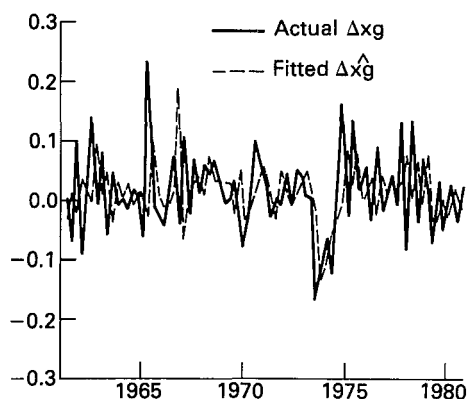


Figure 1

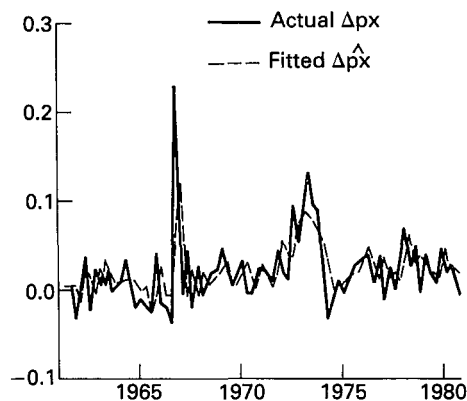


Figure 2

$$\Lambda_1 = \begin{pmatrix} \lambda_{11} & \lambda_{12} \\ 0 & \lambda_{22} \end{pmatrix}$$

Testing Λ_1 against Λ_0 (unrestricted form) is thus based on the *LR* test. The *LR* test statistic under Λ_1 distributed as χ_1^2 is 2.4. Since the critical values of χ_1^2 at the 5 and 1 per cent levels are 3.84 and 6.63, respectively, the hypothesis $\lambda_{21} = 0$ is not rejected.

Estimation of the model (6) with other obvious restrictions on Λ :

$$\Lambda_2 = \begin{pmatrix} 1 & \lambda_{12} \\ 0 & \lambda_{22} \end{pmatrix}, \quad \Lambda_3 = \begin{pmatrix} \lambda_{11} & \lambda_{12} \\ 0 & 1 \end{pmatrix}$$

$$\Lambda_4 = \begin{pmatrix} \lambda_{11} & 0 \\ 0 & \lambda_{22} \end{pmatrix}, \quad \Lambda_5 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

with values of the likelihood function as

$$L_2 = 290.1$$

$$L_3 = 274.2$$

$$L_4 = 288.7$$

$$L_5 = 271.8$$

suggests that these restrictions are rejected at a 5 or even 1 per cent level. The adjustment mechanism Λ_4 in equations (4) and (5), the equilibrium hypothesis Λ_5 as well as the hypothesis Λ_3 proposed by Orsi (1982) are not supported by the data in the case of specification (12)–(13). Orsi does not give any theoretic rationalization for the specification Λ_3 . Moreover, he tests the specification Λ_3 against Λ_5 ($\Lambda_5 = I$), i.e. a restricted disequilibrium specification against an equilibrium specification. Instead of taking Λ_3 as a maintained hypothesis, it is more interesting to proceed first from the unrestricted Λ and to test specifications Λ_3 and Λ_5 , among others, as restricted forms of the maintained hypothesis.

As a summary, the *LR* test statistics under restrictions Λ_1 – Λ_5 against the maintained hypotheses of either Λ_0 or Λ_3 are as follows:

	<i>Maintained hypothesis</i>	
	Λ_0	Λ_3
Λ_1	2.4 (3.8)	
Λ_2	8.6 (6.0)	
Λ_3	40.0 (6.0)	
Λ_4	11.0 (6.0)	
Λ_5	44.8 (9.5)	4.8 (6.0)

where the 5 per cent critical values of χ_k^2 are in parentheses and the degrees of freedom k equal the number of restrictions on λ_{ij} ($i, j = 1, 2$).

Accordingly, the equilibrium hypothesis is not rejected when the maintained hypothesis is Λ_3 . This is in contrast to the results suggested by Orsi. However, when the maintained hypothesis is Λ_0 the equilibrium hypothesis $\Lambda_5 = I$ is convincingly rejected.

Thus in the aggregative framework with reduced form models for xg^e and px^e , the adjustment mechanism Λ_1 is data admissible, implying that

export volumes are determined by demand and supply considerations and that export prices adjust slowly to the long-run equilibrium price:

$$px_t = \lambda_{22} px_t^e + (1 - \lambda_{22}) px_{t-1} \quad (16)$$

or

$$\Delta px_t = \lambda_{22}(px_t^e - px_{t-1}) \quad (17)$$

where the estimate of the adjustment coefficient is $\lambda_{22} = 0.53$.

(ii) *Model (6): xg^e and px^e in Structural Reduced Form*

Secondly, the restrictions on Λ in (6) are tested where xg^e and px^e are reduced forms expressed in terms of the structural parameters of (1) and (2) written in the log-linear form:

$$xg_t^e = \frac{\alpha_1 \beta_1}{\alpha_1 - \beta_1} \left(-\frac{\alpha_0}{\alpha_1} + \frac{\beta_0}{\beta_1} + pf_t - pd_t - \frac{\alpha_2}{\alpha_1} mf_t + \frac{\beta_2}{\beta_1} cu_t \right) \quad (18)$$

$$px_t^e = \frac{1}{\alpha_1 - \beta_1} (\beta_0 - \alpha_0 + \alpha_1 pf_t - \beta_1 pd_t - \alpha_2 mf_t + \beta_2 cu_t) \quad (19)$$

where $\alpha_1 < 0$, $\alpha_2, \beta_1, \beta_2 > 0$ (cf. equations (1) and (2)).

Estimating the unrestricted system (6) with (18) and (19) inserted, yields the following estimates for the structural parameters with $L'_0 = 287.1$:

	Coefficient	Asymptotic standard error
α_0	3.32	0.22
α_1	-1.67	0.21
α_2	1.08	0.03
β_0	8.48	0.17
β_1	4.92	1.09
β_2	-0.22	1.21
λ_{11}	0.54	0.11
λ_{12}	0.55	0.17
λ_{21}	0.11	0.05
λ_{22}	0.55	0.07

Except for the estimate of the coefficient of capacity utilization (CU) β_2 , the signs of the structural coefficients are as expected and significant according to the conventional t -test. The estimated coefficients of Λ are all positive and less than one.

Testing (6) with (18) and (19) and restricting $\lambda_{21} = 0$, gives the LR statistic 5.6, so that the hypothesis $\lambda_{21} = 0$ is not rejected at the 1 per cent level. However, the hypotheses corresponding to cases $\Lambda_2 - \Lambda_5$ are rejected since the values of the likelihood function are:

$$L'_2 = 279.1$$

$$L'_3 = 261.4$$

$$L'_4 = 278.1$$

$$L'_5 = 261.3$$

Thus, even in the case of the adjustment model with structural export demand and supply functions, the general adjustment mechanism ($\lambda_{21} = 0$, $\lambda_{22} \neq 1$) suggested by Orsi is supported by empirical considerations, with estimated coefficients as follows:

	<i>Coefficient</i>	<i>Asymptotic standard error</i>
α'_0	3.30	0.15
α'_1	-1.62	0.22
α'_2	1.08	0.03
β'_0	8.56	0.12
β'_1	5.43	0.85
β'_2	1.49	1.02
λ'_{11}	0.69	0.08
λ'_{12}	0.62	0.16
λ'_{21}	0	—
λ'_{22}	0.46	0.06

The coefficient estimates are roughly the same as in the unrestricted model, except that the coefficient β_2 has changed considerably.

(iii) *Models Based on (8)–(9)*

Finally, the disequilibrium adjustment model (8)–(9) is considered.¹⁰ Estimating this model unconstrained with (1)–(2) in log-linear form inserted in (8) and (18)–(19) inserted in (9) gives $L''_0 = 287.2$. Testing the empirical validity of this model and of the model above in which export quantities are also adjusted with respect to the equilibrium values is less straightforward since the models are non-nested. However, with computed values for the likelihood function in both cases the discrimination between the two models is, in this context, assessed first

¹⁰ The test statistics for a linear version of (8) are:

$$xg: \bar{R}^2 = 0.971 \text{ SEE} = 0.063 \text{ LM1} = 0.36 \text{ LM4} = 0.78 \text{ LMH} = 4.82$$

(1.96) (1.96) (3.84)

$$C_f = 0.88 \text{ } C_b = 0.67 \text{ } C_f^2 = 0.12 \text{ } C_b^2 = 0.24$$

(0.95) (0.95) (0.18) (0.18)

The test statistics for px are those presented in sub-section (i).

by the Akaike Information Criterion (AIC) (Akaike, 1978).¹¹ The values of the AIC, $AIC' = -554.2$ and $AIC'' = -554.4$, suggest that the model (8)–(9) might marginally be selected.¹²

As the AIC rule is not especially powerful in discriminating between the models, the non-nested procedure suggested by Pesaran and Deaton (1978) for testing systems of non-linear equations is utilized. Denoting the competing disequilibrium adjustment models, i.e. the model (6) with (18)–(19) and the model (8)–(9) with (1)–(2) in the log-linear form, H_0 and H_1 , respectively, the tests are based on a modified likelihood ratio, first taking H_0 as the maintained hypothesis and then reversing the procedure. However, since the equation for export prices is identical in both H_0 and H_1 it is necessary to test only the equations for export volumes.

With H_0 as the maintained hypothesis, the test statistic (see Pesaran and Deaton, 1978 for details) distributed asymptotically as $N(0, 1)$ under H_0 is -12.02 . On this evidence the validity of H_0 cannot be maintained. In the case of H_1 as the maintained hypothesis the test statistic is 0.12 , indicating that H_1 cannot be rejected. Together, the tests thus support hypothesis H_1 , i.e. that in the aggregate framework the adjustment process is not symmetric in the case of export volumes and prices.

The estimates for the structural parameters in model (8)–(9) are:

	<i>Coefficient</i>	<i>Asymptotic standard error</i>
α_0^H	3.32	0.14
α_1^H	-1.67	0.23
α_2^H	1.08	0.04
β_0^H	8.49	0.18
β_1^H	4.92	1.21
β_2^H	-0.22	1.27
λ_{11}^H	0.70	0.14
λ_{12}^H	-0.01	0.04
λ_{21}^H	0.11	0.04
λ_{22}^H	0.55	0.07

It is seen that the estimates are almost the same as those of the preceding unconstrained model, except that the estimate for λ_{12} is not significantly different from zero.

¹¹ According to the AIC, the decision rule is to select the model for which $AIC = -2L + 2n$ is the minimum, where n is the number of parameters estimated. On the relative power of this test procedure, see e.g. Judge *et al.* (1980).

¹² Discrimination between the structural variant of model (6) in sub-section (ii) and the reduced form models (7) and (6) in (i) favours the last two models. However, this is not relevant given that the last two models are not structural.

Tests with different restrictions on Λ in (8) and (9) give support at the 1 per cent significance level for the following specifications:

$$\Lambda_6 = \begin{pmatrix} 1 & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \end{pmatrix} \quad \text{and} \quad \Lambda_7 = \begin{pmatrix} \lambda_{11} & 0 \\ \lambda_{21} & \lambda_{22} \end{pmatrix}$$

The restriction $\lambda_{11} + \lambda_{12} = 1$ is not rejected at the 1 per cent significance level. In this case the estimates for the elements of Λ are:

$$\Lambda_8 = \begin{pmatrix} 1.07 & -0.07 \\ (0.04) & (0.04) \\ 0.16 & 0.59 \\ (0.04) & (0.08) \end{pmatrix}$$

with asymptotic coefficient standard errors in parentheses. Furthermore, the restrictions with $\lambda_{11} = 1$ and $\lambda_{12} = 0$ are not rejected, as the estimates in Λ_8 suggest, implying that the adjustment occurs along the demand curve.

Moreover, the adjustment mechanism within the model (10)–(11), i.e.:

$$\Lambda_9 = \begin{pmatrix} 1 - \lambda_{12} & \lambda_{12} \\ 0 & \lambda_{22} \end{pmatrix}$$

is not rejected but other plausible restricted versions of Λ with $\lambda_{11} + \lambda_{12} = 1$ are rejected, including the restriction $\lambda_{21} = 0$ and $\lambda_{22} = 1$.

According to the *LR* test, the static model with $\Lambda = I$ in the framework of model (8)–(9) is thus not data admissible. Also, the residual standard errors for *xg* and *px* in the static model, 0.061 and 0.037, respectively, are somewhat larger than the residual standard errors in the dynamic model with $\Lambda = \Lambda_9$ (model (10)–(11)), 0.058 and 0.029, respectively.

The economic implication of the above static and dynamic models are examined on the assumption of a 10 per cent permanent increase in *PF*, i.e. a devaluation or, equivalently, an increase in competitors' prices, from the beginning of 1971 onwards. The simulation results are presented in Figures 3 and 4, where *PXS*, *XGS* and *XGVS* are the multipliers for the price of exports, volume of exports and value of exports calculated as percentage deviations of the disturbed solution and control solution. The corresponding variables for the dynamic model are *PXD*, *XGD* and *XGVD*.

According to the simulations, export prices in domestic currency rise by nearly half of the devaluation percentage. In the static model this effect is immediate while in the dynamic model adjustment is completed in four quarters (Figure 3). However, in both cases the value of exports and thus profits in domestic currency (Figure 4) rises by about the same percentage, so that the implications of the models are

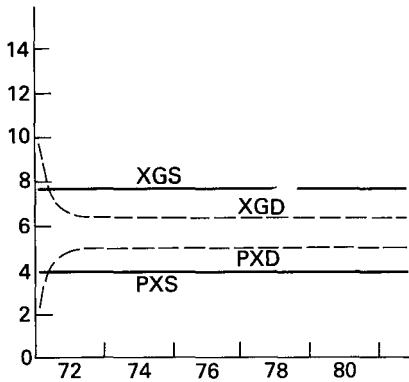


Figure 3

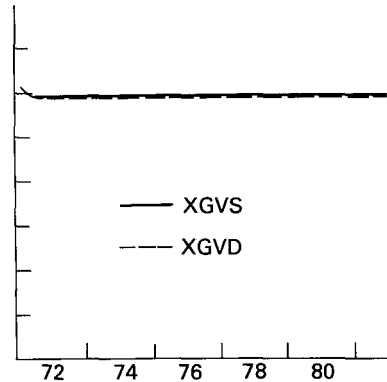


Figure 4

rather similar. Of course, the simulations are very partial and not very realistic, particularly with respect to the long-run.

In summary, the test results seem to suggest that there is empirical support for model (8)–(9) with the adjustment mechanism as in (10)–(11). However, the tests are conducted with aggregative data and in the framework of simple models. Assuming that the adjustment mechanisms of export volumes and prices do not differ between different export categories, the evidence suggests the use of model (8)–(9) with restrictions as in Λ_9 as a basic framework for the estimation of even disaggregated models for export volumes and prices.

IV. CONCLUSIONS

In the theoretical part of the paper two disequilibrium adjustment models for exports of goods were discussed. In the first model, observed export volumes and prices were assumed to adjust to long-run equilibrium values. In the second model, assuming that changing prices is costly and that exporters' behaviour is characterized by market shares adherence, export prices adjust with respect to the long-run equilibrium price while export volume is affected by demand and supply conditions. Discrimination between the two types of non-nested disequilibrium adjustment models was assessed and the results indicated the empirical validity of the second model. Moreover, the restrictions in the models implying equilibrium specifications were rejected. Thus, the conclusion is that Finnish export volumes and prices, and perhaps also those of other small open economies, are determined in a complicated way involving simultaneous demand and supply effects and slow adjustment. Since empirical support was found for the adjustment specifications as against equilibrium formulations, there would seem to be scope

for also utilizing the disequilibrium adjustment models with disaggregated export data and in other markets. On the other hand, testing the minimum model together with a price adjustment equation has not been attempted. One possibly fruitful research area in this connection would be to test the empirical validity of the conventional minimum specification with prices adjusting according to excess demand as compared with the disequilibrium adjustment models studied in this paper.

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APPENDIX: VARIABLES AND SOURCES OF DATA

- XG = volume of exports to market economies, seasonally adjusted, 1975 prices in FIM
- PX = unit value index of XG , 1975 = 100
- MF = weighted volume of imports of most important market economies for Finland, 1975 = 100 (weights: UK 37%, Sweden 31%, FRG 17%, France 8% and USA 7%)

PF = weighted unit value index of imports of most important market economies for Finland, in FIM, 1975 = 100 (weights as in *MF*)

PD = price of production in manufacturing industry

CU = capacity utilization rate of the Finnish economy, GD/GP

GD = volume of gross domestic product in producers' prices, seasonally adjusted, 1975 prices, in FIM

GP = volume of potential gross domestic product, 1975 prices, in FIM

The data for *XG* and *PX* are derived from the Board of Customs Monthly Bulletin. Seasonally adjusted volume indices for calculating *MF* are taken from the Main Economic Indicators of the OECD. The data for constructing *PF* are obtained from the International Financial Statistics of the IMF. The data source for *PD* and *GD* is the National Income Accounts. Variable *GP* is estimated from a production function.

A Dynamic Disaggregated Model of Finnish Imports of Goods

By *E. Aurikko*, Helsinki¹⁾

Abstract: The purpose of this paper is to test and estimate dynamic aggregated and disaggregated models of import demand with quarterly Finnish data. The main conclusions are that the log-linear functional form is preferable to the linear form and that there is empirical support in favor of estimation of import demand models in a disaggregated framework. On the whole, adjustment of Finnish imports of goods is relatively fast.

1. Introduction

With increased interest in econometric modelling of the Finnish economy, there have also been numerous econometric studies on Finnish imports of goods. Annual aggregated models are used in *Vartia* and *Halttunen*, quarterly disaggregated models in *Aurikko* [1975, 1984], and annual disaggregated models in *Korkman* and *Mannermaa* and *Kaski*. Important foreign studies include those of *Goldstein* and *Khan* [1976] and *Goldstein* et al.

The purpose of this paper is to test and estimate systematically dynamic models of Finnish imports of goods. Prior to this the choice of the functional form and the necessity of disaggregating the models are considered. The specification of the models is as in the quarterly model BOF3 constructed by the Research Department of the Bank of Finland, in which the dynamics is captured simply by Almon distributed lags [*Aurikko*, 1984]. While in the majority of the studies on import demand the log-linear functional form is adopted as the convenient form, it has not, in fact, been tested with the Finnish data. Testing the appropriate functional form as well as the desirability of the disaggregation is thus an important point of departure for the dynamic specification searches, which are based on an exhaustive testing procedure.

In the next section some theoretical considerations of import supply and demand are discussed. In section 3 the tests are performed and the methodology of the estimation of import demand models, together with the estimation results and simple simulations, are presented. In the final section some concluding comments are given.

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2. Theoretical Background

Because Finnish imports account for only a small share of total world imports and have only a minor influence on world-market prices, it is assumed that import prices are exogenous. Furthermore, it is assumed that the supply of Finnish imports is very elastic at the prevailing world-market price so that ordinary least squares estimation of import demand is appropriate.

Conventionally, import demand is explained by log-linear models with some activity variable and relative prices of imports and domestic production as the main explanatory variables. This specification is based on the assumption that imported goods and domestic goods are imperfect substitutes. In the framework of a general trade theory, the desired import demand M_k for good k can be expressed in the form $M_k = aD_k (PM_k / PD_k)^{-\delta}$.² Together with supply effects, the specification for the import demand for good k can be written in log-linear form as

$$\log M_k = a' + \alpha \log D_k - \delta \log (PM_k / PD_k) + \beta \log CUT, \quad (1)$$

where D_k is the expected total domestic demand for good k , PM_k and PD_k are the expected import and domestic prices, respectively, and CUT is the capacity utilization rate. It is allowed in (1) that $\alpha \neq 1$. In addition, supply effects are approximated by the variable CUT .³ It is assumed that the variable CUT is a proxy for nonprice rationing [Gregory, 1971].

Alternatively, the use of variable CUT in (1) might be interpreted as representing the effects of cyclical factors. With α , δ and β assumed positive, this implies, in particular, that a rise in domestic capacity utilization increases the propensity to import.

Specification (1) is suitable for imports of final goods where the activity variable is the corresponding total domestic demand. In the case of raw materials, it is assumed that domestic demand for raw materials is proportional to the total demand. A rationalization of this assumption is discussed in Goldstein et al. Thus the model for imports of raw materials is of the form (1), where variable D_k is replaced by GDP . The extent to which the demand for raw materials is focused on imports depends on the ability of domestic production to compete in terms of price and delivery. The former is approximated by a price ratio variable and the latter by the capacity utilization rate variable. Thus it is assumed that, with increasing domestic capacity utilization, the activity elasticity of imports is larger in the short-run than in the long-run, implying that fluctuations of imports can exceed activity fluctuations in the short-run. Import demand for fuels and lubricants is specified in section 3 in the somewhat different framework of a simple energy model.

²) See Armington [1969], Hickman and Lau [1973] and Aurikko [1975]. For a recent survey of both theoretical and empirical issues in foreign trade, see Goldstein and Khan [1985].

³) This effect is assumed in the disaggregated models of imports of raw materials and consumption goods.

3. Empirical Results

3.1. Testing the Functional Form and Disaggregation

Data utilized in the testing and estimation of the import demand models are quarterly and seasonally adjusted and cover the period 1963.1 – 1983.4. They are obtained from the data base of the quarterly model BOF3 constructed by the Research Department of the Bank of Finland.⁴⁾ A detailed description of the data can be found in the Appendix.

In the discussion of the import demand model in section 2 log-linear functional form was assumed. This assumption, although based on theoretical considerations, is not necessarily correct so that the choice between the linear and log-linear functional forms is first tested. The testing is performed both in the framework of an aggregate import demand equation and in disaggregated models.

Estimation results of simple conventional static and dynamic aggregate import demand models are presented in Table 1.

Before discussing the functional form issue, it can be noted that the use of price ratios in the import demand models in Table 1 assumes homogeneity in prices. This property is tested for the models in Table 1. The test statistics for the homogeneity restriction, i.e. that the sum of the coefficients of import prices and domestic prices is equal to zero, distributed as $F_{1,69}$, are .04, .01, .79 and .04, respectively. Since the critical value of $F_{1,69}$ at the 5 per cent level is 3.98, the homogeneity restriction clearly cannot be rejected in any of the models.⁵⁾

From the estimation results in Table 1, there seems to be no apparent and unambiguous way to discriminate between the linear and log-linear forms since both models, in static or dynamic form, perform rather well, although \bar{R}^2 is higher in the latter model. Thus the choice of the appropriate functional form is examined on empirical grounds.

Consequently, the aggregated import demand model is estimated using an extended Box – Cox method. In this procedure a power function is used in which all variables, except the constant term and the dummy variables, are transformed as $X(\lambda) = (X^\lambda - 1) / \lambda$, which reduces to a linear equation for $\lambda = 1$ and to a log-linear equation for $\lambda = 0$. However, since the Durbin – Watson statistics indicate existence, at least in the static models, of positive autocorrelation in the residuals, the method suggested by *Savin* and *White* is used. In this method the first order autocorrelation parameter ρ and the coefficient λ in the power function are estimated simultaneously. Note that it is somewhat restrictive to compare only linear and log-linear models. Recently developed Lagrange multiplier tests could be used to assess the adequacy of the specifications against the more general extended Box – Cox specification [see *Godfrey/Wickens*, 1981; *Tse*, 1984]. Alternative plausible functional forms for the aggregate import model are considered in *Aurikko* [1985].

⁴⁾ See Bank of Finland [1983].

⁵⁾ In the linear model, the use of the price ratio instead of the price difference is based on the approximation $PMG / PD \approx 1 + PMG \cdot PD$ derived from a Taylor series expansion in the base year.

MG	Const.	GDPF	$\frac{PMG}{PD}$	CUT	DS63	DFT69	MG_{-1}	\bar{R}^2	SEE	DW	Dm
	-2892 (1629)	.37 (.02)	-3389 (701)	4289 (1361)	534 (307)	-288 (172)		.946	350	1.13	
	-2899 (1442)	.24 (.04)	-2131 (681)	3781 (1211)	696 (270)	-156 (155)	.37 (.08)	.958	310		.87
logMG	logGDPF	$\log\frac{PMG}{PD}$	logCUT				logMG ₋₁				
	-6.30 (.83)	1.50 (.08)	-.74 (.11)	.70 (.22)	.24 (.05)	-.06 (.03)		.963	.06	1.20	
	-4.02 (.90)	.98 (.14)	-.48 (.12)	.61 (.19)	.30 (.05)	-.05 (.03)	.33 (.07)	.971	.05		.24

Tab. 1: Aggregate Import Demand Models

The standard error estimates of the coefficients are in parentheses, \bar{R}^2 is the coefficient of determination adjusted for degrees of freedom, *SEE* is the standard error estimate of the residual variance, *DW* is the Durbin – Watson statistic and *Dm* the Durbin *m*-statistic, *MG* is the volume of imports of goods. *PMG* the corresponding unit value index, *GDPF* is the volume of *GDP* at factor prices, *PD* is prices in manufacturing industry, *CUT* is the capacity utilization rate, *DS63* is a dummy variable for the dock strike in 1963 and *DFT69* a dummy variable for the change in the method of compiling foreign trade statistics in 1969.

Estimation results and test statistics for the simple aggregate models in Table 1 are

Model	Hypothesis			
	λ	ρ	$\lambda=1$	$\lambda=0$
Static	-.17	.48	21.0	.6
Dynamic	-.15	.11	23.8	1.6

The test statistic is distributed as $\chi_1^2[\chi_1^2(.05) = 3.84]$ so that the hypothesis $\lambda = 0$, implying the log-linear form, clearly cannot be rejected in either case. This result is in line with results obtained elsewhere [see *Khan/Ross*, 1977; *Boylan/Cuddy/O'Muircheartaigh*; *Gandolfo/Petit*].

There do not seem to be any studies in the literature which test the functional form for disaggregated import demand models. Moreover, as the aim of this paper is to estimate disaggregated models, the functional form is also tested in a disaggregated framework. In the following, imports of goods are disaggregated according to user into imports of raw materials (MR), fuels and lubricants (MFL), investment goods (MI) and consumption goods (MC).

The following simple models according to the specification (1) are estimated⁶⁾

⁶⁾ Cf. *Aurikko* [1975, 1984]. The test statistics for the restrictions in the log-linear form of models (2) – (5) implying homogeneity in prices are .16, .11, 2.30 and 10.02, respectively. The homogeneity hypothesis is data admissible in all models except for that of imports of consumption goods, which make up only 15 per cent of total imports of goods. Thus, even in the disaggregated models, the use of price ratios is not entirely unjustified.

$$\begin{aligned} \text{MR} = & -2974 + .16 \text{ GDPF} - 1310 (\text{PMR/PD}) + 4125 \text{ CUT} + 161 \text{ DS63} \\ & (1073) \quad (.01) \quad (380) \quad (864) \quad (90) \\ & - 660 \text{ DFT69} \\ & (105) \end{aligned} \quad (2)$$

$$\bar{R}^2 = .951 \quad \text{SEE} = 217 \quad \text{DW} = 1.13$$

$$\text{MFL} = -618 + .09 \text{ GDPF} - 327 (\text{PMFL/PCP}) + 123 \text{ DS63} + 146 \text{ DFT69} \\ (255) \quad (.01) \quad (94) \quad (120) \quad (75)$$

$$\bar{R}^2 = .725 \quad \text{SEE} = 138 \quad \text{DW} = 1.60 \quad (3)$$

$$\text{MI} = 775 + .15 \text{ ITOT} - 698 (\text{PMI/PD}) + 157 \text{ DS63} \\ (114) \quad (.01) \quad (101) \quad (84) \quad (4)$$

$$\bar{R}^2 = .752 \quad \text{SEE} = 97 \quad \text{DW} = 1.16$$

$$\begin{aligned} \text{MC} = & -1057 + .07 \text{ CTOT} - 661 (\text{PMC/PCP}) + 1459 \text{ CUT} + 107 \text{ DS63} \\ & (328) \quad (.005) \quad (141) \quad (251) \quad (51) \\ & + 174 \text{ DFT69} \\ & (34) \end{aligned} \quad (5)$$

$$\bar{R}^2 = .921 \quad \text{SEE} = 58 \quad \text{DW} = 1.56$$

where

- MR = volume of imports of raw materials (excl. crude oil)
- GDPF = volume of gross domestic product at factor prices
- PMR = import prices of raw materials
- PD = prices of production in manufacturing industry
- CUT = index of capacity utilization in the economy
- DS63 = dummy variable for the dock strike in 1963
- DFT69 = dummy variable for the change in the method of compiling foreign trade statistics in 1969
- MFL = volume of imports of fuels and lubricants (incl. crude oil)
- PMFL = import prices of fuels and lubricants
- PCP = private consumption prices
- MI = volume of imports of investment goods
- ITOT = volume of investment
- PMI = import prices of investment goods
- MC = volume of imports of consumption goods
- CTOT = volume of consumption
- PMC = import prices of consumption goods

Because of apparent autocorrelation of the residuals in the estimated equations (2) – (5), the Savin – White method is utilized with the results shown in Table 2.

Model		λ	ρ	Hypothesis	
				$\lambda=1$	$\lambda=0$
(2)	Static	-.21	.41	37.0	1.9
	Dynamic	-.16	.03	33.6	0.9
(3)	Static	.28	.21	7.2	3.2
	Dynamic	-.05	-.34	11.8	9.2
(4)	Static	.58	.42	3.4	4.4
	Dynamic	.58	.46	1.4	3.4
(5)	Static	.26	.29	11.8	5.6
	Dynamic	.52	.05	10.8	7.9

Tab. 2: Tests of Functional Form for Models (2) – (5)

In Table 2, the dynamic model is obtained by adding the lagged dependent variable to the explanatory variables in models (2) – (5). The tests give strong support for the log-linear specification in the disaggregated models as well, especially the models of *MR* and *MFL*, which account for about 70 per cent of total imports of goods. However, the disaggregated models were used without there being any empirical reasons for doing so. It is therefore necessary to test the aggregated specification against the disaggregated one.

In the framework of the linear system (2) – (5), the obvious way of doing this is to test the equality of the coefficients of the activity and relative price variables. However, as these variables do not sum to the corresponding aggregate variables the test would not be especially relevant. Thus, assessing the desirability of disaggregation is based on the classical proposition by *Orcutt* of possible bias in estimated aggregate elasticities. In aggregate import models, goods with relatively low price elasticities may show large price variations and, by exerting a dominant effect on the estimated aggregate price elasticity, may result in a downward bias in the estimate. The same argument also applies to the activity elasticity.

Thus, if the elasticities in the disaggregated models are equal, then there is no preference for the disaggregated models. These considerations suggest that it is useful and important to test the equality of the activity and price elasticities in the disaggregated import demand models. If the hypothesis of equal elasticities is rejected, this can be interpreted as evidence in favour of the disaggregated specification. The testing is performed by applying to the system of log-linear models (2) – (5) the seemingly unrelated regression equations (SURE) [*Zellner*] estimation method. The SURE estimation method is particularly suitable here because it can be expected that the disturbances in models (2) – (5) are contemporaneously correlated and therefore a potential gain in efficiency of the parameter estimates may be obtained. Moreover, in the SURE estimation framework constraints across different equations are effectively tested.

Test statistics for equality of coefficients of the activity variable, relative prices and the lagged dependent variable for the disaggregated import demand models in log-

linear form are summarized in Table 3. The statistics are given for the static system (2) – (5) and the corresponding dynamic system with the lagged dependent variable added to the explanatory variables and having the coefficients a_6 , b_5 , c_4 and d_6 , respectively. The coefficients a_1 , b_1 , c_1 and d_1 refer to the coefficients of the activity variable and a_2 , b_2 , c_2 and d_2 to the price ratio in models (2) – (5).

	$a_1=b_1=c_1=d_1$	$a_2=b_2=c_2=d_2$	$a_6=b_5=c_4=d_6$	Joint F-test
Static	9.59 (2.64)	6.09 (2.64)		20.53 (2.13)
Dynamic ^a	4.08 (2.64)	2.91 (2.64)		
Dynamic ^b	6.35 (2.64)	3.23 (2.64)		11.14 (2.13)
Dynamic	.28 (2.64)	4.17 (2.64)	2.07 (2.64)	7.44 (1.93)
^a coefficients a_6 , b_5 , c_4 and d_6 unrestricted				
^b coefficients a_6 , b_5 , c_4 and d_6 restricted equal				

Tab. 3: *F*-Test Statistics for the System (2) – (5) (5% Critical Values in Parentheses)

The *F*-test statistics in Table 3 give strong support for the rejection of the hypothesis of equality of the values of the coefficients of the activity variables and relative prices in the static log-linear system (2) – (5). In the corresponding dynamic specification, the different test alternatives point to the same conclusion. According to the above discussion, the results thus favour the disaggregated specification.⁷⁾

3.2. Dynamic Analysis

In searching dynamic specifications of the models of disaggregated import demands, a dynamic testing procedure as suggested by *Mizon* is adopted. In this framework a general unrestricted dynamic model is taken as the maintained hypothesis which is simplified systematically in the light of empirical evidence. The testing thus begins from the most general model and proceeds sequentially to more restricted models. A less satisfying alternative is to start from a simple restricted formulation and assess if it is necessary to adopt a more general dynamic specification arising, for example, from slow adjustment and expectation formation mechanisms.

⁷⁾ Because of significant residual autocorrelation in some of the models of the system (2) – (5), the calculations in Table 3 were also performed by an extended *SURE* estimation method in which autocorrelation of the residuals is allowed [see *Harvey*]. The tests statistics were approximately the same as in Table 3.

The testing procedure is applicable to models of the form

$$\theta(L)'X_t = w_t, \quad (6)$$

where X_t is a vector of the dependent variable and k explanatory variables, w_t is an error term and $\theta(L)$ is a vector of $(k+1)$ polynomials in the lag operator L with orders m_0, m_1, \dots, m_k and with $\theta_0(L)$ operating on the normalized dependent variable. The orders of the polynomials determining the systematic dynamics of the model (6) are taken sufficiently large to ensure that the error term w_t is white noise.⁸⁾

Denoting the autoregressive – distributed lag model as $AD(m_0, m_1, \dots, m_k)$, the maintained hypothesis is $AD(\bar{m}_0, \bar{m}_1, \dots, \bar{m}_k)$, where the lag lengths $\bar{m}_0, \bar{m}_1, \dots, \bar{m}_k$ are specified a priori to capture the dynamics of the data generation process. The model discrimination problem is accomplished in a two-stage testing procedure. In the first stage, sequential tests for reducing the order of dynamics in $AD(\bar{m}_0, \bar{m}_1, \dots, \bar{m}_k)$ are conducted either for all $(k+1)$ variables simultaneously or for each variable separately. In the second stage, conditional on the first, it is tested if there are common factors in the model. The determination of the error dynamics of the model $AD(\bar{m}_0, \bar{m}_1, \dots, \bar{m}_k)$ arrived at in the first stage in the form of the number of common factors extractable from the model consists of testing the sequence of hypotheses

$$\rho_r(L) \alpha_{\bar{m}-r}(L) = \theta_{\bar{m}}(L) \quad (7)$$

for $r = 0, 1, \dots, \bar{m}$, where $\bar{m} = \min(\bar{m}_i)$. Thus the first test is for one common factor. If this test is not rejected a test for two common factors is conducted and so on. The procedure is continued as long as the hypotheses are accepted.

In analysing disaggregated import demand models with the dynamic sequential testing procedure, somewhat more refined explanatory variables are used than in the case of models (2) – (5). In model (4) of imports of investment goods the logarithmic variable RHO describing the degree of credit rationing in the economy is added. In the case of imports of investment goods, it is assumed that a tightening of credit availability (i.e. an increase in RHO) slows down imports not only indirectly through investment demand but also directly.⁹⁾

In model (5) of imports of consumption goods, the activity variable (CTM) is the volume of total consumption ($CTOT$) with private demand for services (CS) consumed domestically and a part of public demand not containing imports ($.82 \cdot CG$) deducted. Thus

$$CTM = CTOT - CS - .82 \cdot CG. \quad (8)$$

⁸⁾ In (6) it is assumed, without loss of generality, that only a purely autoregressive error structure is present [Mizon, 1977].

⁹⁾ In Finland, investment has traditionally been financed largely with domestic bank loans or foreign loans. With relatively low institutionally-set domestic interest rates during the estimation period, excess demand, and thus credit rationing in the domestic credit market, has been an almost permanent phenomenon. Direct spill-over effects from credit rationing to imports of investment goods are captured by the variable RHO [Aurikko, 1982].

The effect of the turnover tax (*TSR*) on import prices of consumption goods is incorporated in the relative price variable, i.e.

$$PMCT / PCP = (100 + TSR \cdot D5863) PMC / PCP, \quad (9)$$

where *D5863* is a dummy variable for the sales tax reform in 1964. In addition, the dummy variable *DMCP* for the extent of cash payments regulations on imports of consumption goods is used. It is assumed that a tightening of access to foreign financing reduces imports of consumption goods.

Imports of fuels and lubricants (including crude oil) are explained in the framework of a simple energy model.¹⁰ It is assumed that the total demand for energy (*CEN*) depends on production (*GDPF*) and the relative price of energy and domestic private demand (*PEN / PCP*)

$$CEN = C(GDPF, PEN / PCP). \quad (10)$$

Assuming full utilization of domestic energy capacity, including nuclear energy (*CEND*), imports of fuels and lubricants are obtained as a residual

$$MFL = CEN - k \cdot CEND, \quad (11)$$

where *k* is a constant conversion factor for different units of measurement of *MFL* and *CEND*.

The price ratio in (10) is constructed as follows

$$(1.1 \cdot PMFL + 100 (.6TEBR + .4TEDR)) (100 + DTO \cdot TSR \cdot D5859) / PCP, \quad (12)$$

where the index of import prices of fuels and lubricants (*PMFL*) is multiplied by 1.1 to correspond to average money prices. To this is added a weighted average of excise tax rates for gasoline (*TEBR*) and diesel oil (*TEDR*). This price variable is multiplied by the sales tax rate (*TSR*)¹¹ applied up to the year 1974 modified by the dummy variable *D5863* for the sales tax reform in 1964. The price ratio (12) is assumed to reflect long-run effects of energy conservation.

Estimation results of the general *AD*-models and restricted models for the disaggregated import demand models are in Tables 4 – 11. In addition to the test statistics described above following statistics are also presented. *AR* (4) and *LM* (4) are test statistics for fourth order autocorrelation distributed as *N* (0,1) [see *Breusch/Pagan*]. In addition several test statistics for the stability of parameter estimates are presented: *H* (20) is the homogeneity test statistic with a moving regression length of 20 quar-

¹⁰) The elasticities based on this approach are more realistic than those based on specification (3). Moreover the model is suitable for long-run simulations as reliable estimates are available for domestic energy capacity.

¹¹) The dummy variable *DTO* is equal to one up to the year 1974 and zero thereafter.

ters distributed as $F_{18,49}$. C_f , C_b , C_f^2 and C_b^2 are Cusum and Cusum Squares test statistics where the recursive residuals are computed forwards (f) and backwards (b), and $Z(8)$ a post-sample test statistic computed from the eight quarterly prediction errors for the years 1982 – 83 distributed asymptotically as χ^2_8 [see Harvey].¹²⁾

lag	0	1	2	3	4	Σ
logMR	-1.00 (.10)	.22 (.09)	.09 (.09)	.04 (.10)	.01 (.09)	-.64
logGDPF	2.56 (.76)	-1.41 (.95)	.29 (.85)	-.44 (.55)	-.33 (.52)	.67
$\log\left(\frac{PMR}{PD}\right)$	-.61 (.18)	.54 (.22)	.04 (.21)	-.54 (.21)	.12 (.20)	-.44
logCUT	-.85 (.80)	2.04 (.87)	-.41 (.76)			.78
A_i	-1.53 (1.02)	.21 (.05)	-.28 (.04)			

$\bar{R}^2 = .982$ SEE = .058 Dm = 1.31 (1963.1 - 1981.4)

Tab. 4: General AD-Model of log MR (Standard Error Estimates of the Coefficients in Parentheses)

lag	0	1	2	3	4	Σ	F-statistic
logMR	-1.00 (.07)	.23 (.07)				-.77	.76 (2.76)
logGDPF	2.38 (.63)	-1.50 (.65)				.88	.61 (2.76)
$\log\left(\frac{PMR}{PD}\right)$	-.56 (.13)	.47 (.12)		-.47 (.12)		-.56	.34 (2.76)
logCUT	-.74 (.60)	2.01 (.61)				1.27	.32 (4.00)
A_i	-2.58 (.77)	.21 (.05)	-.31 (.04)				
Joint F-test							.47 (1.99)

$$\bar{R}^2 = .984 \quad \text{SEE} = .055 \quad \text{Dm} = 1.30 \quad \text{LM}(4) = .87 \quad (1963.1 - 1981.4)$$

$$H(20) = 1.10 \quad C_f = .47 \quad C_b = .91 \quad C_f^2 = .11 \quad C_b^2 = .22 \quad Z(8) = 10.8$$

(1.78) (.95) (.95) (.19) (.19) (15.5)

A_0 = constant

A_1 = DS63

A_2 = DFT69

Tab. 5: Estimates and F-Test Statistics for a Restricted Model of log MR (Standard Error Estimates of the Coefficients and 5% Critical Values in Parentheses)

¹²⁾ Because of the use of dummy variables the conventional Chow test statistics for parameter constancy for the post-sample period could not be computed

lag	0	1	2	3	4	5	6	7	8	Σ
logCEN	-1.00	.31	.16							-.69
		(.13)	(.12)							
logGDPF	2.04	-.87	-.59	-.41	.64					.81
	(.62)	(.80)	(.78)	(.76)	(.61)					
$\log(\frac{PEN}{PCP})$	-.11	.18	-.05	-.34	.32	-.05	-.07	-.04	.03	-.13
	(.14)	(.21)	(.21)	(.20)	(.21)	(.21)	(.21)	(.21)	(.15)	
A_i	-3.23	.11	.13							
	(1.75)	(.07)	(.06)							

$\bar{R}^2 = .795$ SEE = .083 Dm = 1.03 (1963.1 - 1981.4)

Tab. 6: General AD-Model of log CEN (Standard Error Estimates of the Coefficients in Parentheses)

lag	0	1	2	3	4	Σ	F-statistic
logCEN	-1.00	.37				-.63	.45
		(.11)					(4.00)
logGDPF	1.99	-1.16				.83	.55
	(.53)	(.56)					(2.76)
$\log(\frac{PEN}{PCP})$				-.25	.15	-.10	.29
				(.13)	(.12)		(2.17)
A_i	-3.10	.10	.13				
	(1.31)	(.07)	(.05)				
Joint F-test							.35
							(1.95)

$\bar{R}^2 = .812$ SEE = .079 Dm = 1.17 LM(4) = 1.15 (1963.1 - 1981.4)

$H(20) = 1.02$ $C_f = .13$ $C_b = .65$ $C_f^2 = .16$ $C_b^2 = .10$ $Z(8) = 5.2$
 (1.79) (.95) (.95) (.19) (.19) (15.5)

A_0 = constant
 A_1 = DS63
 A_2 = DFT69

Tab. 7: Estimates and F-Test Statistics for a Restricted Model of log CEN (Standard Error Estimates of the Coefficients and 5% Critical Values in Parentheses)

lag	0	1	2	3	4	Σ
logMI	-1.00 (.12)	.26 (.13)	.09 (.13)	.08 (.13)	.04 (.12)	-.53
logITOT	.83 (.31)	-.28 (.32)	.19 (.32)	.18 (.32)	-.21 (.29)	.71
log($\frac{PMI}{PD}$)	-.96 (.35)	.49 (.49)	-.07 (.47)	.20 (.49)	-.05 (.38)	-.39
RHO	-.19 (1.09)	.79 (1.43)	.27 (1.45)	-1.77 (1.42)	.40 (1.03)	-.50
A_i	-2.51 (1.35)	.34 (.09)	.11 (.07)			

$\bar{R}^2 = .768$ SEE = .105 Dm = 1.07 (1963.1 - 1981.4)

Tab. 8: General AD-Model of log MI (Standard Error Estimates of the Coefficients in Parentheses)

lag	0	1	2	3	4	Σ	F-statistic
logMI	-1.00 (.08)	.26 (.08)				-.74	.54 (2.78)
logITOT	.95 (.16)					.95	.38 (2.54)
log($\frac{PMI}{PD}$)	-.55 (.15)					-.55	.57 (2.54)
RHO				-.68 (.35)		-.68	.27 (2.54)
A_i	-3.24 (1.16)	.31 (.08)	.13 (.06)				
Joint F-test							.41 (1.79)

$\bar{R}^2 = .798$ SEE = .098 Dm = .33 LM(4) = 1.65 (1963.1 - 1981.4)

$H(20) = .93$ $C_f = .53$ $C_b = .64$ $C_f^2 = .10$ $C_b^2 = .14$ $Z(8) = 10.2$
 (2.08) (.95) (.95) (.19) (.19) (15.5)

A_0 = constant
 A_1 = DS63
 A_2 = DFT69

Tab. 9: Estimates and F-Test Statistics for a Restricted Model of log MI (Standard Error Estimates of the Coefficients and 5% Critical Values in Parentheses)

lag	0	1	2	3	4	Σ
logMC	-1.00 (.11)	.11 (.09)	.02 (.09)	-.09 (.09)	-.10 (.08)	-1.06
logCTM	1.49 (.45)	.02 (.49)	.32 (.47)	-.27 (.44)	.26 (.39)	1.82
$\log\left(\frac{PMCT}{PCP}\right)$	-.77 (.26)	.14 (.38)	.08 (.38)	-.39 (.38)	-.04 (.30)	-.98
logCUT	.01 (.57)	.84 (.62)	.42 (.52)			1.27
A_i	-4.85 (2.17)	.31 (.06)	.25 (.05)	-.04 (.02)		
$\bar{R}^2 = .944$ SEE = .062 $D_m = 0.81$ (1963.1 - 1981.4)						

Tab. 10: General AD-Model of log MC (Standard Error Estimates of the Coefficients in Parentheses)

lag	0	1	2	3	4	Σ	F-statistic	
logMC	-1.00					1.00	.92 (2.54)	
logCTM	1.82 (.11)					1.82	.31 (2.54)	
$\log\left(\frac{PMCT}{PCP}\right)$	-.78 (.15)					-.78	.68 (2.54)	
logCUT		1.14 (.24)				1.14	.31 (3.17)	
A_i	-6.24 (1.57)	.29 (.05)	.28 (.04)	-.04 (.02)				
Joint F-test								.60 (1.88)
$\bar{R}^2 = .948$ SEE = .059 DW = 1.66 AR(4) = -1.61 (1963.1 - 1981.4)								
$H(20) = 1.45$ $C_f = .80$ $C_b = .89$ $C_f^2 = .18$ $C_b^2 = .20$ $Z(8) = 7.5$ (1.95) (.95) (.95) (.19) (.19) (15.5)								
$A_0 = \text{constant}$ $A_1 = \text{DS63}$ $A_2 = \text{DFT69}$ $A_3 = \text{DMCP}$								

Tab. 11: Estimates and F-Test Statistics for a Restricted Model of log MC (Standard Error Estimates of the Coefficients and 5% Critical Values in Parentheses)

The test statistics for the stability of parameter estimates indicate that the restricted import demand models are very stable. Moreover, inspection of the Quandt's log-likelihood ratio statistics for the models does not indicate any obvious structural changes in the regressions. As the test statistics do not indicate any first order or fourth order autocorrelation, the common factor tests are performed for the models of *MR* and *CEN*.

Testing the validity of common factor restrictions could be based on Wald tests in which case estimation of only the unrestricted model would be needed [see *Harvey*]. However, the constraint between coefficients of more dynamic models would be complicated. Thus we use the *LR*-test where the transformed structure [cf. equation (6)] is estimated by a nonlinear maximum likelihood algorithm. According to the test results in Table 12 the restriction for one common factor is rejected in both cases.

	χ^2
MR	19.6 (7.8)
CEN	6.6 (6.0)

Tab. 12: χ^2 -Test Statistics for the Common Factor Restriction for *MR* and *CEN* (5% Critical Values in Parentheses)

For comparison, the short-run and long-run elasticities from the estimated general and restricted dynamic import demand models are computed in Table 13.¹³⁾

		short-run elasticity		long-run elasticity	
		general model	restricted model	general model	restricted model
MR	activity	.67	.88	1.05	1.14
	price	-.44	-.56	-.69	-.73
MFL ¹⁴⁾	activity	1.29	1.32	1.86	2.08
	price	-.21	-.16	-.30	-.25
MI	activity	.71	.95	1.33	1.28
	price	-.39	-.55	-.73	-.74
MC	activity	1.82	1.82	1.72	1.82
	price	-.98	-.78	-.92	-.78

Tab. 13: Estimated Short-Run and Long-Run Activity and Price Elasticities of the Import Demand Models

¹³⁾ The "short-run" elasticities are calculated simply as a sum of the contemporaneous and lagged activity and relative price coefficients. The long-run elasticities are obtained by dividing the former by one minus the sum of the coefficients of the lagged dependent variable.

¹⁴⁾ Computed by assuming unchanged supply of domestic energy and using the average value of 1.63 for the ratio $CEN / (CEN-35 \cdot CEND)$ in the estimation period.

The elasticities estimates seem to be fairly robust between the general and restricted models. Long-run elasticities for the aggregated imports of goods weighted by the shares in 1980 are 1.39 (activity) and -.62 (price) for the general specification and 1.49 and -.61, respectively, for the restricted specification.¹⁵⁾

Summarizing the results, it can be noted that the estimated dynamic disaggregated import demand models are fairly satisfactory, with stable and plausible parameter estimates. The dynamic properties of the models are illustrated by means of a devaluation simulation in Figures 1 and 2 in which a permanent devaluation of 10 per cent is assumed to be undertaken at the beginning of 1971. It is also assumed, somewhat simplifying, that all import prices rise simultaneously by the same percentage.¹⁶⁾ The multipliers are calculated as percentage deviations of the disturbed solution and control solution.

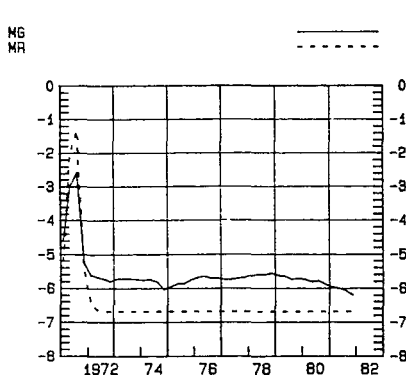


Fig. 1

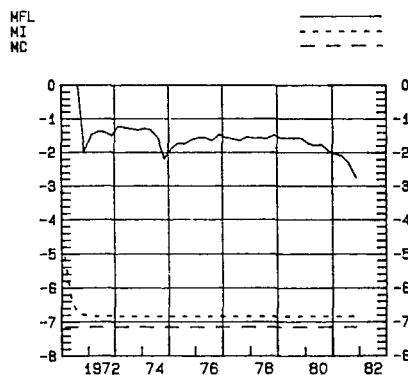


Fig. 2

According to the simulations, import volumes, except fuels and lubricants, respond quite sharply to the devaluation, reflecting the partial price elasticities of the models. The dynamics of the price as well as activity multipliers are not very complicated and suggest that static specifications might be a suitable approximation for dynamic specifications.¹⁷⁾

¹⁵⁾ These are roughly comparable to estimates of 1.54 and -.65 obtained from similar but basically static specifications [see *Aurikko*, 1984]. Because of the presence of the capacity utilization variable *CUT*, the short-run activity elasticity of imports of raw materials is in fact greater than the long-run elasticity. If the capacity utilization rate is changing, the value of the short-run elasticity is somewhat over 2.

¹⁶⁾ For a theoretical and empirical discussion [see *Aurikko*, 1982].

¹⁷⁾ A similar conclusion is presented in *Goldstein and Khan* [1976] and *Gandolfo and Petit* [1983].

4. Concluding Remarks

In this paper dynamic aggregated and disaggregated import demand models have been analysed empirically with quarterly Finnish data. The main results are that a log-linear functional form is preferable to a linear form, that there is empirical evidence favoring the estimation of disaggregated models and that the price homogeneity hypothesis is not rejected, thus allowing the use of price ratios in the estimation of import demand models. According to the estimation results, Finnish import demand is fairly elastic with respect to the ratio of import prices to domestic prices. Moreover, the domestic capacity utilization rate has a positive effect on imports making the short-run activity elasticity of imports greater than the long-run elasticity. In addition, credit rationing directly dampens imports somewhat. Finally, adjustment of import quantities is fairly rapid, suggesting that static specifications might be a suitable approximation for dynamic specifications.

Data Appendix

Variables and Data Sources

CEN	= total energy consumption, seasonally adjusted, in tonnes of oil equivalent
CEND	= domestic energy consumption (incl. nuclear energy), seasonally adjusted, in tonnes of oil equivalent
CG	= volume of public consumption of services, seasonally adjusted, 1975 prices
CS	= volume of private consumption of services, seasonally adjusted, 1975 prices
CTM	= $CTOT - CS - .82 \cdot CG$
CTOT	= volume of total consumption, seasonally adjusted, 1975 prices
CUT	= capacity utilization rate in the Finnish economy, GDPF/GDPOT
DFT69	= dummy variable for change in the method of compiling foreign trade statistics in 1969
DMCP	= dummy variable for the extent of cash payments regulations on imports of consumption goods
DS63	= dummy variable for the dock strike in 1963
DT0	= dummy variable for sales tax on fuels; equal to one up to 1974 and zero thereafter
D5863	= dummy variable for sales tax reform in 1964
GDPF	= volume of gross domestic product in producers' prices, seasonally adjusted, 1975 prices

GDPOT	= volume of potential gross domestic product, 1975 prices
ITOT	= volume of total investment, seasonally adjusted, 1975 prices
MC	= volume of imports of consumption goods, seasonally adjusted, 1975 prices
MFL	= volume of imports of fuels and lubricants (incl. crude oil), seasonally adjusted, 1975 prices
MG	= volume of total imports of goods, seasonally adjusted, 1975 prices (MG = MR + MFL + MI + MC)
MI	= volume of imports of investment goods, seasonally adjusted, 1975 prices
MR	= volume of imports of raw materials (excl. crude oil), seasonally adjusted, 1975 prices
PCP	= private consumption prices, 1975=100
PD	= prices of production in manufacturing industry, 1975=100
PEN	= $(1.1 \cdot PMFL + 100(.6 \cdot TEBR + .4 \cdot TEDR))(100 + DTO \cdot TSR \cdot D5863)$
PMC	= unit value index of imports of consumption goods, 1975=100
PMCT	= $(100 + TSR \cdot D5863)PMC$
PMFL	= unit value index of imports of fuels and lubricants, 1975=100
PMG	= unit value index of total imports of goods, 1975=100
PMI	= unit value index of imports of investment goods, 1975=100
PMR	= unit value index of imports of raw materials, 1975=100
RHO	= relative logarithmic excess demand for credit
TEBR	= excise tax rate for gasoline
TEDR	= excise tax rate for diesel oil
TSR	= sales tax rate, per cent

All the series are from the data base of the quarterly BOF3 model [Bank of Finland]. The data for *CEN* and *CEND* are obtained from the Energy Review of the Ministry of Trade and Industry. The series *MC*, *MFL*, *MG*, *MI*, *MR*, *PMC*, *PMFL*, *PMG*, *PMI* and *PMR* are from the Board of Customs Monthly Bulletin. The data source for *CG*, *CS*, *CTOT*, *GDPF*, *ITOT*, *PCP* and *PD* is the National Income Accounts. The variable *GDPOT* is estimated from a production function and the variable *RHO* is calculated as a relative logarithmic excess demand for credit.

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TESTING THE FUNCTIONAL FORM OF FINNISH AGGREGATE IMPORTS

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Various test procedures are used to examine the functional form of Finnish aggregate imports. None of the alternatives – the log-linear, logit and exponential forms – is found to be a satisfactory specification.

1. Introduction

Economic theory seldom offers any guidance on the choice of the appropriate functional form when specifying and estimating econometric models. This is also the case in international trade theory, where the most commonly used functional forms have assumed the linear or log-linear form. The choice between this restricted class of functional forms in the context of aggregate import demand has been assessed in several studies using the Box–Cox (1964) procedure [see Khan and Ross (1977), Boylan, Cuddy and O’Muircheartaigh (1980) and Gandolfo and Petit (1983)]. Lately, the Lagrange multiplier approach has been developed to test the linear and log-linear forms against the more general Box–Cox specification [Godfrey and Wickens (1981), and Ghosh, Gilbert and Hughes Hallet (1983)].

However, in addition to the linear, log-linear and the general Box–Cox functional forms, other plausible and interesting functional forms could be considered. This is important because the choice of the functional form has implications for forecasts and policy appraisal. The aim of this paper is to examine the functional form issue in the case of Finnish aggregate import demand using some alternative forms as discussed in section 2. In section 3, discrimination between the models is performed using nested and non-nested test procedures.

2. Theoretical considerations

In the conventional specification of an aggregate import demand model, the quantity of imports demanded (M^d) is related to the relative price of imports and domestic production (P) and to real domestic income (Q). Assuming non-price rationing [Gregory (1971)] or business cycle effects approximated by the capacity utilization rate (C) [see Aurikko (1984)], the linear form of the equation is

$$M_t^d = a_0 + a_1 P_t + a_2 Q_t + a_3 C_t + a_4 D_t + e_t, \quad (1)$$

where e_t is a random error term. In (1) it is assumed that $a_1 < 0$, $a_2, a_3 > 0$, implying, in particular,

that a rise in domestic capacity utilization increases the propensity to import. The dummy variable, D , captures the effects of the change in the method of compiling foreign trade statistics in 1969. In the case of a small country, import prices can be taken as exogenous and import supply as infinitely elastic, so that ordinary least squares estimation is appropriate.

Eq. (1) is an equilibrium relation implying instantaneous adjustment, which, in the presence of uncertainty and various frictions, might be too restrictive. It is thus assumed that imports are adjusted according to a conventional partial adjustment mechanism,

$$M_t - M_{t-1} = \alpha(M_t^d - M_{t-1}), \quad 0 \leq \alpha \leq 1, \quad (2)$$

where α is the adjustment coefficient. Inserting (1) into (2) a 'dynamic' linear import equation is obtained,

$$M_t = \alpha a_0 + \alpha a_1 P_t + \alpha a_2 Q_t + \alpha a_3 C_t + \alpha a_4 D_t + (1 - \alpha)M_{t-1} + \alpha e_t. \quad (3)$$

The log-linear equation corresponding to eq. (3) is

$$\log M_t = \alpha' b_0 + \alpha' b_1 \log P_t + \alpha' b_2 \log Q_t + \alpha' b_3 \log C_t + \alpha' b_4 D_t + (1 - \alpha') \log M_{t-1} + \alpha' e_t, \quad (4)$$

where α' is the adjustment coefficient and parameters b_0, \dots, b_4 correspond to parameters a_0, \dots, a_4 in (1).

The logit model can be considered as an alternative specification for aggregate imports. It is written as

$$\log \left[\frac{M_t^d}{(Q_t - M_t^d)} \right] = c_0 + c_1 \log P_t + c_2 \log C_t + c_3 D_t + u_t, \quad (5)$$

where u_t is an error term and $c_1 < 0$, $c_2 > 0$. The logit form is especially suitable in long-run forecasts and policy appraisal since the constraint $0 \leq M_t/Q_t \leq 1$ is always met. Assuming the partial adjustment mechanism, the dynamic logit specification is

$$\begin{aligned} \log \left[\frac{M_t}{(Q_t - M_t)} \right] &= \beta c_0 + \beta c_1 \log P_t + \beta c_2 \log C_t + \beta c_3 D_t \\ &+ (1 - \beta) \log \left[\frac{M_{t-1}}{(Q_{t-1} - M_{t-1})} \right] + \beta u_t, \end{aligned} \quad (6)$$

where β is the adjustment coefficient.

The last specification to be examined is the exponential form expressed as

$$M_t^d = \left[\exp(d_0 P_t^{d_1} C_t^{d_2} \exp(c_3 D_t)) \right] Q_t \exp(v_t). \quad (7)$$

The corresponding dynamic formulation, with γ denoting the adjustment coefficient, is

$$\log M_t = \gamma \left[(d_0 P_t^{d_1} C_t^{d_2} \exp(c_3 D_t)) + \log Q_t \right] + (1 - \gamma) \log M_{t-1} + \gamma v_t, \quad (8)$$

where v_t is an error term. With $M/Q < 1$, this implies that $d_0 < 0$, $d_1 > 0$, $d_2 < 0$.

In order to assess the properties of models (3), (4), (6) and (8), it is useful to examine their (relative) price and activity elasticities¹ as shown in table 1.

¹ The elasticities are calculated assuming C unchanged.

Table 1
Price and activity elasticities of models (3), (4), (6) and (8).

Model	Price elasticity		Activity elasticity	
	Short-run ^a	Long-run ^b	Short-run ^a	Long-run ^b
(3)	$(\alpha a_1 P)/M$	$(a_1 P)/M$	$(\alpha a_2 Q)/M$	$(a_2 Q)/M$
(4)	$\alpha' b_1$	b_1	$\alpha' b_2$	b_2
(6)	$[\beta c_1(Q - M)]/Q$	$[c_1(Q - M)]/Q$	1	1
(8)	$\gamma d_0 d_1 C^{d_2} P^{d_1}$	$d_0 d_1 C^{d_2} P^{d_1}$	γ	1

^a Calculated setting M_{t-1} constant.

^b Calculated setting $M_t = M_{t-1}$.

In the linear model (3), the price and activity elasticities depend on movements in the variables P , Q and M . The price elasticity decreases over time while the activity elasticity tends towards unity. In the log-linear model (6), the elasticities are constants, which might also be theoretically too restrictive. In the logit formulation, both short- and long-run activity elasticities are equal to one and the price elasticities vary inversely with the proportion of imports in production. Finally, in the exponential model (8), the activity elasticities are constants while the price elasticities decrease in absolute value as capacity utilization rises. Moreover, the price elasticity is larger the greater the change in the relative prices. As the functional forms for import demand have different but plausible properties and there is no precise theoretical guidance for choosing among them, the issue is essentially an empirical one.

3. Empirical analysis

The data utilized in estimating and testing the functional form of Finnish aggregate imports are quarterly and seasonally adjusted and cover the period 1964.I–1983.IV. They are obtained from the data base of the BOF3 quarterly model constructed by the Research Department of the Bank of Finland.²

First, the linear and log-linear functional forms are considered. According to the estimation results of (3) (not reported here) and (4) (see table 2), both models perform rather well and are stable with no first order or fourth order autocorrelation.³ Thus, we now consider the choice of the appropriate functional form by using the Box–Cox method. In this procedure a power function is estimated in which all variables, except the constant and the dummy variable, are transformed as $X(\lambda) = (X^\lambda - 1)/\lambda$, reducing to a linear form for $\lambda = 1$ and to a log-linear form for $\lambda = 0$. The test statistics for parameter λ in the power function for the hypotheses $\lambda = 1$ and $\lambda = 0$ are 13.87 and 1.42, respectively. Since the test statistic is distributed as χ_1^2 with a 5 percent critical value of 3.84, the hypothesis $\lambda = 0$, implying the log-linear form, cannot be rejected.

² See Bank of Finland (1983). Variable M is the volume of total imports of goods, Q is the volume of gross domestic product in producers' prices, both in 1975 prices. Variable $P = PM/PD$, where PM is the unit value index of M and PD stands for output prices in manufacturing industry, with 1975 = 100 for both. The capacity utilization rate is calculated as $C = Q/QP$, where QP is the volume of potential gross domestic product estimated from a production function. The dummy variable D stands for the change in the method of compiling foreign trade statistics in 1969.

³ The use of price ratios in (3) and (4) assumes homogeneity in prices. The test statistic for the homogeneity restriction (the sum of the coefficients of import prices and domestic prices is equal to zero), distributed as $F(1, 73)$, is 1.57 for (3) and 0.01 for (4). Since the 5 percent critical value of $F(1, 73)$ is 3.98, the homogeneity restriction cannot be rejected. In the linear model (3), the use of the price ratio rather than the price difference is based on the approximation $PM/PD \approx 1 + PM - PD$.

Only linear and log-linear models are compared above. A more general approach is to test the adequacy of the linear and log-linear forms against the general Box-Cox specification. The test is performed by using the procedure due to Andrews (1971) and developed by Godfrey and Wickens (1981). The t -test statistics for the hypotheses $\lambda = 1$ and $\lambda = 0$ are 1.33 and 0.78, respectively, implying that neither of the hypotheses can be rejected.⁴ Since the procedure provides no guidance when choosing between the linear and log-linear forms, this suggests the need to test other functional forms as well, and in the present context, namely models (6) and (8), together with specification (4), for which some empirical support was found.

According to the maximum likelihood estimation results in table 2, all models are rather satisfactory, although residual variance is relatively high in the logit model (6). There seems to be no first-order autocorrelation according to the h -statistics. However, in the case of the non-linear models, the distribution of the h -statistic is unknown. Utilizing the computed likelihood values in table 2, the discrimination between the models is examined first by the Akaike Information Criterion (AIC) [Akaike (1978)].⁵ The values of the AIC for models (4), (6) and (8) are -242.6 , -192.8 and -241.4 , respectively, indicating that the log-linear specification might marginally be selected.

Since the AIC rule is not especially powerful in discriminating between the models, next some non-nested test procedures are utilized. First, the encompassing principle advocated by Mizon and Richard (1983) is used to test models (4) and (6). However, because of multicollinearity of the variables $Q - M$ and Q in the nested version of the models, the approximation $\log[M/(Q - M)] \approx \log(M/Q)$ was adopted. F -test statistics for the non-overlapping variables, implying the restrictions leading to (4) or (6), were 1.12 and 6.43, respectively, distributed as $F(1, 73)$ and $F(2, 73)$, which suggests that the log-linear form cannot be rejected.

The exponential model (8) is highly non-linear and cannot be nested with the other models. Thus, the non-nested procedure suggested by Pesaran and Deaton (1978) for testing non-linear equations is

Table 2
Maximum likelihood estimates for models (4), (6) and (8).^a

Model	Coefficients					α'	$\hat{\delta}^2$	h	L
	b_0	b_1	b_2	b_3	b_4				
(4)	-3.54 (0.99)	-0.52 (0.17)	1.23 (0.10)	0.86 (0.31)	-0.11 (0.04)	0.62 (0.07)	0.0024	-1.30	127.3
	c_0	c_1	c_2	c_3		β	$\hat{\delta}^2$	h	L
(6)	-0.92 (0.08)	-0.38 (0.11)	0.94 (0.24)	-0.23 (0.03)		0.52 (0.08)	0.0046	-1.13	101.4
	d_0	d_1	d_2	d_3		γ	$\hat{\delta}^2$	h	L
(8)	-1.24 (0.02)	0.21 (0.10)	-0.60 (0.26)	0.13 (0.02)		0.58 (0.07)	0.0025	-1.68	125.7

^a Asymptotic standard error estimates of the coefficients are in parentheses, $\hat{\delta}^2$ is the estimate of the residual variance, L is the logarithm of the value of the maximized likelihood function and h is the Durbin h -test statistic for first-order autocorrelation.

⁴ Because of the lagged dependent variable, the test is only asymptotically valid.

⁵ The AIC rule selects the model for which $AIC = -2L + 2n$ is the minimum, where n is the number of parameters estimated. See Judge et al. (1980) on the relative power of this test procedure.

Table 3
N-statistics and $\hat{\delta}^2$ for hypotheses H_1 , H_2 and H_3 .

Maintained hypothesis	Alternative hypothesis		
	H_1	H_2	H_3
H_1	0.0024	3.21	-1.31
H_2	-3.12	0.0046	-4.17
H_3	-4.15	3.86	0.0025

used. Denoting the competing models (4), (6) and (8) as H_1 , H_2 and H_3 , respectively, the test is based on a modified likelihood ratio, taking H_1 , H_2 and H_3 in turn as the maintained hypothesis. The *N*-statistics calculated for all pairs of hypotheses distributed asymptotically as $N(0, 1)$, as well as the $\hat{\delta}^2$ values in the diagonal, are given in table 3.

Comparing first hypotheses H_1 and H_3 , the *N*-statistics in table 3 indicate that the log-linear form cannot be rejected. However, in spite of the relatively poor fit of H_2 , it provides evidence to reject both H_1 and H_3 . Concerning hypotheses H_2 and H_3 , it is also seen that each rejects the other. Thus, the log-linear form does not seem to be an altogether satisfactory model.⁶ In H_2 and H_3 there is one less parameter to be estimated than in H_1 , which might favour H_1 . Estimating the exponential form, without constraining the activity elasticity equal to one, gives $\hat{\delta}^2 = 0.0024$ and $L = 127.4$. The *N*-statistics for this case with first H_1 as the maintained hypothesis and reversing the procedure are -5.15 and -3.84, respectively, suggesting that both formulations are rejected.

In summary, it can be noted that the log-linear specification for Finnish aggregate imports is not without serious contenders. The evidence provided by the logit and exponential alternatives cast some doubt on the empirical validity of the popular log-linear form. From the point of view of policy appraisals the specifications give quite different results concerning, for example, the effects of exchange rate policies, since the long-run price elasticities for H_1 , H_2 and H_3 calculated using sample averages are -0.52, -0.28 and -0.26, respectively.

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⁶ The results should be interpreted with caution, being valid only asymptotically. However, no small sample corrections were made on the *N*-statistics.

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A Dynamic Analysis of Finnish Export Prices

In this paper the degree of dependency of Finnish export prices on the exchange rate, competitors' prices and domestic costs is investigated. A distinction is made between heterogeneous and homogeneous output. A dynamic model selection procedure, especially in the form of an error correction mechanism, is utilized in both aggregated and disaggregated frameworks. The conclusion is that changes in exchange rates and in competitors' prices are transmitted to Finnish export prices fairly quickly and virtually in full, while the effects of domestic costs are relatively modest.

I. INTRODUCTION

It is often assumed that the tradeables goods of small open economies are relatively homogeneous with prices being determined primarily by world market prices. Empirical evidence for this proposition in the case of Finland is given in Aurikko (1980, 1982), Korkman (1980), Vartia and Salmi (1981) and Sukselainen (1984). For extensive studies with Swedish and UK data, see Calmfors and Herin (1979) and Ormerod (1980). However, even if the law of one price is, as a first approximation, a suitable assumption for import prices in the case of export goods the degree of substitutability and market power of the producers might be greater.

Export prices of relatively homogeneous, easily substitutable products are likely to move closely in line with world market or competitors' prices, although some at least temporary divergence in prices, can occur as a result of domestic cost developments. Export prices of relatively heterogeneous products, which are more incompletely substitutable, might reflect stronger cost pressures. These considerations also suggest that it is necessary to study export price formation in a disaggregated framework.

The aim of this paper is to test systematically the degree of dependency of Finnish export prices on the exchange rate, competitors' prices and domestic cost

developments. In the testing of the models a dynamic model selection procedure, especially in the form of the so-called error correction mechanism, is utilized. First, the issue is investigated in an aggregated framework and then disaggregated models are examined. In the next section some theoretical considerations of export price determination are discussed. Section III presents the estimation and test results. The final section concludes.

II. THEORETICAL CONSIDERATIONS

Recently, it has been recognised that changing prices is costly, notably in foreign markets, both because of the administrative costs involved and the implicit costs arising from the possible reaction of customers, particularly in the case of large price changes.¹ Other reasons for the failure of prices to adjust to clear markets continuously may be connected with the monopolistic power of exporters and various frictions such as information costs, imperfect information and rationing.

As standard market clearing models would probably require substantial price changes in response to often volatile supply or demand changes in domestic or international markets, it is assumed [see Minford (1978)] that market clearing takes place through the adjustment of quantities rather than through the relatively more costly adjustment of prices. Consequently, export prices are kept comparatively stable in the long-run equilibrium. Alternatively, introducing uncertainty concerning demand or supply conditions allows for the possibility of either price- or quantity-setting behavior modes or both [Leland (1972)]. In the framework of a stochastic demand curve for a monopolist, the conditions for the optimal behavior are dependent on the shape of the marginal cost function [Lim (1980)].²

In the following, assuming optimal price-setting behavior, some dynamic micro-economic considerations resulting in partial price adjustment are discussed. With non-negligible costs of changing prices and monopolistic competition, the problem is to maximize the expected present discounted value of profits less the costs of price adjustment. The solution to this standard optimal control problem is a linear difference equation which gives optimal price as a function of the price in the

¹ See Barro (1972) for one of the first theoretical treatments on this subject. For a recent intertemporal study, see Rotemberg (1982). Empirical support for the proposition that in the short-run quantities tend to be more flexible than prices in the adjustment behavior of firms is given by Kawasaki, McMillan and Zimmerman (1982).

² Lim argues that quantity setting behavior is preferable to price setting behavior for risk neutral firms with increasing marginal costs (strictly convex cost curve) known with certainty. However, this result is entirely due to the asymmetric and incomplete treatment of costs. Taking also costs of price adjustment into account symmetrically with costs of quantity adjustment, it is easily seen that the proposition is valid only if the cost curve is more convex than the price adjustment cost curve, i.e. if it is costlier to change quantities than prices. As argued above the converse might be a more realistic assumption.

previous period and expectations of future optimal prices [Rotemberg (1982)]. If these are assumed to follow a random walk the solution reduces to the partial adjustment equation implying that increasing the costs of price adjustment tends to make price movements more sluggish.

Above it was argued that firms are price setters with partial price adjustment with respect to equilibrium prices (PX^*). The specification of equilibrium export prices is based on the approach by Bruno (1979), according to which a reduced-form domestic currency equilibrium price equation for a profit maximizing monopolistic firm is of the form

$$(1) \quad PX^* = F(PFOR, CD, CUT),$$

where $PFOR$ is competitors' prices and CD domestic costs, all measured in domestic currency, and CUT an index of domestic capacity utilization. Equation (1) is derived subject to diminishing returns to scale, with the capital stock fixed in the period under consideration, perfect competition in the markets for the inputs and less than perfect competition in the market for output implying monopolistic competition. Since variable CUT in (1) is the ratio of actual output to potential output, it approximates the positive scale variable effect from the demand function and the negative productivity effect from the production function. Equation (1) is linearly homogeneous with respect to $PFOR$ and CD , and for small open countries competitors' prices tend to dominate export price formation.³

In this study, a distinction is made in the terminology of e.g. Calmfors and Herin (1979) between heterogeneous and homogeneous output. In the former category, which consists of imperfectly substitutable products and has considerable monopoly power in the markets, pricing is significantly dependent on domestic costs. In the latter class price formation is strongly dominated by competitor's or world market prices.

In the case of relatively heterogeneous output, equation (1) is specified in the log-linear form as

$$(2) \quad PX^* = \alpha_1 PFOR^{\alpha_2} ULCD^{\alpha_3} CDO^{\alpha_4} CUT^{\alpha_5},$$

where $ULCD$ and CDO are domestic unit labor costs and other domestic costs measured in domestic currency. This division of total costs is adopted to capture the different weights of the cost elements in the price formation. In (2) according to the above discussion $\alpha_2 + \alpha_3 + \alpha_4 = 1$. The specification of long-run equilibrium export prices in the case of relatively homogeneous output is nested in (2) with $\alpha_3 = \alpha_4 = 0$, implying that export prices closely follow world market prices. The specification also implies that in the long-run exchange rate changes are fully passed through to the export prices expressed in domestic currency.

³ Empirical support is provided in Amano (1974).

III. EMPIRICAL RESULTS

III.1. Data and Estimation Methodology

The data utilized in the estimation of the models are quarterly and seasonally adjusted, cover the period 1962.1—1983.4, and obtained from the data base of the quarterly model constructed by the Research Department of the Bank of Finland.⁴ A description of the data can be found in the Appendix.

In the estimation of an aggregate export price model, an error correction mechanism (ECM) [see Salmon (1982)] taking into account the dynamic relationships and steady state properties suggested by economic theory is first tested. Model discrimination is then accomplished by utilizing the dynamic model selection and hypotheses testing procedures suggested by Mizon (1977). Finally, disaggregated export price models are estimated and tested in the ECM and a more general dynamic framework making use of the distinction between homogeneous and heterogeneous categories of goods.

III.2. Aggregated Export Prices

It was assumed above that the long-run export price equation is linearly homogeneous with respect to competitors' prices and domestic costs. Together with the dynamics reflecting slow adjustment of prices and expectations formation mechanisms, this suggests the use of a simple ECM assumed to exist only with respect to competitors' prices and labor costs. An aggregated dynamic export price model is first written in the framework of specification (2) as

$$(3) \quad \log PXG = a_0 + \sum_1^4 a_i \log PXG_{-i} + \sum_0^1 b_j \log PFOR_{-j} + \sum_0^1 c_k \log CDFO_{-k} \\ + \sum_0^1 d_h \log PMID_{-h} + \sum_0^1 e_l \log FXSUS_{-l} + \sum_0^4 f_m \log CUT_{-m}$$

where relatively short lags are assumed and variable CDFO represents relative unit labor costs and PMID is assumed to approximate relative other costs.⁵ Exchange rate FXSUS is added in (3) to account for the temporary effect arising from changes in exchange rates to export prices expressed in domestic currency but contracted originally in terms of foreign currency. The variables are defined as

CDFO = ((YW4 + SOCC4)/(GDP4 · FXSUS))/ULCUS

YW4 = wages and salaries in manufacturing industry

SOCC4 = employer's social security contributions in manufacturing industry

⁴ See Bank of Finland (1983).

⁵ Use of the relative cost variable in (3) to reduce multicollinearity is based on the homogeneity properties of (1) with the coefficients of PFOR and CD summing to one in logarithmic form. Thus (1) can be expressed as $(1') \log PX^* = a' + \log PFOR + b' (\log CD - \log PFOR) + c' \log CUT$, where PFOR in parentheses is approximated by the foreign cost variable.

GDP4 = volume of production in manufacturing industry

ULCUS = unit labor cost in USA

PMID = PMIUS/PMUS

PMIUS = import prices of investment goods in USD

PMUS = import prices of USA in USD.

Equation (3) is re-arranged as

$$(4) \quad \Delta \log \text{PXG} = a_0 + \sum_2^4 a_i \log \text{PXG}_{-i} + b_0 \Delta \log \text{PFOR} + c_0 \Delta \log \text{CDFO} \\ + (a_1 - 1) \log \text{PXG}_{-1} + (b_0 + b_1) \log \text{PFOR}_{-1} \\ + (c_0 + c_1) \log \text{CDFO}_{-1} + \sum d_h \log \text{PMID}_{-h} \\ + \sum e_i \log \text{FXSUS}_{-i} + \sum f_m \log \text{CUT}_{-m}.$$

The ECM model is obtained with the following restrictions

$$(5) \quad \begin{aligned} & \text{a) } a_2 + a_3 + a_4 = 0 \\ & \quad \quad \quad \Sigma d_h = 0, \Sigma e_i = 0, \Sigma f_m = 0 \text{ and} \\ & \text{b) } (a_1 - 1) + (b_0 + b_1) + (c_0 + c_1) = 0 \text{ or} \\ & \text{c) } (a_1 - 1) + (b_0 + b_1) = (c_0 + c_1) = 0 \text{ or} \\ & \text{d) } (a_1 - 1) + (c_0 + c_1) = (b_0 + b_1) = 0. \end{aligned}$$

With restrictions a) and b) (hypothesis H_0) the ECM exists with respect to both competitors' prices and labor costs. Testing the ECM model for aggregated export prices, the hypotheses a) and c) (H_1) and a) and d) (H_2) are nested in H_0 . Thus a sequential testing procedure is adopted where the tests are conducted by means of joint F-tests.⁶

Table 1. F-test statistics for the hypotheses in (5) (5 % critical values in parentheses)

H_0	H_1	H_2
3.83 (2.37)	3.69 (2.25)	4.78 (2.25)

The test statistics in Table 1 indicate that all the ECM hypotheses are clearly rejected at the 5 % level.⁷

In searching dynamic specifications of the model for aggregated export prices a dynamic testing procedure suggested by Mizon (1977) is adopted. In this framework a general unrestricted dynamic model is taken as the maintained hypothesis and is simplified systematically in the light of empirical evidence. The approach

⁶ Throughout it is assumed that $a_1 \neq 1$.

⁷ Of course, if H_0 is rejected also the more restricted H_1 and H_2 are rejected. However, adding variables PFOR and CDFO lagged for two and three quarters and computing the F-statistics as in Table 1, indicates that H_0 case is not rejected at the 1 % level, implying also that competitors' prices have considerable weight in the explanation of aggregate export prices.

differs from that of distributed lags or time series analysis in that it determines the maximal lags and draws a distinction between systematic and error dynamics in the data generation process of the model. The underlying idea is to begin from the most general model and to test sequentially more restricted models rather than to start from a simple restricted formulation and try to assess if it is necessary to adopt a more general dynamic specification.

The testing procedure is applicable to autoregressive-distributed lag models. The model discrimination is accomplished in a two-stage procedure based on a simplification search. In the first stage, sequential tests for reducing the order of dynamics in the maintained autoregressive-distributed lag model are conducted either for all the variables simultaneously or for each variable separately. In the second stage, conditional on the first, it is tested whether there are common factors in the model arrived at in the first stage.

In view of a priori considerations, empirical evidence of strong dependency of Finnish export prices on world market or competitors' prices and the relatively large number of regressors, the pre-specified lags for aggregated export prices were set relatively short. The estimation results of the general model (maintained hypothesis) are as shown in Table 2.⁸

The signs of the estimates of the general autoregressive-distributed model in Table 2 are, with the the exception of the coefficient for other relative costs

Table 2. General AD-model of logPXG (standard error estimates of the coefficients in parentheses)

variable	lag				Σ
	0	1	2	3	
logPXG	-1.00	.67 (.12)	.01 (.12)		-.32
logPFOR	.79 (.10)	-.38 (.19)	.07 (.20)	-.20 (.10)	.28
logCDFO	.04 (.08)	.10 (.11)	-.01 (.07)		.13
logPMID	.13 (.06)	-.13 (.08)	-.13 (.07)		-.13
logFXSUS	.07 (.11)	-.12 (.17)	.13 (.19)	.05 (.12)	.13
logCUT	-.17 (.19)	.32 (.17)			.15
Constant	.76 (.35)				

$\bar{R}^2 = .999$ SEE = .019 Dm = .05 (1963.1—1981.4)

⁸ In Table 2, Σ denotes the sum of the lagged coefficients, \bar{R}^2 the adjusted coefficient of determination, SEE is the standard error estimate of the residual variance and Dm is the Durbin m-statistics. The estimation period is shown in brackets.

(PMID), as expected and suggest several simplifying restrictions. The validity of the restrictions are tested in Table 3 for each explanatory variable separately and jointly for all the variables. In Table 3, $H(20)$ is the homogeneity test statistics for stability of parameter estimates with the moving regression length of 20 quarters distributed as $F_{20,46}$, C_f , C_b , C_f^2 and C_b^2 are Cusum and Cusum Squares test statistics for parameter stability where the recursive residual are computed forwards (f) and backwards (b) and $Z(8)$ is a post-sample test statistic computed from the eight quarterly prediction errors for the years 1982—1983 distributed asymptotically as χ_8^2 [see Harvey (1981)].

Table 3. Estimates and test statistics for a restricted model of logPXG (standard error estimates of the coefficients and 5 % critical values in parentheses)

variable	lag				Σ	F-statistics
	0	1	2	3		
logPXG	-1.00	.74 (.07)			-.26	.00 (4.02)
logPFOR	.77 (.08)	-.38 (.11)		-.17 (.04)	.22	.12 (4.02)
logCDFO		.13 (.04)			.13	.16 (3.17)
logPMID	.15 (.05)	-.15 (.05)	-.11 (.03)		-.11	.01 (4.02)
logFXSUS	.09 (.04)	-.19 (.06)	.19 (.06)		.09	.25 (3.17)
logCUT		.24 (.08)			.24	.76 (4.02)
Constant	.66 (.27)					
Joint F-test						.34 (2.11)

$\bar{R}_2 = .999$ SEE = .018 DW = 2.03 Dm = .30 (1963.1—1981.4)

$H(20) = 1.16$ $C_f = .53$ $C_b = .66$ $C_f^2 = .13$ $C_b^2 = .07$ $Z(8) = 14.3$
 (1.80) (.95) (.95) (.19) (.19) (15.5)

The test statistics indicate that the model in Table 3 is very stable. Since the Dm statistic does not indicate any first order autocorrelation, the common factor test can be performed. Testing the validity of common factor restrictions could be based on Wald tests, so that estimation of only the unrestricted model would be necessary [see Harvey (1981)]. However, the constraints between coefficients of more dynamic models would be complicated. Thus the LR-test is used, with

the transformed structure being estimated by a nonlinear maximum likelihood algorithm.

The logarithm of the value of the maximized likelihood function of the unrestricted model of PXG is $L_U = 205.0$ and the corresponding value for the common factor restricted model is $L_C = 164.5$. Thus the value of the LR-test statistic $2(L_U - L_C) = 81.0$, distributed approximately as $\chi^2_3[\chi^2_3(.05) = 11.1]$, suggests that the common factor restriction is rejected.

Since the ECM fails to exist strictly in aggregate export price data according to the test statistics in Table 1 above, it is next tested whether the mechanism is operative in disaggregated models.

III.3. Disaggregated Export Prices

In the following export prices of goods are disaggregated into export prices of wood industry products (PXW), paper industry products (PXPA), metal industry products (PXME) and other industrial products (PXO). Based on various test, not reported here, it is assumed that price setting is homogeneous in the first two export categories and heterogeneous in the last two. The specifications corresponding to these cases are

$$(6) \quad PXWUS = a_1 PXWSWUS^{a_2} P3W^{a_3} CUT^{a_4}$$

$$(7) \quad PXPAUS = b_1 PXPSWUS^{b_2} P3P^{b_3} CUT^{b_4}$$

$$(8) \quad PXME = c_1 PMED^{c_2} CDFO^{c_3} PMID^{c_4} FXSUS^{c_5} CUT^{c_6}$$

$$(9) \quad PXO = d_1 PMED^{d_2} CDFO^{d_3} PMID^{d_4} FXSUS^{d_5} CUT^{d_6}$$

where the new variables are

PXWUS	=	prices of production of wood industry products in USD
PXWSWUS	=	Swedish export prices of wood industry products in USD
P3W	=	$P3US/PXWSWUS$
P3US	=	prices of production in forestry in USD
PXPAUS	=	export price of paper industry products in USD
PXPSWUS	=	Swedish export prices of newsprint in USD
P3P	=	$P3US/PXPSWUS$
PXME	=	export prices of metal industry products
PMED	=	import prices of USA in FIM
PXO	=	export prices of other industrial goods.

In models (6) and (7) variables PXWSWUS and PXPSWUS are assumed to represent competitors' prices and variables P3W and P3P other relative costs. Labor costs are not included in models (6) and (7) due to the relative importance of materials costs in the determination of export prices of these particular homogeneous products based on wood the prices of which are approximated by

prices of production in forestry. It assumed that changes in exchange rates are fully passed through to the export prices in terms of domestic currency so that the dependent variable is expressed in terms of foreign currency. Models (8) and (9) correspond to the specification (2), where variable PMED is a proxy for competitors' prices.

Next, rather than imposing the restrictions untested as is often done in econometric work, it is tested whether the ECM is in fact a suitable specification. The testing proceeds by applying F-tests on the restrictions implying the ECM from a general dynamic model.

The general dynamic model in the homogeneous case (PXW and PXPA) is written as

$$(10) \quad \log PXWUS = a_0' + \sum_{i=1}^4 a_i' \log PXWUS_{-i} + \sum_{j=0}^1 b_j' \log PXWSWUS_{-j} \\ + \sum_{k=0}^4 c_k' \log P3W_{-k} + \sum_{h=0}^4 d_h' \log CUT_{-h},$$

where four-quarter lags are assumed except for the variable PXWSWUS where only two-period lags are assumed. In the corresponding equation for PXPA, variable PXWSWUS is replaced by PXPSWUS and P3W by P3P.

Re-arranging model (10) as in (4) it is seen that the restrictions implying the ECM are

$$(11) \quad \begin{aligned} & a) \quad a_2' + a_3' + a_4' = 0 \\ & b) \quad \sum c_k' = 0 \\ & c) \quad \sum d_h' = 0 \\ & d) \quad (a_1' - 1) + (b_0' + b_1') = 0. \end{aligned}$$

The general dynamic model for the heterogeneous case (PXME and PXO) is written analogously to (3) as

$$(12) \quad \log PXME = a_0'' + \sum_{i=1}^4 a_i'' \log PXME_{-i} + \sum_{j=0}^1 b_j'' \log PMED_{-j} \\ + \sum_{k=0}^1 c_k'' \log CDFO_{-k} + \sum_{h=0}^1 d_h'' \log PMID_{-h} \\ + \sum_{l=0}^1 e_l'' \log FXSUS_{-l} + \sum_{m=0}^4 f_m'' \log CUT_{-m},$$

where again relatively short lags are assumed and the ECM model is obtained with restrictions as in (5).

Joint F-test for the restrictions in (11) implying the error correction mechanism in the case of PXW yielded the test statistic $F_{4,59} = 2.61$, with 5 and 1 % critical values of 2.53 and 3.65, respectively. For PXPA, the statistic is 3.93. Accordingly, the ECM formulation cannot be rejected only for the export prices of wood industry products, while in the model for export prices of paper industry products

separate F-tests show that all the other restrictions except $\Sigma d_t^2 = 0$ are data admissible. The F-test statistics for the hypotheses in (11) are as in Table 4.

Table 4. F-statistics for the hypotheses in (11) (5 % critical values in parentheses)

	F-statistics	5 % critical value
a)	3.69	(4.00)
b)	0.01	(4.00)
c)	5.85	(4.00)
d)	3.52	(4.00)

In the framework of heterogeneous export price formation, i.e. metal and other industrial products, the ECM hypotheses H_0 are rejected as the test statistics $F_{5,58}$ are 7.06 and 7.19, respectively, with 5 % critical value of 2.37.

In searching dynamic specifications of the models of export prices of metal and other industrial products, the dynamic testing procedure is adopted. Again the pre-specified lags for export prices of metal industry products (PXME) were set relatively short. The estimation results of the general model (maintained hypothesis) are as shown in Table 5. The tests for the restrictions as suggested by the estimates in Table 5 are presented in Table 6.

Table 5. General AD-model of logPXME (standard error estimates of the coefficients in parentheses)

variable	lag				Σ
	0	1	2	3	
logPXME	-1.00	.13 (.12)	.17 (.12)		-.70
logPMED	-.29 (.51)	1.60 (.90)	-.84 (.90)	.18 (.46)	.65
logCDFO	-.58 (.25)	.88 (.33)	-.07 (.23)		.23
logPMID	.31 (.25)	.59 (.31)	-.32 (.26)		.58
logFXSUS	.46 (.53)	-1.03 (.92)	1.28 (1.02)	-.57 (.54)	.14
logCUT	-.95 (.61)	1.38 (.57)			.43
Constant	1.50 (.94)				

$\bar{R}^2 = .989$ SEE = .062 Dm = .25 (1963.1—1981.4)

Table 6. Estimates and test statistics for a restricted model of logPXME (standard error estimates of the coefficients and 5 % critical values in parentheses)

variable	lag				Σ	F-statistics
	0	1	2	3		
logPXME	-1.00				-1.00	1.71 (3.15)
logPMED		.97 (.02)			.97	.50 (2.76)
logCDFO	-.37 (.21)	.64 (.22)			.27	.14 (4.00)
logPMID	.52 (.17)	.40 (.17)			.92	1.59 (4.00)
logFXSUS	.36 (.28)	-.36 (.28)	.46 (.24)	-.46 (.24)	0	.98 (3.15)
logCUT	.65 (.33)				.65	2.59 (4.00)
Constant	1.93 (.58)					
Joint F-test						1.01 (1.99)

$\bar{R}^2 = .989$ SEE = .060 DW = 1.69 (1963.1—1981.4)

H(20) = 1.42 $C_f = .64$ $C_b = .71$ $C_f^2 = .07$ $C_b^2 = .14$ Z(8) = 5.8
(1.83) (.95) (.95) (.19) (.19) (15.5)

A similar simplification search in the case of export prices of other industrial products (PXO) yielded the results in Tables 7 and 8.⁹

In summary, it can be noted that the estimation results are statistically acceptable and theoretically plausible and the parameter estimates reasonably stable.¹⁰

⁹ The common factor restriction for the model in Table 8 is rejected as the LR-statistic is 22.4 (11.1).

¹⁰ The estimated equations and test statistics for parameter stability for the models of PXW and PXPA where Σd_n is not constrained equal to zero are

$$\Delta \log PXWUS = -1.09 - .25 \log(PXWUS_{-1}/PXWSWUS_{-1}) + .79 \Delta \log PXWSWUS + .17 \Delta \log P3W$$

(.33) (.07) (0.05) (0.05)

$$-.16 \Delta \log P3W_{-2} - .18 \log(CUT_{-1} \cdot CUT_{-3}) + .55 \log CUT_{-2}$$

(.04) (.10) (.21)

$\bar{R}^2 = .805$ SEE = 0.25 Dm = .41 (1963.1—1981.4)

H(20) = .80 $C_f = .50$ $C_b = .67$ $C_f^2 = .28$ $C_b^2 = .26$ Z(8) = 13.2
(1.79) (.95) (.95) (.19) (.19) (15.5)

$$\Delta \log PXPAUS = -1.02 - .23 \log(PXPAUS_{-1}/PXPSWUS_{-1}) + .81 \Delta \log PXPSWUS + .16 \Delta \log P3P$$

(.25) (.06) (0.04) (0.04)

$$-.13 \log(CUT/CUT_{-2}) + .35 \log CUT_{-1}$$

(.07) (.15)

$\bar{R}^2 = .825$ SEE = .018 Dm = .20 (1963.1—1981.4)

H(20) = 1.30 $C_f = .89$ $C_b = .99$ $C_f^2 = .31$ $C_b^2 = .25$ Z(8) = .87
(1.92) (.95) (.95) (.18) (.18) (15.5)

Figure 1.

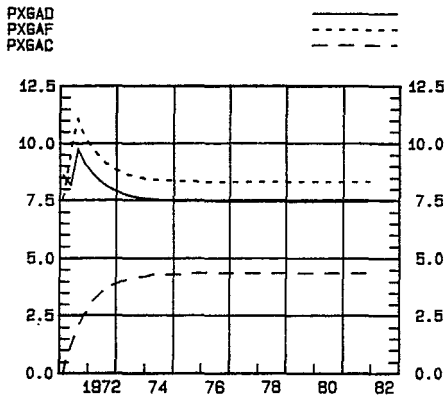
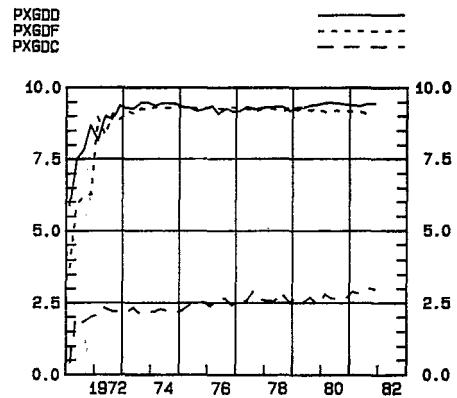


Figure 2.



However, the dynamic properties of the estimated export price equations are not immediately obvious. The nature of these can best be illustrated by means of some simulations.

III.4. Simulations

In order to assess the degree of dependency of Finnish export prices on the exchange rate, competitors' prices and domestic cost developments, the simulations in Figures 1 and 2 are illustrative. In Figure 1 the aggregate export price

Table 7. General AD-model of $\log PXO$ (standard error estimates of the coefficients in parentheses)

variable	lag				Σ
	0	1	2	3	
$\log PXO$	-1.00	-.01 (.11)	.43 (.10)		-.58
$\log PMED$	.35 (.50)	1.11 (.87)	-.73 (.88)	-.22 (.44)	.51
$\log CDFO$	-.09 (.25)	.48 (.32)	-.15 (.22)		.24
$\log PMID$	.08 (.24)	.36 (.29)	-.32 (.24)		.12
$\log FXSUS$	-.03 (.52)	-.57 (.88)	.48 (.94)	.45 (.51)	.33
$\log CUT$	.06 (.59)	.54 (.57)			.60
Constant	.90 (.98)				

$\bar{R}^2 = .991$ $SEE = .061$ $Dm = .19$ (1963.1—1981.4)

model is simulated alternatively for a 10 per cent devaluation or increase in competitors' prices or domestic costs, respectively, from the beginning of 1971 onwards. The corresponding multipliers PXGAD, PXGAF and PXGAC are calculated as a percentage deviation of the disturbed solution and control solution. In Figure 2 the disaggregated export price models are simulated correspondingly and aggregated with volume weights.

Table 8. Estimates and test statistics for a restricted model of logPXO (standard error estimates of the coefficients and 5 % critical values in parentheses)

variable	lag				Σ	F-statistics
	0	1	2	3		
logPXO	-1.00		.42 (.09)		-.58	.01 4.00
logPMED		.88 (.18)	-.43 (.19)		.45	.42 (3.15)
logCDFO		.38 (.08)			.38	.28 (3.15)
logPMID	-.27 (.15)	.27 (.15)			0	1.62 (3.15)
logFXSUS				.54 (.11)	.54	.55 (2.76)
logCUT		.72 (.29)			.72	.89 (4.00)
Constant	1.77 (.61)					
Joint F-test						.93 (1.95)

$\bar{R}^2 = .991$ $SEE = .060$ $DW = 2.05$ $Dm = .28$ (1963.1—1981.4)

$H(20) = 1.08$ $C_f = .82$ $C_b = .92$ $C_f^2 = .24$ $C_b^2 = .26$ $Z(8) = 14.4$
 (1.84) (.95) (.95) (.19) (.19) (15.5)

Both simulations indicate strong and, in the long-run, almost complete dependency of Finnish export prices on the exchange rate or competitors' prices, especially in the case of disaggregated models reflecting properties of the ECM. Domestic costs also affect export prices but more modestly, even in the long-run. Of course, these results are only partial and thus not very realistic particularly with respect to the long-run. The most important economic policy implication is that exchange rate policies, even when coupled with successful incomes policies, seem to exert only a transitory and, in the long-run, very weak relative price effect on export volumes. In these circumstances changes in profitability in the ex-

port industries can be an important channel through which exchange rate policies affect export volumes.¹¹

IV. CONCLUDING REMARKS

In this paper dynamic models of export prices are specified and tested in the case of Finland. The main result is empirical support for the hypothesis of the strong dependency of Finnish export prices on the exchange rate or competitors' prices. Domestic cost developments are less important in explaining export price behavior. These results are similar to earlier studies on the determination of export prices of small open economies. However, the degree of dependency and dynamics of Finnish export prices in relation to the exchange rate, competitors' prices and domestic costs is somewhat different when the distinction between homogeneous and heterogeneous goods is made. In export prices of homogeneous goods a simple error correction mechanism exists with respect to competitors' prices, domestic cost developments having only a transitory effect. Export prices of heterogeneous goods are more responsive to movements in domestic costs. The results suggest that imposing restrictions on the dynamics in the form of error correction mechanisms is not always data admissible and must be tested.

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¹¹ For a theoretical and empirical discussion, see Aurikko (1982).

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APPENDIX: Variables and Data Sources

CDFO	= $((YW4 + SOCC4)/(GDP4 \cdot FXSUS))/ULCUS$
CUT	= capacity utilization rate in the Finnish economy, $GDPF/GDPOT$
FXSUS	= exchange rate FIM/USD
GDPF	= volume of gross domestic product in producers' prices, seasonally adjusted, 1975 prices, in FIM
GDPOT	= volume of potential gross domestic product, 1975 prices, in FIM
GDP4	= volume of production in manufacturing industry, seasonally adjusted, 1975 prices, in FIM
PFOR	= weighted unit value index of imports of most important market economies for Finland, in FIM, 1975 = 100 (weights UK 37 %, Sweden 31 %, FRG 17 %, France 8 % and USA 7 %)
PMED	= import prices of USA in FIM
PMI	= unit value index of imports of investment goods, 1975 = 100, in FIM
PMID	= $(PMI/FXSUS)/PMUS$
PMUS	= import prices of USA in USD
PXG	= unit value index of exports of goods, 1975 = 100, in FIM
PXME	= unit value index of exports of metal industry products, 1975 = 100, in FIM
PXPAUS	= unit value index of exports of paper industry products, in USD
PXO	= unit value index of exports of other industrial goods, 1975 = 100, in FIM
PXPSWUS	= Swedish export prices of newsprint in USD
PXWSWUS	= Swedish export prices of wood industry products, in USD
P3P	= $P3US/PXPSWUS$
P3US	= prices of production in forestry in USD
P3W	= $P3US/PXWSWUS$
SOCC4	= employers' social security contributions in manufacturing industry, seasonally adjusted, in FIM
ULCUS	= unit labor costs in USA
YW4	= wages and salaries in manufacturing industry, seasonally adjusted, in FIM.

The data for PMI, PXG, PXME, PXPAUS, PXO and PXWUS are from the Board of Customs Monthly Bulletin. Indices for calculating PMED, PMUS, PXPSWUS and PXWSWUS are obtained from IMF's International Financial Statistics. Variables PFOR and ULCUS are from OECD statistics. The data source for GDPF, GDP4, P3US, SOCC4 and YW4 is the National Income Accounts. Variable GDPOT is estimated from a production function.

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