BANK OF FINLAND DISCUSSION PAPERS

17/95

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Exchange Rates and Import Prices in Finland: Estimation of Exchange Rate Pass-Through

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ISBN 951-686-458-9
ISSN 0785-3572

Suomen Pankin monistuskeskus
Helsinki 1995

Abstract

The purpose of this study is to examine the relationship between import prices and exchange rates in Finland. The concept of pass-through is associated with how prices of internationally traded goods are affected by changes in exchange rates. Pass-through is said to be complete when the exporter of the good does not adjust prices in his home currency. This means that exchange rate fluctuations are totally reflected in local import prices abroad. On the contrary, if import prices in local currencies remain stable, it is the prices received by exporters that must adjust to exchange rate movements. This paper presents a simple static theoretical model for pass-through. After that, some estimation results for Finnish import prices are shown. Estimation results are mixed, but it is evident that depreciation of markka increases import prices.

Tiivistelmä

Tutkimuksessa analysoidaan tuontihintojen ja valuuttakurssin välistä yhteyttä Suomessa aikavälillä 1980—1994. Analyysi keskittyy pass-through käsitteen ympärille. Kyseisellä termillä tarkoitetaan tässä yhteydessä sitä, kuinka ulkomaiset yritykset muuttavat vientihyödykkeidensä hintoja Suomen markan ulkoisen arvon muuttuessa. Pass-through:n sanotaan olevan täydellistä silloin, kun hyödykkeen viejäyritys ei muuta hintaa omassa valuutassaan. Tämä siis merkitsee, että valuuttakurssimuutokset heijastuvat vain paikallisessa tuojamaan valuutassa. Jos taas tuontimaan hinnat eivät muutu valuuttakurssin muuttuessa, niin tällöin ulkomaisen vientiyrityksen saaman hinnan täytyy joustaa. Tutkimuksessa esitetään yksinkertainen staattinen teoreettinen malli pass-through-yhtälön johtamiseksi. Teoreettisesta mallista johdetaan yhtälöt, joita käytetään tutkimuksen empiirisessä osassa. Estimointitulokset eivät ole ristiriidattomia, mutta tulosten mukaan on selvä, että markan ulkoisen arvon heikentyessä tuontihinnat nousevat.

Contents

1 Introduction

Import prices depend on many factors. For example, foreign costs and exchange rates affect the exporter's pricing behaviour. The purpose of this study is to examine the relationship between import prices and exchange rates in Finland. The immediate practical concern is with the inflationary effects of a declining markka. In most cases economists expect a declining currency to contribute to an acceleration of inflation. There are also opposing views, as Krugman (1986) has noted. The opponents argue that foreign firms do not cut their prices when the currency (e.g. markka) appreciates and instead maintain their pricing to market as currency depreciates. Thus these observers argue that currency depreciation has only minor effects on import prices. This paper does not attempt to determine the exact relative importance of import prices in inflation but instead concentrates solely on pass-through equations.

The concept of pass-through is associated with how prices of internationally traded goods are affected by changes in exchange rates. Pass-through is said to be complete when the exporter of the good does not adjust prices in his home currency. This means that exhange rate fluctuations are totally reflected in local import prices abroad. On the contrary, if import prices in local currencies remain stable, it is the prices received by exporters that must adjust to exhange-rate movements. In this case pass-through is said to be zero.

It has been recognized that the pass-through of exchange-rate changes to import prices is a time consuming process and the total effect depends on the market structure (for theoretical models, see e.g. Krugman 1986, Mann 1986, Dornbusch 1987). It has also been commonly assumed that the adjustment process is stable even during a period of flexible exchange rates, which is the basis of traditional partial equilibrium models. In these models, a currency depreciation is expected to increase import prices in the range of 50 to 100 per cent in a time span of two years, depending on the exchange rate and price indices used (Goldstein and Khan (1985)). Naturally, these pass-through effects vary across countries, with smaller total effects observed in larger countries.

In the case of the United States it has resently been argued that the pass-through has lengthened and that the prices of a certain group of imported goods have been kept fairly rigid in the presence of sharp swings in the dollar. Krugman (1986) reported that German exporters of machinery and transport equipment tended to price to market by absorbing 35 to 40 percent of the real appreciation of the dollar after 1980 by raising their prices to the U.S compared with prices in other markets. Mann (1986) also shows that dollar prices of some products remained quite stable during the appreciation of 1981-1985, indicating a substantial increase in profit margins collected by foreign exporters. These results are on line with theoretical models presented, for example, by Krugman (1986), which predict that the pass-through of exhange-rate changes is variable and depends on, among other things, whether the changes are perceived to be transitory or permanent. The more transitory the change, the smaller and slower the pass-through.

Pass-through is usually defined as the elasticity of import prices with respect to the nominal exchange rate. In theory this is not the right way to proceed, as Ohno (1989) has noted. Suppose, on the one hand, that a nominal depreciation is accompanied by a proportional inflation at home. In this purely nominal depreciation nothing real is changed. The real exchange rate and competitiveness remain the same, exports will be priced the same abroad and pass-through will be zero in the absence of money illusion. On the other hand, if there is no inflation differential and therefore the depreciation is both nominal and real, one might expect the export firm to adjust its prices to the new situation. This study follows others that use nominal exchange rates. The use of other more complicated specifications in empirical work is not straightforward, and this is left to future studies.

We address three basic questions in this study. What are the current estimates of the timing and magnitude of the effect of changes in the exchange rate on import prices? Has this relationship changed during the estimation period? What would be the implications for Finnish import prices of a further depreciation of the markka?

The study is divided into the following parts. First, the analytical framework is presented to clarify the concept of pass-through. This also provides a basis for the empirical analysis. Next we describe the data and how it is constructed. After that the estimation results are presented, followed by some concluding remarks.

2 A simple model for the pass-through equation

As already mentioned pass-through can be broadly defined as the extent to which a change in the nominal exchange rate induces a change in import prices. In the analysis below we have chosen to focus on a very narrow definition of pass-through: the partial derivative of the import price with respect to the nominal exchange-rate in a model that relates import price to the exchange rate and other variables. This analysis follows closely to the model presented by Hooper and Mann (1989). For more advanced theoretical models see e.g. Dornbusch (1987), Marston (1990), Giovannini (1988), Feenstra (1989).

Despite the models simplicity we chose this type of analytycal framework because, at least to our minds, it gives an intuitive picture of the pass-through problem.

The model is one type of markup model for price discrimination. Hence, it is assumed that the firms considered here are characterized by imperfect competition. Thus, the pass-through coefficient is likely to be the result of conscious price-setting behaviour by the export firm. In other words, foreign suppliers are assumed to sell in several markets and to have some degree of control over price in the Finnish market because of product differentiation or other market imperfections.

Suppose that a typical foreign firm sets the price of its export to Finland in its own currency (PX^*) at a markup η over its marginal cost of production (C^*).

$$PX^* = \eta C^* \tag{1}$$

Now, the Finnish import price, in markka, is derived by multiplying the above equation by the foreign exchange rate (ER).

$$PM = ER * PX^* = ER * \eta * C^* \tag{2}$$

The markup (η) is assumed to be variable. It responds to both competitive pressures in the Finnish market and demand pressures in all markets combined. We can measure competitive pressures in the Finnish market by the gap between the competitors' prices in the Finnish market and foreign production costs in markkaa. Demand pressure on foreign output is measured by capacity utilization. Using the markup model implies that the supply and demand curves are not infinitely elastic.

Thus, the markup can be specified as

$$\eta = \left(\frac{P}{C^*ER}\right)^{\alpha} (CU^*)^{\beta}. \tag{3}$$

P is the average Finnish price level of the good in question and CU^* is the capacity utilization of the foreign firm. As Hooper and Mann (1989) mentioned, capacity utilization is used as a proxy for tightness of market demand, which could arise from either domestic or foreign markets. Let us suppose that overall market demand increases. In most cases that implies that production increases more quickly than capacity, and firms recognize that they are nearing the potential output of the factory (in other words, the supply curve becomes vertical). Firms that have market power can now increase profits by increasing markups. On the other hand, if market demand falls, this means there is a slack in capacity and firms are willing to cut markups to maintain sales and market share. Thus, the sign of β is expected to be positive.

Substituting equation 3 into 2 and taking the logarithm we get

$$pm = er + \alpha(p - er - c^*) + \beta cu^* + c^*, \tag{4}$$

where lower case letters denote logarithmic values. Rearrenging gives

$$pm = (1-\alpha)er + \alpha p + (1-\alpha)c^* + \beta cu^*. \tag{5}$$

The pass-through coefficient (the partial derivative of pm with respect to er) is $(1-\alpha)$, where $0 \leq \alpha \leq 1$. At one extreme, where the foreign firm (exporter) prices to the Finnish market (or is a price taker in a competitive Finnish market) so that α is equal to one, pass-through is zero. This means (holding cu^* constant) that the exporter sets the Finnish import price equal to the Finnish domestic price. Thus, changes in the exchange rate (and foreign costs) have no effect. This means that exporters adjust their markups. At the other extreme, where the exporter does not face any competition in Finland and α is zero, changes in the exhange rate are passed through completely and markups do not change. Now we can rewrite equation 4 as

$$pm - er - c^* = \alpha(p - er - c^*) + \beta cu^*. \tag{6}$$

The above equation expresses the markup on sales to the Finnish market as a function of capacity utilization and the gap between the Finnish price (in foreign currency) and the foreign cost. When α is close to one (pass-through is low), a rise in er (depreciation of the markka) results in a decline in foreign profit margins.

2.1 Limitations of the model

The first severe limitation of the above model is that it is a partial-equilibrium model. The pass-through has been defined as a partial derivative that reflects the willingness of foreign firms to adjust their profit margins to offset changes in the exchange rate. As Hooper and Mann (1989) note, a more general model might take into account other, less direct, effects of exchange rates on import prices. For example, to the extent that a depreciation of the Finnish markka lowers foreign costs or reduces Finnish demand, the total pass-through will be less than that indicated by the partial derivative (the impact of a depreciation on the Finnish price level could work in the opposite direction, to increase total pass-through.) Thus, a more complicated model might express foreign costs as a function of the exchange rate (and possibly other factors too). In the empirical part of this study, foreign costs are treated exogenously.

The second limitation of the theoretical model presented above is that it is static. The pass-through of a given exchange-rate change may change over time. In particular, firms may be willing to squeeze their profit margins initially in response to a decline in the Finnish markka, but not indefinitely. If profit margins were returned gradually to desired levels, ceteris paribus, pass-through would tend to build up gradually over time. This possibility is allowed for in the empirical part of this study. We specify the import equations with a distributed lag on the competitiveness coefficients $\alpha_0, \alpha_1, ..., \alpha_T$. In this case, the short-run pass-through coefficient(in other words, the contemporaneous effect of the exchange rate on import prices) is $(1 - \alpha_0)$. The long-run pass-through coefficient is $(1 - \sum_{i=1}^{T} \alpha_i)$. Under a scenario in which the pass-through were to increase gradually over time and eventually become complete, the initial coefficient, α_0, would be close to one and susequent values of α_i would be smaller and negative, so that $\sum_{i=1}^{T} \alpha_i$ would approach zero over time. This means that markups would respond immediately to a shift in the exchange rate but over time would return to their original levels, as Hooper and Mann (1989) noted.

The third obvious limitation of the model is that it imposes the same rate of pass-through on exchange rates and foreign costs (equation 5), as well as a consistent effect for competing Finnish prices. Generally, exchange rates are more variable over time than are foreign production costs or Finnish prices. Firms may be more willing to absorb into their profit margins changes in exchange rates (assuming that they are likely to be reversed in the future) than changes in the costs or Finnish prices, which are more likely to be sustained. In the empirical part we allow for different rate of pass-through on exchange rates and foreign costs.

3 Econometric specifications

From the above model, it is straightforward to derive the empirical import equations. For example, the most restrictive form is an equation that imposes all of the cross-coefficient restrictions in equation 5, but allows lags in the α coefficient. The constraints are imposed by estimating the profit margin equation, 6. It can be written as

$$pm_t - er_t - c_t^* = \sum_{i=0}^{T} \alpha_i (p - er - c^*)_{t-i} + \beta cu_t^*, \tag{7}$$

which can also be written as

$$pm_t = (er + c^*)_t + \sum_{i=0}^{T} \alpha_i (p - er - c^*)_{t-i} + \beta cu_t^*. \tag{8}$$

The less restrictive form allows the coefficient of p_{t-i} to differ from α_i:

$$pm_t = (er + c^*)_t - \sum_{i=0}^{T} \alpha_i (er + c^*)_{t-i} + \sum_{i=1}^{T} \gamma_i p_{t-i} + \beta cu_t^*. \tag{9}$$

The least restrictive form allows the coefficient of c_t^* to differ from α_i as well:

$$pm_t = (er + c^*)_t - \sum_{i=0}^{T} \alpha_i er_{t-i} - \sum_{i=0}^{T} \delta_i c_{t-i}^* + \sum_{i=0}^{T} \gamma_i p_{t-i} + \beta cu_t^*. \tag{10}$$

After some rearrangement equation 9 can be written as

$$pm_t = \sum_{i=0}^{T} \zeta_i (er + c^*)_{t-i} + \sum_{i=0}^{T} \gamma_i p_{t-i} + \beta cu_t^*, \tag{11}$$

where the short-run pass-through coefficient, ζ_0, is equal to $(1 - \alpha_0)$ in equation 9 and the long-run pass-through coefficient ,$\sum_{i=0}^{T} \zeta_i$, is equal to $(1 - \sum_{i=0}^{T} \alpha_i)$.

In a similar way we can rearrange equation 10 as

$$pm_t = \sum_{i=0}^{T} \zeta_i er_{t-i} + \sum_{i=0}^{T} \pi_i c_{t-i}^* + \sum_{i=0}^{T} \gamma_i p_{t-i} + \beta cu_t^*, \tag{12}$$

where $\pi_0 = (1 - \delta_0)$ and $\sum_{i=0}^{T} \pi_i = (1 - \sum_{i=0}^{T} \delta_i)$.

These above models can be thought of as a 'guide' to finding the final empirical specifications. The model selection criteria will be based purely on statistical considerations. The above formulations are useful in the sense that they tell us what kinds of variables to include and they allow for testing the economic theories in question.

4 Data

The selection of data for analyzing exchange-rate pass-through can significantly affect the analysis. Because of the considerable effort involved in constructing the data for foreign countries, as well as severe limitations in data availability in a number of cases, we were constrained to a fairly small sample of countries. The data are quarterly data. Although, monthly data would certainly have been preferable, they are not available (exchange rates are the only high frequency variable). The time period is 1980:1 to 1993:4. More recent data are not available from many of the foreign countries. In the following subsections we describe the data used in this study. Appendix 1 gives the sources of the data.

4.1 Selection of foreign countries

In theory, in order to study the exchange-rate pass-through to import prices countries that export to Finland should be included in the analysis. In practice this is not possible. As in other studies we have chosen those countries with the largest shares in total Finnish imports. These top nine suppliers of Finnish imports during 1980-1993 were Germany, Sweden, United Kingdom, United States, Japan, Denmark, France, Italy and Norway. In 1980 these countries accounted for 52.3 percent of total Finnish imports. In 1985 their share was 56.3 percent and in 1993 65 percent.

The distribution of imports across these countries has been quite stable over the period in question, as seen in table 1.

Table 1 **Sample of nine countries. Calculated weights(percent). Selected years**

COUNTRY	1980	1985	1993
Germany	23	27	25
Denmark	5	4	5
France	6	6	7
United Kingdom	16	13	14
Italy	5	6	6
Norway	4	4	7
Sweden	23	21	16
Japan	6	9	9
United States	11	10	11

Weights for 1985 are used in aggregating foreign data accross the nine countries.[1]

4.2 Import prices

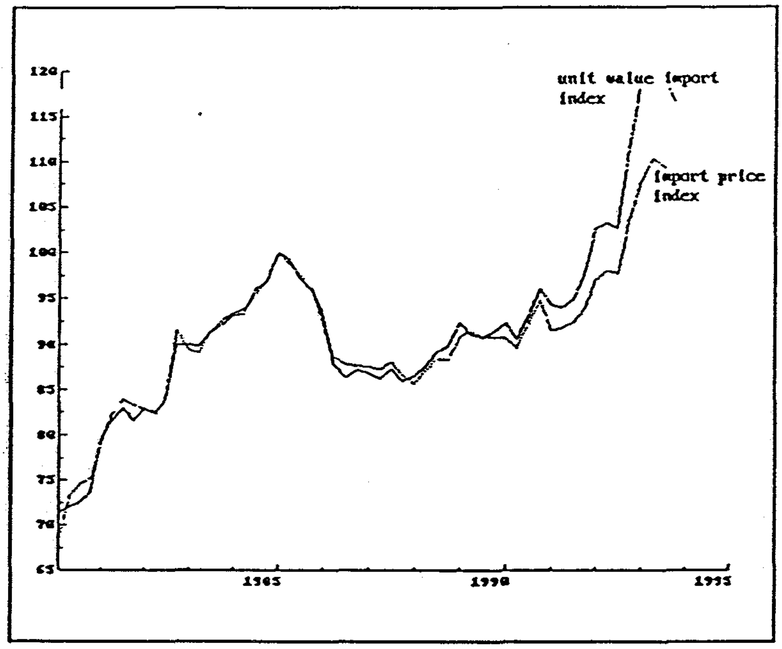
Selection of a suitable import price index (dependent variable) is crucial. There are two possibilities: the import price index (pure price index) collected by the Statistics Finland or the unit value import index collected by National Board of Customs. Unit value import indices are calculated by dividing the value of imports by the physical quantities of imports. While this is perfectly legitimate for a single product, the procedure yields spurious price indices when different products are combined in one index. For example, when the commodity composition of imports changes, a unit value index will change even if all true prices of the component import products remain unchanged. Similarly, because unit value indices are not fixed-weight indices, a price increase accompanied by a decrease in quantity demanded automatically lowers that good's weight in the index. The National Board of Customs is reported to have a procedure (not reported!) which tries to minimize the problems mentioned above.

Many foreign countries do not have import price indices at all. They use only unit value indices. Because we have both types available, it is intresting to compare

[1] If import shares vary much, it is suitable to use variable weights in aggregating foreign data. Opinions differ as to what is the optimal way to construct the weights. This problem is left to more advanced studies.

import price and unit value import indices in Finland over the period 1980-1993.

Figure 1 **Import price index and Unit value import index**



From figure 1 we see that the time paths of the two series are very similar. Throughout the 1980s series are closely related but they diverge around the begining of this decade. The correlation between the two variables is 0.98 for 1980:1-1993:4, i.e the levels are strongly related. It is intresting to look at the changes. The correlation between first differences is 0.85, which is also quite high. We would draw the the conclusion that it makes no real difference whether one uses a unit value import index or import price index. We tried both series as a dependent variable and the differences were marginal.

In this study we use import price indices in estimations because they are theoretically preferable.

Usually pass-through equations are estimated for total import excluding oil products. In this study pass-through equations are also estimated for the following sectors: investment goods and consumption goods. The reason for this is that one can argue, for example, that in some sectors changes in exchange rates pass-through is quicker than in others or that the magnitude of pass-through differs between sectors.

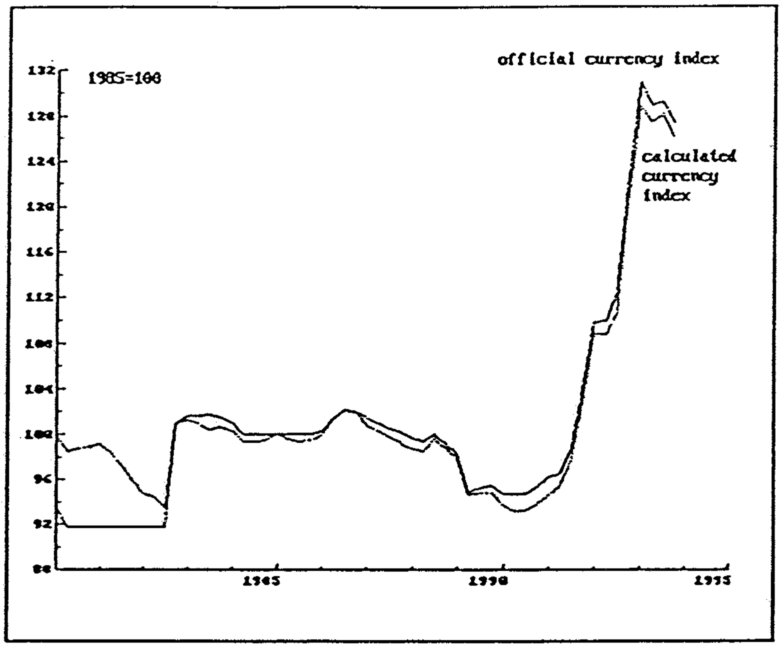
One should keep in mind that studying different sectors is not without problems. It is clear that the distribution of importing countries varies as between sectors. For example, Japan may have a bigger share in the transportation sector than in the manufacturing sector. Thus in principle, when modelling different sectors one should calculate the weights for all the sectors in question because of the aggregation of foreign data. This requires very detailed information and much effort in constructing the data. We leave this to the future studies.

4.3 Exchanges rates

In the 1970s and early 1980s the main goal of exchange-rate policy was to ensure that Finnish products were internationally price competitive. This was done through devaluations (usually in concert with other Nordic countries). Exchange- rate policy was also used to prevent foreign inflationary pressures from spreading into Finland. The revaluations of 1979 and 1980 are examples of this. From the beginning of 1978 to June 1991 the markka was pegged to a currency index. For technical details see Puro (1984). The markka was allowed to fluctuate inside the range set by the Government. From June 1991 the range has been based on the ECU. Since August 1992 the markka has been floating. For detailed information on the markka's fluctuations and the institutional backround see the excellent paper by Kajanoja (1994).

Figure 2. shows the markka's currency index ($1985:1 = 100$) from 1980:1 to 1993:4. This index is weighted by foreign trade shares. From the figure we see that since it was floated the markka has depreciated sharply (it appreciated after 1993:4). We have also calculated the currency index (using the same formula as in the official index), which includes the above-mentioned nine countries. It is obvious that this 'own' index is almost the same as the official index because the included countries play a major role in Finnish foreign trade.

Figure 2 **Official currency index and calculated currency index**

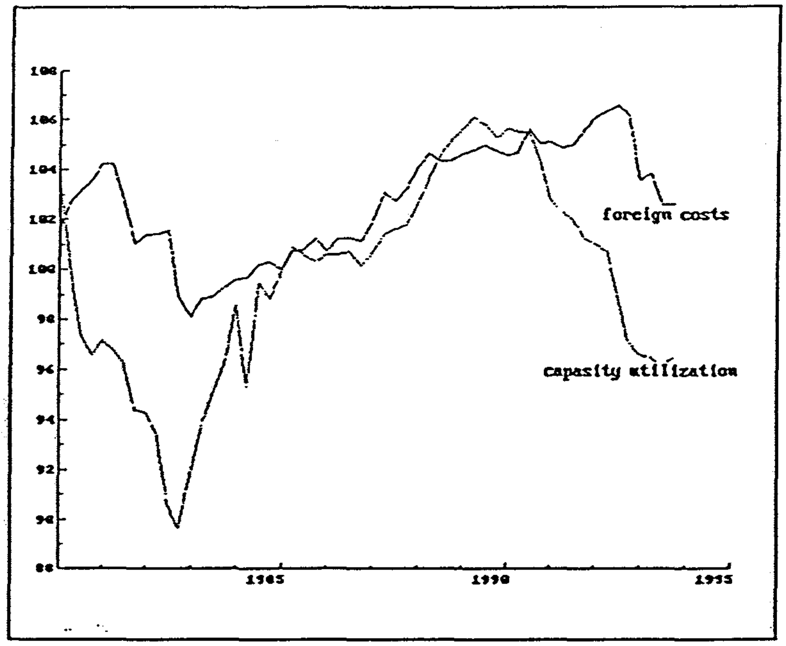


4.4 Foreign capacity utilization and foreign cost data

Capacity utilization rates were collected from national sources where available. These rates were not available for Japan and Denmark. We used average capacity utilization rates as proxies for these countries, despite the weaknesses of this approach.

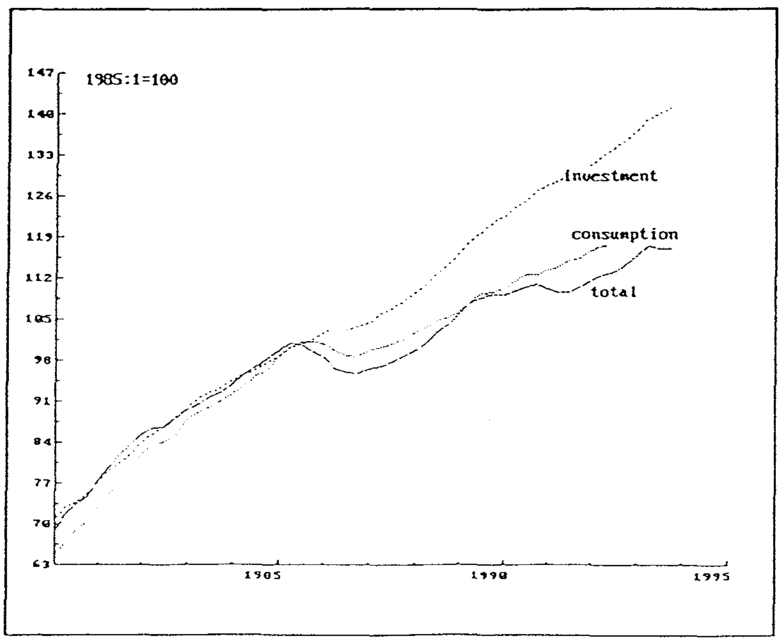
A theoretically proper way to construct foreign cost indices is to use unit labour costs and price indices for raw material and energy inputs and to weight them by production in each country in question. This means that one needs input-output tables for the countries included. This procedure is too complicated, so unit labor costs are used as a proxy for foreign costs. Figure 3 shows these series.

Figure 3 **The capacity utilization index and the foreign cost index**



Producers price indices are used as a proxy for the Finnish price level in the estimations. The next figure shows the average producers price index and producers price indices for consumption and investment goods.

Figure 4 **Producers price indices**



5 Estimation results

This section discusses the estimation of (unconstrained) equation 12 in section 3. In the following all the variables are logarithms. We employ the ordinary least squares (OLS) estimation method and we also consider estimates using error-correction estimation techniques. We started the analysis by estimating simple static regression models (not shown). A closer look at regression diagnostics revealed that the residuals were autocorrelated and all statistical tests (e.g. Box-Pierce test and normality test) reject the static models. So, it is clear that the phenomena in question are dynamic. Estimating the model recursively (for details, see e.g. Spanos 1986), we can test for constancy of the model's parameters. It is evident that in case of static models the model is marked by parameter instability (because they do not take the needed dynamic nature in account). In case of stochastic difference equations (see later) we did not found any statistically significant coefficient changes. Our conclusion is that there has not been big changes in relationship between exchange rate and import prices. It is important to point out that in this study we have not taken account changes in exchange rate regime. In future studies one should put more effort in modelling exchange rate effects.

5.1 Results from the dynamic regressions

In this subsection we try to find a good distributed lag model of the form,

$$pm_t = const. + \sum_{i=0}^{T} \zeta_i er_{t-i} + \sum_{i=0}^{T} \pi_i c_{t-i} + \sum_{i=0}^{T} \gamma_i p_{t-i} + \beta cu_t + \epsilon_t. \qquad (13)$$

The reasons why there are no lagged dependent varibles in the model are discussed later.

The reason we chose to estimate distributed lag models is that in several international studies concerning U.S import prices the authors have used this kind of specification (also with quarterly data) and it is intresting to compare the results. For example, Hooper and Mann use quarterly data from 1973:1 to 1988:4. They have used surprisingly long lagged variables (seven quarters for the exchange rate, eight quarters for foreign costs etc), but they do not present any diagnostic tests.

They report that in the long run a 10 percent depreciation of a dollar lowers markups 4 percent(or raise import prices 6 percent). The short-run coefficient (not shown in their paper) suggests a 20 percent pass-through on impact.

We found that it is very difficult to find a good distributed lag model. Almost in every case the lagged variables are not statistically significant and the diagnostic tests reject the models. The next table shows one model estimated for import prices of consumption.

Table 2 **Distributed lag model for pm(consumption)**

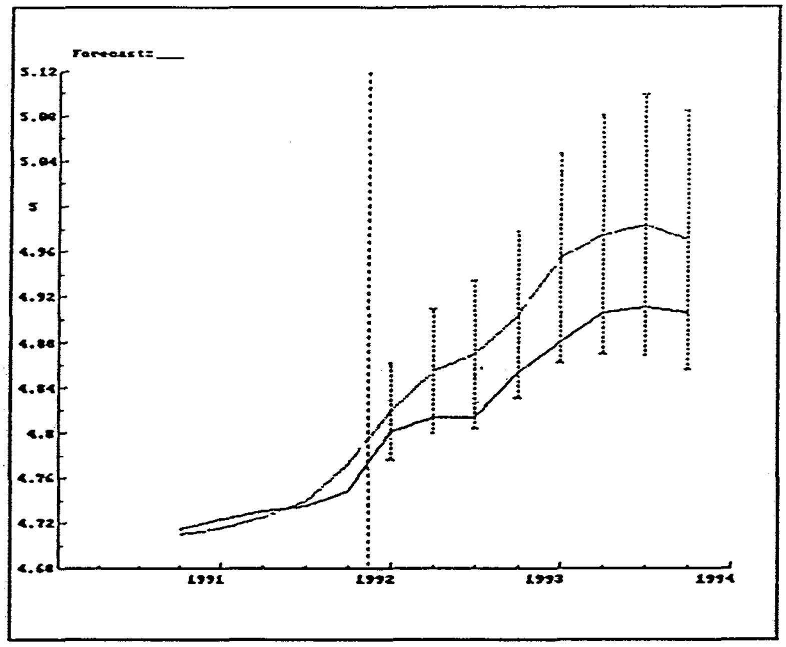
The present sample is: 1981 (2) to 1993 (4)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR
Constant	-4.3954	0.62151	-7.072	0.0000	0.5619
er	0.33381	0.12509	2.669	0.0110	0.1544
er_1	0.21314	0.17353	1.228	0.2267	0.0372
er_2	-0.0016455	0.16887	-0.010	0.9923	0.0000
er_3	0.023375	0.17357	0.135	0.8936	0.0005
er_4	-0.070161	0.18451	-0.380	0.7058	0.0037
er_5	0.062134	0.13650	0.455	0.6515	0.0053
c	0.18098	0.34327	0.527	0.6010	0.0071
c_1	0.30657	0.31565	0.971	0.3374	0.0236
cu	0.19207	0.099782	1.925	0.0616	0.0868
p	0.063211	0.28951	0.218	0.8283	0.0012
p_1	0.65645	0.27150	2.418	0.0204	0.1304

R2 = 0.991636 F(11, 39) = 420.34 [0.0000] = 0.013414 DW = 0.593
RSS = 0.007017462956 for 12 variables and 51 observations

As the above table shows, almost all the parameters are statistically insignificant (but have the right signs). The high coefficient of determination comes from common trends, and diagnostic tests reject the model. For example, the Box-Pierce test rejects the null hypothesis (residuals are white noise) clearly. The serie er is highly autoregressive. The standard error of the coefficient of er_t has increased sharply from the simple regression. This effect is called collinearity and is viewed as deriving from the high correlation between er_t and er_{t-i} when these are used to explain pm_t. The next figure shows the model's forecasting ability.

Figure 5 **Forecasting ability of the model**



These kinds of models cannot take into account fluctuations in the markka. The models suggest that for import prices of consumption a 10 percent depreciation in the markka increases import prices 3-4 per cent in the short run, depending on the model specification. The long-run increase in prices is about 5-6 per cent. For investment goods the short-run effect is smaller, about 2.5-3.5 per cent, but the long-run effect is much higher, 7.5-8.5 per cent. One possible explanation for this is that in general delivery times are long for investment goods. The short-run effect is greatest for total import prices. The long-run effect is about same for total import prices. Of course, one should be cautious in interpreting these figures.

Including lagged endogenous variables in the model (stochastic difference equations) we generally get models with good explanatory power. Now, the form of the estimated model is

$$pm_t = const. + \sum_{i=1}^{T} \alpha_i pm_{t-i} + \sum_{i=0}^{T} \zeta_i er_{t-i} + \sum_{i=0}^{T} \pi_i c_{t-i} + \sum_{i=0}^{T} \gamma_i p_{t-i} + \beta cu_t + \epsilon_t \quad (14)$$

The next two tables give the estimation results for import prices of investment and consumption.

Table 3 **Stochastic difference equation for pm(investment)**

```
The present sample is:  1980 (2) to 1993 (4)
```

Variable	Coefficient	Std.Error	t-value	t-prob	PartR
pm_1	0.59142	0.094865	6.234	0.0000	0.4423
er	0.60917	0.066337	9.183	0.0000	0.6325
er_1	-0.40821	0.083179	-4.908	0.0000	0.3295
c	-0.16796	0.062899	-2.670	0.0103	0.1270
p	0.25246	0.067964	3.715	0.0005	0.2197
cu	0.12605	0.050440	2.499	0.0159	0.1130

```
R = 0.999997    = 0.00887835  DW = 1.88
* R does NOT allow for the mean *
RSS = 0.003862427342 for 6 variables and 55 observations
```

Table 4 **Stochastic difference equation for pm(consumption)**

```
The present sample is:  1980 (3) to 1993 (4)
```

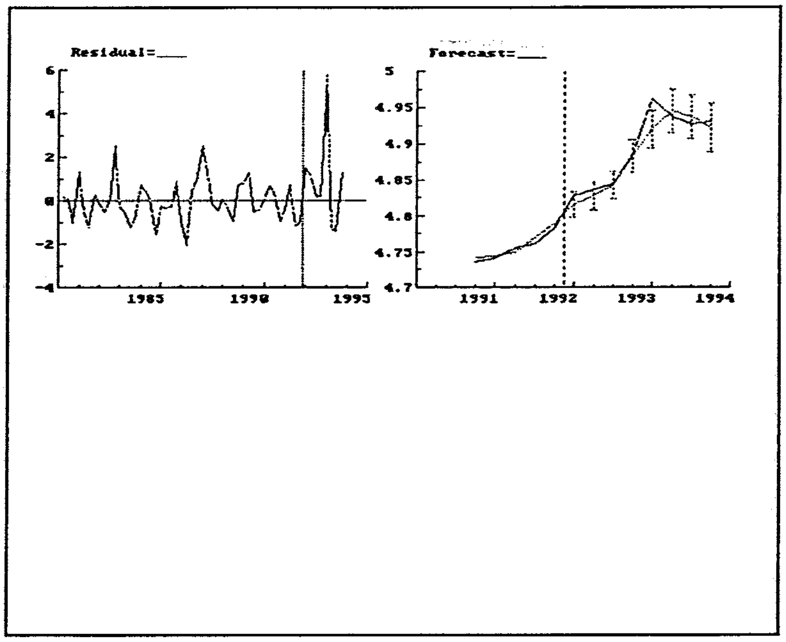
Variable	Coefficient	Std.Error	t-value	t-prob	PartR
Constant	-1.1205	0.37315	-3.003	0.0043	0.1610
pm_1	0.73967	0.074042	9.990	0.0000	0.6798
er	0.39067	0.057569	6.786	0.0000	0.4949
er_1	-0.22971	0.068686	-3.344	0.0016	0.1922
c	0.12162	0.068116	1.786	0.0806	0.0635
cu	0.049097	0.049550	0.991	0.3268	0.0205
p	0.17438	0.061830	2.820	0.0070	0.1447

```
R = 0.997503  F(6, 47) = 3129 [0.0000]    = 0.00762485  DW = 1.80
RSS = 0.002732500721 for 7 variables and 54 observations
```

For investment all parameters are statistically significant, and the constant is excluded. For consumption the parameters have the right signs but not all of them are statistically significant. The Durbin-Watson statistics are not valid because of lagged endogenous variables and the same is true also for the Box-Pierce test. As can be seen from the above tables, lagged dependent variables are very powerful regressors, which leaves little explanatory power to the other variables. This may be the reason why distributed lag models are more popular.

The next figure shows the forecasts and standardized residuals from the import price of the investement equation.

Figure 6 **Model residuals and forecasts**



As can be seen from the above figures, the model's forecasting ability is quite good and the residuals are not autocorrelated. From the χ^2-test, we see that the residuals are normally distributed. This is also the case for the import price of consumption goods.

The modelling of total import prices was not very succesfull. We did not found a good dynamic model. In every case, one can say that above models are not good, but it can be said that devaluation of markka increases import prices(but not by the same amount, suggesting less than complete pass-through). An increase in Finnish producers-prices increases import prices. For foreign costs and capacity utilization, the results are mixed.

5.2 Error correction mechanism

Using Error-correction term is a way of capturing adjustments in a dependent variable which depend not on the level of some explanatory variable but on the extent to which an explanatory variable deviats from an equilibrium relationship with the dependent variable.

Let us start with the simple stochastic difference equation

$$pm_t = \gamma + \alpha pm_{t-1} + \beta_0 er_t + \beta_1 er_{t-1} + \epsilon_t. \tag{15}$$

The above equation can be written as

$$\Delta pm_t = \gamma + (\alpha - 1)pm_{t-1} + \beta_0 \Delta er_t + (\beta_0 + \beta_1)er_{t-1} + \epsilon_t. \tag{16}$$

After some rearrangement and manipulation the above equation can be written as

$$\Delta pm_t = \gamma + \beta_0 \Delta er_t + (\alpha - 1)\left[pm_{t-1} - \frac{\beta_0 + \beta_1}{1 - \alpha}\right] + \epsilon_t. \tag{17}$$

Now, the terms inside the brackets are called the Error-correction mechanism. For further details see e.g. Davidson-MacKinnon (1993).

We start the analysis by testing unit roots for import prices and exchange rates. The next table shows the results from the unit root test.

Using Error-correction terms is a way of capturing adjustments in a dependent variable which depend not on the level of some explanatory variable but on the extent to which an explanatory variable deviats from an equilibrium relationship with the dependent variable.

We start the analysis by testing for unit roots for import prices and exchange rates. The next table shows the results from the unit root test.

Table 5. **Unit root tests**

```
Unit root tests for pm(total)
       The present sample is:  1980 (2) to 1993 (4)
 Dickey-Fuller test for Lmp80m; DLmp80m on
 Variable     Coefficient    Std.Error  t-value
 Constant         0.38897      0.15647    2.486
 pm_1           -0.084544     0.034759   -2.432

  = 0.0234504  DW = 1.38  DW(pm) = 0.07657  DF(pm) = -2.432
 Critical values used in DF test: 5%=-2.915 1%=-3.552
 RSS = 0.02914576716  for 2 variables and 55 observations

 Unit root tests for er
       The present sample is:  1980 (2) to 1993 (4)
 Dickey-Fuller test for Lomaind; DLomaind on
 Variable     Coefficient    Std.Error  t-value
 Constant        -0.17771      0.19019   -0.934
 er_1            0.039457     0.041238    0.957

  = 0.022296  DW = 1.29  DW(er) = 0.08064  DF(er) = 0.9568
 Critical values used in DF test: 5%=-2.915 1%=-3.552
 RSS = 0.0263468107  for 2 variables and 55 observations
```

The above tests show that we cannot reject the hypothesis that $\beta - 1 = 0$: both variables appears to have a unit root (I(1)). The same is true for the import prices of consumption and investment.

The next table shows the simple dynamic regression and its lag structure.

Table 6 **Dynamic regression for pm(total) and its lag structure**

Modelling pm(total) by OLS
The present sample is: 1980 (2) to 1993 (4)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR
Constant	0.22295	0.17198	1.296	0.2007	0.0319
pm_1	0.83780	0.035552	23.566	0.0000	0.9159
er	0.54137	0.12036	4.498	0.0000	0.2840
er_1	-0.43008	0.12892	-3.336	0.0016	0.1791

R = 0.953666 F(3, 51) = 349.9 [0.0000] = 0.0193142 DW = 1.43
RSS = 0.01902495421 for 4 variables and 55 observations

Analysis of lag structure

Lag	0	1	2	3	4	5	
pm	-1	0.838	0	0	0	0	-0.162
Std.Err	0	0.0356	0	0	0	0	0.0356
Constant	0.223	0	0	0	0	0	0.223
Std.Err	0.172	0	0	0	0	0	0.172
er	0.541	-0.43	0	0	0	0	0.111
Std.Err	0.12	0.129	0	0	0	0	0.0439

Tests on the significance of each variable

variable	F(num,denom)	Value	Probability	Unit Root t-test
pm	F(1, 51) =	555.34	[0.0000] **	-4.5623**
Constant	F(1, 51) =	1.6806	[0.2007]	1.2964
er	F(2, 51) =	13.565	[0.0000] **	2.5371

Tests on the significance of each lag

Lag	F(num,denom)	Value	Probability
1	F(2, 51) =	279.83	[0.0000] **

Tests on the significance of all lags up to 1

Lag	F(num,denom)	Value	Probability
1- 1	F(2, 51) =	279.83	[0.0000] **

The unit-root t-tests show that the two basic variables matter for long-run levels, which rejects the lack of cointegration. The F-tests on the lag polynomials show that each also matters dynamically. We found that lag lengths higher than one are insignificant.

Because both variables are I(1)-processes and cointegrated, we can calculate the long-run solution. The long-run solutions can be technically calculated even if the variables are not cointegrated, but the interpretations are not valid in this case.

The next table shows static long-run equation for total imports respect to exchange rate.

Table 7 **Static long-run equation for pm (total)**

```
Solved Static Long-run equation
      pm(total) =    +1.375              +0.6861 er
 (SE)                (1.024)             (0.2222)

 WALD test Chi(1) = 9.5378 [0.0020] **
```

The long-run coefficient of er is 0.68. This means that a 10 percent depreciation of the markka leads to an approximately 7 percent increase in total import prices in the long-run.

The next table shows long-run solutions for the import prices of consumption and investment.

Table 8 **Static long-run equations for consumption and investment**

```
Solved Static Long-run equation

     pm(cons.) =   -0.4979                +1.16 er
 (SE)              (1.733)                (0.3766)

 WALD test Chi(1) = 9.4815 [0.0021] **


Solved Static Long Run equation
     pm(inv.) =    +2.253              +0.5578 er
 (SE)              (2.061)             (0.4435)

 WALD test Chi(1) = 1.5819 [0.2085]
```

The long-run coefficient for consumption is 1.16 and for investment 0.56. The results are intuitive. Import prices of consumption goods are very sensitive to movements in exchange rate and import prices of investment goods are not. One possible explanation for this is that in most cases investment goods are big, expensive projects and their pricing to market differs substantially from other goods.

6 Conclusions

This study concerns the exchange rate effect on import prices. The analysis starts by investigating a simple static partial equilibrium model. From this model we can derive equations for empirical analysis.

The data construction is crucial for this kind of study. Despite the considerable effort in constructing the data used in the empirical part of the study, it is clear that the proxies used are not the optimal ones. In particular, one should put more effort into the construction of foreign cost and capacity utilization series. Appendix A gives some data sources.

Despite the weaknesses in data the results are quite intresting. Earlier studies have been mainly concerned with the effect of exchange rate changes on U.S. import prices for manufactured goods. Studies made of the 1970s usually suggests that almost all changes in exchange rates are reflected in import prices. Hooper and Mann (1989) were among the first to get results showing that the pass-through of exchange rate changes was not complete. They report that some 50-60 percent of the change in the nominal exchange rate is reflected in the prices of manufactured imports. They also conclude that their results are robust across alternative functional forms.

The results obtained in this study are similar than those in Hooper and Mann. In their study they do not present any regression diagnostics and they argue that a distributed lag model fits the data well. That is not the case in this study. We found that there are a lot of statistical problems(e.g. collinearity between lagged values) in distributed lag models. Next we tried stochastic difference models. These models fit well but the problem is that lagged endogenous variables clearly dominate and exogenous variables have very little explanatory power. We also found that there has not been any changes in relationship between exchange rate and import price in period in question.

In the next step we used reparametrizations in estimating error-correction models. First we found that all the variables are integrated of order one. After that unit root tests told us that variables (pm and er) are cointegrated. This means that the error-correction mechanism is valid and has the proper interpretations. The results show that the long-run static equilibrium value between total import prices and exchange rate is about 0.7. A 10 per cent depreciation in the markka increases total import prices 7 per cent in the long run. Intresting point is that the long-run equilibrium solutions differ between sectors. For import prices of consumption goods the exchange rate effect is very strong. The static long-run equilibrium is 1.16 and for import prices for investment goods it is only 0.55.

In future research it would be fruitful to disaggregate the data even more and to estimate the exchange rate effect for all the sectors. One should also keep in mind that our exchange rate regime has changed over the years and that this certainly has some effect on foreign firms pricing behavior.

Despite the fact that distributed lag models do not fit very well, it is evident (see results from the error correction model) that exchange rate changes have effects on our import prices. The results also show that increases in the domestic price level in the relevant sector lead to increases in import prices. This means that domestic price instability affects the inflation process also via import prices.

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8 Appendix A

SOURCES OF RAW DATA

Data series	*Source*
Import price indices	Statistics Finland
Exchange rates	Bank of Finland
Foreign costs	IMF quarterly data
Capacity utilization	OECD Main Economic Indicators
Producers price indices	Statistics Finland

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