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**Working Paper**

## Markets Shares, Financial Constraints, and Pricing Behavior in the Export Market

Working Paper, No. 1999:15

**Provided in Cooperation with:**

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*Suggested Citation:* Gottfries, Nils (2001) : Markets Shares, Financial Constraints, and Pricing Behavior in the Export Market, Working Paper, No. 1999:15, Uppsala University, Department of Economics, Uppsala,  
<https://nbn-resolving.de/urn:nbn:se:uu:diva-2462>

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**MARKET SHARES, FINANCIAL CONSTRAINTS,  
AND PRICING BEHAVIOR IN THE EXPORT MARKET\***

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Final version .....2001-10-08

A structural dynamic model of price and quantity adjustment is estimated on time-series data for exports and export prices. Two sources of dynamics are considered: *customer markets* and *pre-set prices*. As predicted by the customer market model, the market share adjusts slowly after a change in the relative price and financial conditions affect prices. Prices are found to be sticky in the sense that they do not reflect the most recent information about costs and exchange rates. A parsimoniously parameterized structural model explains about 90 percent of the variation in market share and the relative price.

*Keywords:* customer market, switching cost, markup, sticky price, nominal rigidity

*JEL Classification* D43, E31, F41

INTRODUCTION

How do firms set prices in foreign markets? Are they price takers or price setters? How is the quantity of exports determined? Are exporting firms able to sell any amount they want at the going world market price - so that exports depend mainly on supply factors in the home country - or do exporting firms face downward sloping demand curves - so that foreign market demand is an important determinant of exports? Do the answers to these questions depend on which time horizon one has in mind? If so, how quick is the adjustment? How long is the long run?

Answers to these questions are important for open economy macroeconomics. They determine the effects of exchange rate changes and the way in which inflation and business cycles are transmitted between countries. Consequently, a large number of empirical studies of exports and export prices have examined these issues; for references see Goldstein

and Khan (1985), Gottfries (1986), Menon (1995), Goldberg and Knetter (1997). Most such studies start from static theory, but add dynamics when the equations are estimated, and the dynamics is important for the empirical fit of the models; both quantities and prices typically respond with lags to various explanatory variables.

The presence of lags raises several issues. The first issue concerns the choice of restrictions to impose on the lag structure. Since one typically has a very limited sample, rather tight restrictions must be imposed, but without an explicit theoretical model of the dynamics, there is no basis for such restrictions. As emphasised by Goldstein and Khan (1985), estimates of polynomial lag structures are sensitive to the restrictions imposed. With a limited sample, there is little hope that a data-based search for statistically acceptable restrictions leads to the right specification; hence there is a need for theory to guide the choice of restrictions to impose on the lag structure. Second, economic theory suggests that lags on the quantity side will have implications for pricing behavior since price setting becomes a dynamic optimization problem, and those implications may be worth examining empirically. Third, short-run price and quantity adjustment plays a central role in macroeconomic theory. How firms respond to competitors' prices, costs, and demand is crucial for aggregate price and quantity adjustment over the business cycle and, ultimately, for the role of monetary policy (see e. g. Romer (1996)). If one is interested in price-quantity dynamics, the large variation in exchange rates, competitiveness and demand that we see in export markets make them particularly interesting to study.

In this paper I construct a parsimoniously parameterized structural model of price and quantity adjustment and estimate it on quarterly time series data for Swedish exports and export prices of manufactures 1972-1996. The model allows for two sources of dynamics: *customer markets* and *predetermined prices*.

Lags in quantity adjustment are attributed to *customer markets* à la Phelps and Winter (1970). In a customer market, each firm has a stock of customers and, because of imperfect information and/or switching costs, customers do not immediately switch to the firm with the lowest price, but tend to purchase from the same firm repeatedly. Therefore, the firm faces inelastic demand for its products in the short run, but in the long run the elasticity may be very large. The customer market model has interesting implications for the specification and estimation of the export equation. Most importantly, it implies that the adjustment lag will not be the same with respect to all explanatory variables. A price change has a gradual effect on the market share, but a change in foreign market demand immediately affects exports. By

testing the customer market specification against a more general “error correction” specification, I examine whether this is true in the data.

The customer market model implies that the pricing decision is an investment problem. By charging a low price, the firm invests in the customer stock (market share) which affects future profits. This opens the possibility for *financial factors* to affect pricing decisions. Fitoussi and Phelps (1988) and Phelps (1994) have emphasized the role of interest rates for pricing decisions and Gottfries (1991) and Chevalier and Scharfstein (1994) showed that markups may be countercyclical if firms are financially constrained. Bhaskar, Machin and Reid (1993) and Chevalier and Scharfstein (1994) report evidence that financial constraints affect prices. One purpose of this paper is to investigate whether financial factors affect export prices.

Lags in price adjustment are attributed to *predetermined prices*. One way to allow for predetermined prices is to use only lagged variables as instruments, and this is the first approach taken in this paper. I also estimate the price equation in an alternative way that allows me to *test* whether prices are predetermined in the sense that they do not reflect the most recent information about costs, exchange rates etc.

The model is fitted to quarterly data for Swedish exports and export prices of manufactured goods 1972-1996. While aggregate data has obvious shortcomings, such data also have an advantage: the possibility to obtain long time series with short intervals (100 quarterly observations) that make it possible to examine the dynamic adjustment to a series of major shocks (devaluations etc.) that create substantial variation in the data.

As it turns out, the structural model fits the aggregate data quite well, explaining 80-90 percent of the variation in the market share and the relative price, and most parameter estimates are reasonably precise and plausible. Several results emerge from the estimation: i) the dynamics on the quantity side is very much in line with what one would expect in a customer market: market *shares* adjust slowly towards a long run equilibrium determined by the relative price, but exports respond immediately to demand shocks, ii) the export price depends both on costs and competitors’ prices, iii) a higher interest rate has a positive effect on the price, though the effect is small and somewhat unstable, iv) net borrowing relative to equity, which is used as an indicator of financial constraints, has a large and very significant effect on the price, iv) there is clear evidence that prices are predetermined, consistent with other evidence that, on average, prices are set a few quarters in advance, v) prices are

predetermined in the home currency, implying that the relative price overreacts to exchange rate changes in the short run.

The papers by Gagnon (1989) and Kasa (1992) are similar in spirit to the present one. Both authors construct and estimate dynamic models of trade flows. One difference is that while Gagnon estimates a quantity equation, and Kasa estimates a price equation, I estimate the price and quantity equations simultaneously, imposing the relevant cross equation restrictions. Another difference is that the adjustment lags in the models of Gagnon and Kasa arise because of adjustment costs for changing *quantities* rather than customer relations. While I do not explicitly test the cost-of-adjustment model, I document two features of the data, which are consistent with customer markets, and predetermined prices, but inconsistent with adjustment-cost for changing quantities. First, as noted above, there is clear evidence that price effects take time while foreign market demand has an immediate effect on exports - as predicted by the customer market model. Contrary to this, the cost-of-adjustment model would imply *symmetric* speeds of adjustment of exports with respect to changes in prices and foreign market demand. Second, the result that relative prices overreact to exchange rate shocks in the short run is just the opposite to the prediction of the adjustment cost model. In such a model, the price equation takes a partial adjustment form, implying gradual adjustment of the relative price after an unexpected permanent shock to the exchange rate.

The next section presents the data to be explained and also briefly describes the macroeconomic background. Section II develops the theory that will be used to interpret the data and derives the equations to be estimated. The estimates of the basic model are presented in Section III, and an explicit test for price rigidity (predetermined prices) is presented in Section IV. A comparison with the partial adjustment model is made in Section V and some concluding remarks follow in Section VI.

## I. LABOR COSTS, RELATIVE PRICES, AND MARKET SHARES FOR SWEDISH EXPORTS 1972-1996.

The data is quarterly and covers Swedish exports of manufactured goods, which includes most industrial products except food.<sup>1</sup> Most raw materials are excluded and this is an advantage since prices of raw materials are quite volatile and determined in a very different way than prices of manufactures. When comparing Swedish exports and export prices to

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<sup>1</sup> The focus on "manufactured goods" is motivated by the fact that aggregate time series for this category are reported by the OECD countries in international trade statistics and have been assembled by the National Institute for Economic Research in Sweden.

foreign demand and prices it is important to take account of the fact that the importance of a particular market for the Swedish export industry does not only depend on the size of that market. Because of transport costs, cultural links etc., Sweden trades much more with the other Nordic countries than their share in world trade or production would suggest. To take account of this, I construct weighted indexes of foreign imports and foreign prices, with weights determined by the share of Swedish exports going to the different countries.<sup>2</sup> Precise definitions of the variables are given in Appendix A.

Figure 1 illustrates the correlation between competitiveness measured by the unit labor cost relative to the foreign price,  $W/P^*$ , and the relative price of exports,  $P/P^*$ . Here,  $P$  is the Swedish export price index for manufactured goods and  $P^*$  is a weighted index of import prices of manufactured goods for 14 OECD countries, both in Swedish currency. Until November 1992 Sweden had a fixed exchange rate arrangement where the krona was tied first to the dollar, then to the D-mark, then to a basket of currencies, and finally to the ECU. From November 1992 the krona has been floating.

-----Figure 1 here-----

The Swedish business cycle lagged behind the international cycle in the early 1970's and Swedish inflation was relatively low, but booming international markets and misjudgment of international inflation lead to very high wage increases in the 1975-76 central agreement. In addition, payroll taxes were increased. With a fixed exchange rate this lead to a dramatic loss of competitiveness and increase in the relative price.

Competitiveness was partially restored by two devaluations in April 1977 (6%) and August 1977 (10%), but then there was again some deterioration of competitiveness. Two further devaluations in September 1981 (10%) and October 1982 (16%) improved competitiveness of Swedish industry and this advantage remained for considerable time. In the latter part of the 1980's, tight labor market conditions lead to relatively high nominal wage increases in Sweden and a steady deterioration of competitiveness, leading up to the float and large depreciation of the krona from November 1992. The dramatic depreciation made Swedish industry very competitive. The restoration of confidence in Swedish economic policy raised the value of the krona, which, together with relatively high nominal wage increases, implied a return to a more normal situation.

It is evident that the relative price depends on costs relative to foreign prices, but variations in relative prices are much smaller than variations in costs relative to foreign

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<sup>2</sup> This type of trade-weighting is standard procedure at organizations such as IMF and the National Institute for

prices, suggesting that only part of a cost increase is passed through into export prices. This is consistent with international evidence of less than full pass-through (see e. g. Goldberg and Knetter (1997)). Note also that there is no indication that the pass through of exchange rate changes to relative price takes time. On the contrary, it seems that the relative price *overreacted* in connection with the devaluations in 1981 and 1982. A natural interpretation is that the prices of many export goods are set in kronor and not immediately adjusted when exchange rates change.

Figure 2 illustrates the effect of the relative price on the "market share", defined as Swedish exports to 14 OECD countries ( $Q$ ) divided by trade-weighted imports of manufactures to the same countries ( $Y$ ), both deflated by the relevant price indexes. Both series have been smoothed for illustrative purposes by taking a five-quarter moving average. (For estimation, I use the original, unadjusted data.) In general, an increasing relative price is associated with a falling market share and conversely. A natural interpretation of the counter-clockwise loops is that the relative price affects the market share with a lag.

-----Figure 2 here -----

## II. THEORY

What type of model of "the representative firm" in "the representative market" could be consistent with this data? Clearly, relative prices depend on costs and exchange rates, so firms are not price takers, at least not in the short run, though they may be price takers in the long run.<sup>34</sup> A model with imperfect substitutes seems more promising since it allows different exporters to charge different prices, but the loops observed in Figure 2 cannot be explained by a static model of monopolistic competition. The customer market model of Phelps and Winter (1970) is a natural candidate to explain the above observations. In the customer market model, each firm has a stock of customers and, because of slow diffusion of information, the customer stock adjusts slowly when prices change. While Phelps and Winter

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Economic Research in Sweden.

<sup>3</sup> In the 1970's, studies such as Ringstad (1974) for Norway, Coutts, Godley and Nordhaus (1978) for the UK, and Calmfors and Herin (1979) for Sweden showed that export prices are affected by domestic costs as well as foreign prices. The more recent research on pricing-to-market arrives at the same conclusion, but also documents systematic price discrimination between export markets; see e. g. Goldberg and Knetter (1997), Alexius and Vredin (1999).

<sup>4</sup> In principle, one may argue that the use of aggregate data may be misleading. Even if there is perfect competition and one price in each market, Swedish firms may influence the market price in the markets where they have a significant market share, so that a reduction in the aggregate relative price may reflect a change in the relative price between different markets. However, the *magnitude* of the relative price changes in relation to the variation in costs suggests that this cannot be the main explanation.

assumed goods to be perfect substitutes - and hence the firm's demand curve to be infinitely elastic in the long run - it seems reasonable to allow for the possibility that goods produced by different firms (in different countries) are imperfect substitutes. Below I use a customer market model with imperfect substitutes to derive equations for exports and export prices.<sup>5</sup>

### *Market Share Dynamics*

Assume that there is a continuum of buyers with varying preferences, who buy the good each period. If buyers had perfect information, the fraction of all buyers who would purchase from the representative Swedish firm would be  $\alpha - \eta P_t / P_t^*$  where  $P_t$  is the price charged by the Swedish firm,  $P_t^*$  is the average price in the market and  $\eta > 0$ . In the data, prices are normalized so that the average values of  $P$  and  $P^*$  are unity, so  $\eta$  is the (long run) price elasticity, evaluated at the mean. I assume that an individual Swedish firm is small relative to the market and that it competes with other Swedish firms in the same way as it competes with foreign firms with the same market share. The stock of customers,  $X_t$ , is assumed to adjust slowly towards its long run equilibrium value:

$$(1) \quad X_t = (\alpha - \eta P_t / P_t^*)^\lambda X_{t-1}^{1-\lambda} e^{v_t},$$

where  $0 < \lambda < 1$  and where  $v_t$  is a random shock to the customer stock. (The choice of functional forms is discussed in Appendix B.) Two reasons for sluggishness of have been emphasized in the literature. Phelps and Winter (1970) and Gottfries (1991) derive customer flow equations similar to (1) assuming that customers have *imperfect information* about prices charged by different suppliers and that they only occasionally compare prices. Gottfries (1986), Klemperer (1987) and Farrell and Shapiro (1988) show that *switching costs* have similar implications; see Klemperer (1996) for a review.

Let demand per customer be  $Y_t^\sigma e^{u_t}$  where  $Y_t$  is foreign imports,  $u_t$  is an unobservable exogenous shock, and  $\sigma > 0$ .<sup>6</sup> Then, demand for the firm's exports is

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<sup>5</sup> Other papers which have examined the implications of slow market share adjustment for international economics are Dohner (1994), Gottfries (1986), Froot and Klemperer (1989) and Klemperer (1995).

<sup>6</sup> The substitution between imports and domestically produced goods is not modeled here but foreign imports are taken as given. In principle, the correct definition of market demand includes also sales from domestic producers in each country. Thus, total expenditure on the relevant goods might be a better measure of market demand. On the other hand, there are some nontraded goods included in domestic production. Since imports are largely driven by domestic demand, the difference is probably not large.



$$(2) \quad Q_t = X_t Y_t^\sigma e^{u_t}.$$

The stock of customers is not observable in the available data. To get an equation that can be estimated, use (1) to substitute for  $X_t$  in (2), and then (2) dated  $t-1$  to substitute for  $X_{t-1}$ . Dividing by  $Y_t$  and taking logs we get an equation for the log of the *market share*:

$$(3) \quad q_t - y_t = \lambda \log(\alpha - \eta P_t / P_t^*) + (1 - \lambda)(q_{t-1} - \sigma y_{t-1}) + (\sigma - 1)y_t + v_t + u_t - (1 - \lambda)u_{t-1}$$

where lower case letters denote logs. This *market share equation* is estimated below. An important empirical implication of the model is that the quantity exported responds immediately to changes in foreign market demand while price effects take time. According to the customer market theory, the relevant state variable is not the market share, but the customer stock. The customer stock differs from the market share because of the unobservable demand shock  $u_{t-1}$  and because the elasticity with respect to market demand,  $\sigma$ , may differ from unity.<sup>7</sup>

There are several reasons why estimation of equation (3) by least squares would lead to biased estimates of the long run price elasticity.<sup>8</sup> First, there is the standard simultaneity problem: if there is some upward sloping supply relationship in the background there will be a positive correlation between the error term and the price. Second, measurement errors for prices are very likely because of aggregation problems etc. Both these factors lead to underestimation of the price elasticity. Third, prices are used as deflators in the calculation of  $q_t$  and  $y_t$ , so measurement errors for prices affect these variables too. Fourth, the moving average structure of the error implies a negative correlation between  $q_{t-1}$  and the error term. Therefore, the least squares estimate of the coefficient for  $q_{t-1}$  will have a negative bias, i. e.  $\lambda$  will be overestimated, and hence the long run elasticity will tend to be underestimated (because  $\eta$  is multiplied by  $\lambda$ ). Intuitively, we may think of  $q_{t-1} - \sigma y_{t-1}$  as an imperfect measure of the true state variable, the lagged customer stock, with measurement error  $u_{t-1}$ . This

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<sup>7</sup> The fact that market share equations are problematic if exports from different countries have different income elasticities has been known for a long time - see Junz and Rhomberg (1973) and Goldstein and Khan (1985). The model presented here is qualitatively similar to the models used by Krugman and Baldwin (1987) and Bean (1988).

<sup>8</sup> Conventional specification and estimation of export functions often leads to implausibly low long-run price elasticities; see Goldstein and Khan (1985) for a review of the empirical estimation of export and import functions. Following Goldstein and Khan (1978), Lundborg (1981) found a price elasticity of - .48 for aggregate Swedish exports.

measurement error implies that the estimated coefficient on the state variable will be biased downwards.

Taken together, all these arguments imply that a least squares estimator is likely to *overestimate* the speed of adjustment and *underestimate* the long run price elasticity. Therefore, an appropriate choice of instruments is important for drawing correct conclusions about the long run price elasticity, and the theory suggests that  $q_{t-2}$  should be a valid instrument for  $q_{t-1}$ .<sup>9</sup> To instrument for the price I use the unit labor cost. Sweden is highly unionized and union contract periods have typically been coordinated with a contract length between 1 and 3 years. Thus it seems likely that wages are not much affected by prices in the short run.

There was a major strike in May 1980. I assume that the strike lead to a loss of sales in the quarter of the strike and some postponement of sales to the quarter following the strike. Dummies for these two effects were entered analogous to  $y_t$ . The strike may also have lead to some *permanent* loss of customers, but with only one mayor strike in the data I could not estimate such an effect with any precision.

### *Export Price*

As we will see below, market shares adjust quite slowly and the within quarter price elasticity, evaluated at the mean, is only about one quarter. If the representative firm faces a within quarter price elasticity equal to one quarter, an increase in the price will raise current profits substantially. This does not imply that the firm should raise the price, however, because a higher price would lead to loss of customers and hence loss of *future* profits. Since the customer stock is part of the firm's capital, the pricing decision is an investment problem and the firm must consider the effects on future profits when setting the price.

Thus I assume that the firm in period  $t$  maximizes the expected present value of profits, discounting future profits at the (nominal) discount rate  $i$ . The firm's costs are given by the function  $C(Q_t, R_t)$ ;  $R_t$  being a vector of factor prices, technology shocks etc.. Then we can write the firm's maximization problem:

$$(4) \quad \max_{P_t} E_t \left[ \sum_{j=0}^{\infty} \left( \frac{1}{1+i} \right)^j \left[ P_{t+j} Q_{t+j} - C(Q_{t+j}; R_t) \right] \right]$$

subject to (1) and (2). I assume that the shocks  $v_t$  and  $u_t$  are unknown to the firm when it sets its price and, to simplify, that the firm acts as if it knew future variables with certainty. The foreign price is expected to grow at a constant rate  $\pi$ :  $P_{t+j}^* = (1 + \pi)^j P_t^*$  and that foreign market demand is expected to be constant:  $Y_{t+j} = Y_t$ . Using (1) and (2) to eliminate  $P_{t+j}$  we may then write the maximization problem:

$$(5) \quad \max_{X_t} \sum_{j=0}^{\infty} \left( \frac{1 + \pi}{1 + i} \right)^j \left[ \left( \frac{\alpha}{\eta} - \frac{1}{\eta} X_{t+j}^{1/\lambda} X_{t+j-1}^{1-1/\lambda} \right) X_{t+j} Y_t^\sigma - C(X_{t+j} Y_t^\sigma, R_{t+j}) / P_{t+j}^* \right] P_t^*.$$

In order to derive a simple price equation I assume that the firm has a Cobb-Douglas production function with constant returns to scale and that all factors of production are flexible. Then the marginal cost is independent of the scale of production and proportional to unit labor cost:  $\partial C(Q_t, R_t) / \partial Q_t = c W_t$ ;  $c > 0$ .<sup>10</sup> I assume that expected future unit labor cost relative to the foreign price is determined by:

$$(6) \quad w_{t+j} - p_{t+j}^* = a + \rho^j (w_t - p_t^*);$$

where  $0 < \rho < 1$  and lower case letters denote logs.<sup>11</sup> The nonlinear nature of the problem makes it impossible to find an exact solution, but a log-linear approximation to the optimal pricing rule can be derived:

$$(7) \quad p_t - p_t^* = a_w (w_t - p_t^*) + a_x x_{t-1}.$$

The coefficients  $a_w$  and  $a_x$  are complicated functions of  $\eta$ ,  $\lambda$ ,  $\beta$  and  $\rho$  (see Appendix B). For relevant parameter values the coefficients  $a_w$  and  $a_x$  are between zero and unity. To understand why, the optimal price increases with the lagged customer stock, note that the firm faces a tradeoff between charging a high price, to exploit existing customers, and charging a

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<sup>9</sup> This conclusion could not be drawn without an explicit structural dynamic model.

<sup>10</sup> These assumptions are obviously very strong, but help to keep the model manageable. Fixed or quasi-fixed factors would add further dynamics and also require explicit modeling of the interaction between the domestic market and the export market. While interesting, such an exploration is beyond the scope of the present paper.

<sup>11</sup> I did some experiments including more sophisticated expectations but since no robust results were found I do not report these estimates. In principle, expectations may depend on the exchange rate regime, but since there was a flexible rate for only four years in the sample period, it is not meaningful to test for a regime shift.

low price, to win new ones. If the firm enters a period with a large share of the customers in the market, it has many customers to exploit and few customers to gain, so it sets a high price. In the special case when the long run demand curve is infinitely elastic, the optimal price is independent of the market share, however.

### *Financial Factors*

An important implication of the customer market theory is that financial factors may affect prices. The higher the shadow price of funds, the higher will the price be because firms invest less in market shares when the required return on the investment is high. A high real interest rate should induce firms to set high prices (Fitoussi and Phelps (1988), Phelps (1994)). To test this I include the *real interest rate*,  $ir_t$ , in the price equation. I include the realized real interest rate for the coming year in the equation and instrument as described below. Because of the problems in measuring the expected real interest rate, I do not impose any constraints on the coefficient for the interest rate, as is done with  $a_w$  and  $a_x$ ; see below.

As argued by Gottfries (1991) and Chevalier and Scharfstein (1996), *financial constraints* may affect prices because financially constrained firms will be forced to set higher prices and invest less in market shares. To test whether financial constraints matter, one needs some measure of the financial situation of the representative firm. Standard agency cost models would suggest that a firm's ability to borrow - and hence the shadow price of funds - depends on its *stock* of debt relative to equity. On the other hand there are long-run relations also in financial markets. If a firm wants to raise more money it will either have to convince the existing investors to put larger fractions of their wealth in that particular firm or convince new investors to invest in the firm. Existing investors may be unwilling to put more eggs in the same basket and convincing new investors to invest in the company will typically involve substantial information costs. New investors need to be informed about the firm's business idea, management, assets, and market situation – just as new customers need to be informed about the product. Furthermore, raising new outside capital implies a loss of control for those who currently control the firm. Thus, raising new capital may be costly even if the balance sheet of the company is in good shape. For this reason I included a financial flow variable, *net borrowing relative to equity*,  $b_t$ , as an indicator of financial constraints.<sup>12</sup>

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<sup>12</sup> I also tried using the stock of debt relative to equity as an indicator of financial constraints, but since I was unable to find stable and significant effects, this variable was dropped.

The customer stock is unobservable, but we can use equation (2) to substitute for  $x_{t-1}$  in equation (7). . Furthermore, let  $p_t^* = e_t + p_t^f$ , where  $p_t^f$  is the average market price in foreign currency, and  $e_t$  is the nominal exchange rate. Adding a stochastic term  $\mu_t$ , reflecting other factors, which affect the price, we get the following *price equation* to be estimated:

$$(8) \quad p_t - e_t - p_t^f = a_w(w_t - e_t - p_t^f) + a_x(q_{t-1} - \sigma y_{t-1}) + a_i i r_t + a_b b_t - a_x u_{t-1} + \mu_t.$$

### *Predetermined Prices*

Much macroeconomic theory about price and wage adjustment is based on the notion of infrequent price adjustment. There is also considerable microeconomic evidence that prices are not changed every week. Questionnaire studies such as Assarsson (1989) and Blinder et al. (1998) suggest that firms typically change their prices once or twice per year. Thus it is essential to allow for prices being set in advance, based on expectations that firms have when they set their prices. In the next section, this is done in the standard way, by including actual values of right hand side variables in the price equation, but using only lagged variables as instruments. By instrumenting for  $q_{t-1}$  one also takes care of the fact that  $u_{t-1}$  is correlated with  $q_{t-1}$ . An explicit test of price rigidity is presented in section IV.

## III. ESTIMATION METHOD AND RESULTS

The equations to be estimated are the market share equation (3) and the price equation (8). Constant, seasonal dummies and linear trends were included in the equations.<sup>13</sup> As discussed above, we should expect a first order moving average error, with negative autocorrelation, in the export equation. If prices are set ahead of time, we would expect a low order moving average error, with positive autocorrelation, in the price equation. Therefore, all equations were estimated by generalized method of moments (*GMM*), allowing for third order moving average errors and conditional heteroscedasticity.<sup>14</sup> Seasonally unadjusted data was used. Precise definitions of the variables are given in Appendix A.

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<sup>13</sup> There are signs of a changing seasonal pattern in the quantity data and I therefore included seasonals multiplied by the trend and trend squared in the equations. These interaction variables are also included as instruments.

<sup>14</sup> In this context, the GMM estimator is best thought of as a generalisation of two and three stage least squares that takes account of moving average errors and heteroscedasticity conditional on the instruments. With moving average errors, two stage and three stage least squares would produce consistent estimates of the parameters, but the standard errors would be biased. Program: TSP 4.4.

The following *Instrument set I* was used for the estimation of the market share equation: constant, seasonal dummies, trend,  $q_{t-2}$ ,  $y_{t-2}$ ,  $y_t$ ,  $w_t$ ,  $w_{t-2}$ ,  $w_{t-6}$ ,  $p_t^f$ ,  $p_{t-2}^f$ ,  $p_{t-6}^f$ ,  $e_t$ ,  $e_{t-2}$ ,  $b_t$ ,  $b_{t-2}$ ,  $i_{t-2}$  and the strike dummy for  $t-1$  and  $t-2$  ( $i_t$  is the short-term nominal interest rate). To allow for prices being set in advance, the price equation was estimated using *Instrument set II*, which is the same as instrument set I, but excludes  $y_t$ ,  $w_t$ ,  $p_t^f$ ,  $e_t$ , and  $b_t$ .

### *Exports*

The baseline estimate of the market share equation is shown in Table 1, column 1. The residual autocorrelations are reported in the footnote to the table. As expected, the first autocorrelation is significantly negative and the other autocorrelations are insignificant. The relative price was normalized so that its mean is unity, so  $\eta$  is the long run price elasticity, evaluated at the mean relative price. The estimated long run elasticity is three, which is substantial compared to what one often finds in empirical export equations.<sup>15</sup> An adjustment speed of nine percent indicates very slow adjustment of the customer stock; the within-quarter price elasticity is only .27, and only 31 percent of the adjustment has occurred within one year.

Instrumenting matters for the estimated long run price elasticity. If the equation is estimated by nonlinear least squares (not shown) the estimated speed of adjustment becomes much larger (.22) and the estimated long-run elasticity becomes implausibly low (1.55). These results support the argument above that the "measurement error" with respect to the true state variable (the lagged customer stock) is important.

There is some secular decrease in the market share over the sample period (cf. Figure 2). In principle, a downward trend in the market share could arise because Swedish exporters produce goods with relatively low income elasticity, or because entry of new competitors, deterioration of the relative quality of Swedish exports etc., lead to a gradual loss of market share. Since the income elasticity is not significantly different from unity and the trend variable is insignificant it is difficult to discriminate between these hypotheses. If the trend is left out, the elasticity with respect to foreign market demand becomes significantly smaller than unity but the results are similar in other respects.

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<sup>15</sup> The result is consistent with that of Johansson (1994) who, using a less structural "common trends" model for Swedish exports, found a cointegrating vector which could be interpreted as a long run demand function with a price elasticity of 3.1. Bean (1988) estimated a similar equation for British exports (annual data). He could not reject the hypothesis that the long run price elasticity is infinite, so that a period with high relative price leads to a permanent loss of market share.

The strike dummies indicate that the strike in May 1980 lead to a temporary loss of sales of about 8 percent, of which less than half was recovered in the following quarter.

In columns 2 and 3 I check the stability of the market share equation by estimating it for the first and second half of the sample period. Although the magnitudes change, the qualitative results are similar for the two periods.

Provided that one knows the discount factor,  $\beta$ , and the degree of persistence of relative cost shocks,  $\rho$ , one can use the estimates of  $\lambda$  and  $\eta$  from the export equation to calculate the implied coefficients  $a_w$  and  $a_x$  in the price equation. To do this I postulate that  $\beta$  equals .99 and  $\rho$  equals .91, where the latter is based on an estimate of a first order autoregression for  $w_t - p_t^*$  (equation (6) with  $j=1$ ). The implied values of  $a_w$  and  $a_x$  are reported in columns 1-3. The model implies that elasticity of price with respect to unit labor cost should be about one fifth and the elasticity with respect to the lagged customer stock should be one tenth.

-----Table 1 here-----

### *Export Price*

I did not try to estimate  $\sigma$  from the price equation, but imposed the value obtained from the export equation (.94). The results for the price equation are reported in Column 4 of Table 1. As discussed above, we would expect predetermined prices to result in a low order moving average error. Consistent with this, the first autocorrelation for the errors is significantly positive, and the second is positive, but not significant.

The estimate of  $a_w$  close to .4 indicates that costs have significant effects on the relative price. This estimate is higher than the value implied by the model using the parameter estimates from the quantity equation. The coefficient for the lagged market share,  $a_x$ , is close to the value implied by the estimated export equation in column 1.

The coefficients for the real interest rate,  $a_i$ , and net borrowing  $a_b$ , are both strongly significant with the expected signs. The effect of the interest rate is small, however. A one percentage unit increase in the real interest rate increases the price by only .2 percent. The effect of financial constraints is quantitatively important: the standard deviation of  $b_t$  is .041 so a one standard deviation change in  $b_t$  changes the price about 2 percent! The modest trend could represent a slowly changing markup or some omitted cost factor.

In columns 5 and 6 the price equation is estimated for two sub-periods. The coefficient for the market share,  $a_x$ , is clearly unstable and the coefficient for the interest rate

is insignificant in the first period. The other parameter estimates are qualitatively similar to those for the full sample; the strong and extremely significant effect of net borrowing is noteworthy.

### *Simultaneous Estimation*

The cross equations restrictions on  $a_w$  and  $a_x$  are rejected statistically (the  $p$ -value is .013).<sup>16</sup> Still it may be interesting to see how well the model works when we impose these theoretical constraints. Column 7 shows the result of joint estimation of the export equation (3), the price equation (8), and equation (6) with  $j=1$ , imposing the cross equation restrictions on  $a_w$  and  $a_x$ . (Attempts to estimate the discount factor lead to estimates slightly above unity in several cases and since a discount factor above unity is unappealing it was set to .99.) Most coefficients take similar values as before. Finally, we see from columns 8 and 9 that the results are reasonably similar across periods, again with the exception of the coefficient on the interest rate. For the sub-periods, the *GMM* test of overidentifying restrictions indicates problems with instrument validity.

Although there are some signs of miss-specification, it is worth noting that most parameter estimates are highly significant, reasonable, and qualitatively similar across estimations, and the simultaneously estimated model, with cross equation restrictions, explains much of the variation in the data.

## IV. A TEST OF PRICE RIGIDITY

In the previous section, I allowed for predetermined prices by using only lagged variables as instruments when estimating the price equation. But are prices set ahead of time? Gottfries and Persson (1988) suggest a way in which one may *test* whether the dependent variable is predetermined in the sense that it does not reflect the most recent information about explanatory variables.<sup>17</sup> This test will be used here to find out whether prices are really predetermined.

If prices are set at an earlier point in time, they will be set on the basis of expectations about costs, foreign prices, exchange rates etc. I will use  $E_t$  to denote the expectation that

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<sup>16</sup> The constraints can be found in the Appendix. The test was performed by first jointly estimating the equations without the restrictions and then using the TSP-command ANALYS to test the hypothesis that both constraints are fulfilled. The discount factor was set to .99 for this test.

<sup>17</sup> See Cecchetti (1986,1987) for a related approach and Gottfries, Persson and Palmer (1989) for an application to buffer stock behavior of deposits and reserves. Giovanini (1988) and Marston (1989) also distinguish planned



firms have when they set prices for period  $t$ .<sup>18</sup> The price may be set either in the home currency or in foreign currency. Consider first the case when the price is set in the *home* currency:

$$(9) \quad p_t = a_w E_t(w_t) + (1 - a_w) [E_t(e_t) + E_t(p_t^f)] + a_x E_t(x_{t-1}) + a_i E_t(ir_t) + a_b E_t(b_t) + \mu_t.$$

In the alternative case when a firm sets its price *in foreign currency*,  $p_t - e_t$ , the corresponding equation will be

$$(10) \quad p_t - e_t = a_w E_t(w_t) + (1 - a_w) [E_t(e_t) + E_t(p_t^f)] + a_x E_t(x_{t-1}) + a_i E_t(ir_t) + a_b E_t(b_t) + \mu_t - E_t(e_t).$$

Thus, if a fraction  $\phi$  of the firms set their prices in foreign currency we have:

$$(11) \quad p_t = a_w E_t(w_t) + (1 - a_w) [E_t(e_t) + E_t(p_t^f)] + \phi(e_t - E_t(e_t)) + a_x E_t(x_{t-1}) + a_i E_t(ir_t) + a_b E_t(b_t) + \mu_t$$

The idea in Gottfries-Persson (1988) is to decompose movements in the explanatory variables into those predictable on the basis of lagged information, and those, which could not be predicted. As an example, consider the unit labor cost,  $w_t$ . Let us take as maintained hypothesis that price-setters know a vector of lagged variables,  $z_{t-j}$ , when they set their prices for period  $t$ . Assuming variables to be normally distributed and projecting  $E_t(w_t)$  recursively on  $z_{t-j}$  and the *outcome* for  $w_t$  we get:

$$(12) \quad P(E_t(w_t) | z_{t-j}, w_t) = P(E_t(w_t) | z_{t-j}) + m_w(w_t - P(w_t | z_{t-j})) = P(w_t | z_{t-j}) + m_w(w_t - P(w_t | z_{t-j})).$$

The first equality is the "law of iterated projections" (see Sargent 1979) and the second equality follows from the assumption that  $z_{t-j}$  is known by price-setters. The coefficient  $m_w$  has a value between zero and one and measures the *information advantage* that firms have

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and unplanned variations in prices; the method used here can be seen as a generalization of the method used by Marston (1989).

<sup>18</sup> I allow for prices being *predetermined*, i. e. set at an earlier point in time and/or based on lagging information. I do not allow for prices being fixed *across* periods. This may be more realistic, but it would complicate the analysis and add further dynamics.

concerning  $w_t$ , relative to the information embodied in  $z_{t-j}$ . If agents know  $w_t$ ,  $m_w$  is unity; if agents have no relevant information beyond  $z_{t-j}$ ,  $m_w$  is zero (see Gottfries-Persson (1988)). It follows that we can write  $E_t(w_t)$  as:

$$(13) \quad E_t(w_t) = P(w_t | z_{t-j}) + m_w (w_t - P(w_t | z_{t-j})) + \varepsilon_t^w,$$

where  $\varepsilon_t^w$  is orthogonal to  $P(w_t | z_{t-j})$  and  $w_t$  by construction. This can be used to substitute for  $E_t(w_t)$  in the price equation, and the same procedure can be applied to  $e_t$ ,  $p_t^f$  and  $b_t$ :

$$(14) \quad p_t = a_w [P(w_t / z_{t-j}) + m_w (w_t - P(w_t / z_{t-j}))] \\ + (1-a_w) [P(e_t / z_{t-j}) + m_e' (e_t - P(e_t / z_{t-j})) + P(p_t^f / z_{t-j}) + m_p (p_t^f - P(p_t^f / z_{t-j}))] \\ + a_x E_t(y_{t-1} - \sigma q_{t-1}) + a_i E_t(ir_t) + a_b [P(b_t / z_{t-j}) + m_b (b_t - P(b_t / z_{t-j}))] \\ + a_w \varepsilon_t^w + (1-a_w) \varepsilon_t^e + (1-a_w) \varepsilon_t^p + a_b \varepsilon_t^b + \mu_t.$$

where  $m_e' = m_e + \phi(1 - m_e)/(1 - a_w)$ . Since the coefficients  $a_x$  and  $a_i$  are somewhat unstable I did not try to apply the same procedure for these variables, but instrument as in the previous section. It is assumed that firms do not know  $u_{t-1}$  when they set prices for period  $t$ .

High values of  $m_w$  and  $m_p$  mean that firms are well informed about costs and competitors' prices in foreign currency when they set prices, so Swedish prices respond quickly to changes in these variables, and conversely. Similarly, a high value of  $m_e'$  may mean that firms are well informed about exchange rates when they set prices, but it may also indicate that prices are set in foreign currency, so that prices in Swedish currency change automatically with exchange rates. Note that if all firms set prices in foreign currency ( $\phi=1$ ) and firms have poor ability to predict exchange rates ( $m_e$  is close to zero),  $m_e'$  will be larger than one.

In order to estimate equation (14) one needs to measure the projections. A natural approach is to specify the variable vector  $z_{t-j}$  and estimate projection equations. Thus we write  $P(w_t | z_{t-j}) = \alpha_w z_{t-j}$ , where  $\alpha_w$  is a vector of coefficients and estimate:

$$(15) \quad w_t = \alpha_w z_{t-j} + e_t^w,$$

and similarly for  $e_t$ ,  $p_t^f$  and  $b_t$ :

$$(16) \quad e_t = \alpha_e z_{t-j} + e_t^e$$

$$(17) \quad p_t^f = \alpha_p z_{t-j} + e_t^p,$$

$$(18) \quad b_t = \alpha_b z_{t-j} + e_t^b .$$

In the second step one can use the fitted values from these regressions as measures of the projections and estimate equation (14).<sup>19</sup> The result is presented in column 1 of Table 2. The vector  $z_{t-j}$  was specified as follows: constant, seasonal dummies,  $w_{t-2}$ ,  $w_{t-6}$ ,  $p_{t-2}^f$ ,  $p_{t-2}^f$ ,  $e_{t-2}$ ,  $b_{t-2}$ . The estimated projection equations are not presented since they are of little interest. The estimated  $\alpha$ -coefficients are similar to those presented earlier and again there are signs of a low-order moving average error in the residual. All estimated “adjustment coefficients” are smaller than unity, indicating that firms have imperfect information about conditions in period  $t$  when they set prices for that period and hence adjust less than fully to innovations in costs, exchange rates etc.

-----Table 2 here-----

A problem with this two step procedure is the use of generated regressors in the second step. If one takes these generated regressors as given in the second step, one tends to underestimate the degree of uncertainty in the estimation procedure. To deal with this problem, I follow Mishkin (1983) and I write the price equation in the form

$$(19) \quad p_t = a_w [\alpha_w z_{t-j} + m_w (w_t - \alpha_w z_{t-j})] \\ + (1-a_w) [\alpha_e z_{t-j} + m_e (e_t - \alpha_e z_{t-j}) + \alpha_p z_{t-j} + m_p (p_t^f - \alpha_p z_{t-j})] \\ + a_x E_t(y_{t-1} - \sigma q_{t-1}) + a_i E_t(ir_t) + a_b [\alpha_b z_{t-j} + m_b (b_t - \alpha_b z_{t-j})] \\ + a_w \varepsilon_t^w + (1-a_w) \varepsilon_t^e + (1-a_w) \varepsilon_t^p + a_b \varepsilon_t^b + \mu_t,$$

and estimate it jointly with the projection equations (15)-(18), imposing the relevant cross equation constraints on the  $\alpha$ -coefficients. This approach gives the estimates presented in

column 2 of Table 2. The results are qualitatively similar, but the coefficients  $a_w$  and  $a_b$  change in magnitude and  $a_w$  is now close to the value consistent with the export equation estimates in Table 1.<sup>20</sup> A test of the joint cross equation restrictions on  $a_w$  and  $a_x$  shows that the restrictions are no longer rejected when the price equation is estimated in this way ( $p$ -value is .192).

Column 3 shows simultaneous estimation of (3), (6) and (15)-(19), imposing the cross equation restrictions on  $a_w, a_x, \rho$  and the  $\alpha$ 's. The model explains about 90 percent of the variation in the market share and the relative price. Finally, columns 4 and 5 show that, except for some of the  $m$ -coefficients, the estimates are reasonably stable across periods.

In the full sample estimation of the model (column 3) all  $m$ -coefficients but one are significantly smaller than unity. Since the  $m$ 's measure *information* - not time - this may mean either that prices are set at an earlier point in time, or that firms have lagging information. Note, however, that the estimate of  $m_e$ ' is well below unity and quite precisely estimated. Since information concerning exchange rates is immediately available every day, this result cannot reflect lagging information, but must be taken as evidence that prices are set at an earlier point in time *and* that a large fraction of firms set their prices in Swedish currency. Thus, a natural interpretation of the results is that, on average, prices are set a few quarters in advance. This interpretation is consistent with the results of a questionnaire study by Assarsson (1989), showing that many Swedish industrial firms change their prices once or twice per year.

The results imply that export prices in Swedish currency do not adjust immediately when the exchange rate changes. Hence, the pass-through of exchange rate changes to export prices in foreign currency is *larger* in the short run than in the long run. This is clearly visible in *Figure 1*, and similar to what Gagnon and Knetter (1995) found for most markets, but opposite to Hooper and Mann (1989) who found short-run pass-through to be lower than long-run pass through. A possible reason for the difference is that exporters

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<sup>19</sup> Identification requires that, for example,  $\varepsilon_t^w$  is uncorrelated with  $\alpha_e z_{t-j}$ . A sufficient condition is that the innovations in  $w$  and  $e$  (relative to  $z_{t-j}$ ) are independent.

<sup>20</sup> Since  $w_t$  is obviously correlated with the error term in equation (14), and similarly for equations (15) to (17), the standard test of overidentifying restrictions strongly rejects the model in this case. This is not a sign of misspecification, however. Although the instruments are correlated with the residuals in the projection equations, the error terms in the projection equations (14)-(17) are, by definition, orthogonal to the right hand side variables, which are all included as instruments. Thus the projections of the right hand side variables on the instruments will be orthogonal to the error although some of the instruments are not. Thus 3SLS and GMM will be consistent.

tend to set prices (and invoice) in their own currency, except when they export to the U.S; see Knetter (1989).

Do these results tell us anything about the mode of competition in the market? If the typical Swedish firm is small relative to the market, as I have assumed throughout, there is no *strategic* difference between price and quantity competition. With perfect information about the demand curve, choosing price is *equivalent* to choosing the quantity exported. But if the firm has *imperfect information* about conditions in period  $t$  when it takes its decision for that period, setting the price is not equivalent to setting the quantity. Since there is clear evidence that prices are predetermined relative to exchange rates and other variables, the results indicate that firms compete in prices rather than quantities.

## V. COMPARISON WITH THE PARTIAL ADJUSTMENT MODEL FOR EXPORTS

The result that the relative price overreacts in the short run to exchange rate changes is consistent with customer markets and prices being predetermined in the home currency, but contradicts a model with adjustment costs for changing traded quantities. In such a model, an unexpected persistent improvement in competitiveness due to devaluation would cause exporters to *gradually* reduce their relative prices, so as to achieve a gradual increase of the exported quantity (see equation (23) in Kasa (1992)). The intuitive reason is that, with adjustment costs, firms want to expand exports gradually when their relative costs have decreased.

Another key empirical implication of the customer market model is that exports respond slowly to price changes but quickly to changes in demand. It takes time for buyers to discover price changes and it is costly to change supplier, but a customer who needs to buy more units of the good can immediately increase purchases. Models with costly quantity adjustment imply that the exported quantity responds with the same speed of adjustment to unexpected and permanent changes in all explanatory variables; see equation (4) in Gagnon (1989) and equations (8) and (14) in Kasa (1992). A traditional Koyck lag specification has the same implication. It may therefore be of interest to check more directly what the data says about this issue. In order to do this I embed the export equation in a more general dynamic specification. Log-linearizing (3) and leaving out the error term we get

$$(20) \quad q_t = \lambda \alpha_0 - \lambda \eta (p_t - p_t^*) + (1 - \lambda)(q_{t-1} - \sigma y_{t-1}) + \sigma y_t$$

where  $\alpha_0$  is a positive constant. A standard partial adjustment equation would take the form:

$$(21) \quad q_t = \lambda(\alpha_0 - \eta(p_t - p_t^*) + \sigma y_t) + (1 - \lambda) q_{t-1}$$

These two specifications can be embedded in a more general "error correction" specification of the export equation:

$$(22) \quad \Delta q_t = -\lambda[q_{t-1} - \alpha_0 + \eta(p_{t-1} - p_{t-1}^*) - \sigma y_{t-1}] + a_1(\Delta p_t - \Delta p_t^*) + a_2 \Delta y_t.$$

Comparing the three model we see that the customer market model implies the following constraints on the error correction model:  $a_1 = -\lambda\eta$  and  $a_2 = \sigma$ , while the partial adjustment model implies the following constraints:  $a_1 = -\lambda\eta$  and  $a_2 = \lambda\sigma$ . Thus the natural test of these alternative specifications is to check whether the constraints are accepted statistically. Estimation of the error correction model by *GMM* results in the estimates reported in Table 3. We see that all parameters take values close to those consistent with the customer market model, supporting the prediction that demand has an immediate effect on exports while price effects take time. The constraints associated with the customer market model are easily accepted ( $p$ -value .62) and those associated with the partial adjustment model are strongly rejected ( $p$ -value .00002).<sup>21</sup>

Table 3. Customer markets vs. partial adjustment (equation 22)

$\lambda$	$\eta$	$\sigma$	$a_1$	$a_2$
.0850	2.933	.8461	-.3175	.7197
(.0544)	(1.522)	(.0567)	(.1562)	(.1459)

Note: See notes to Table 1.

## VI. CONCLUDING REMARKS

The present study gives clear answers to the questions posed in the introduction. Firms are price setters, but they take considerable account of competitors' prices when they set their prices. Exporters cannot sell any amount they want, but face very inelastic demand curves in the short run. The long run demand for exports is quite elastic, but market shares change very

slowly, and the dynamic adjustment pattern is consistent with the view that long term customer relations are important.

The results suggest that the dynamic aspects of demand are an important part of a firm's environment. This is important not only for international economics, but also for macroeconomics, industrial organization and corporate finance (cf. Klemperer, 1995). If customers react slowly to price changes in international markets, they probably do so in the market for haircuts. Of course, any business magazine offers plenty of casual evidence that firms view the market share as an important asset of the firm.

There is clear evidence that firms are imperfectly informed about the exchange rate in period  $t$  when they set the price for that period. The price adjusts to less than half the innovation in the exchange rate between period  $t-2$  and  $t$ . This supports theories emphasizing pre-set prices under imperfect information, such as Gordon (1981), Andersen (1985) and Nishimura (1986). The lag in price adjustment appears to be rather short, however.

I found very strong effects of financial constraints on the price: firms set high prices when they are borrowing heavily. This finding may be important for understanding the cyclical properties of prices. Net borrowing is positively correlated with investment, and negatively correlated with profits, and tends to lag a few quarters relative to capacity utilization. Thus net borrowing tends to peak in the downturn, a pattern noted by Brealey and Myers (1986). A natural interpretation is that firms decide to invest when capacity utilization is high, and since investment projects cannot be halted immediately, they find themselves in a financial squeeze when demand turns down. Hence they raise prices in the downturn, and such pricing behavior is likely to have a destabilizing effect on the economy. Further exploration of these dynamic interactions is a topic for future research, however.

#### ACKNOWLEDGEMENTS

The paper was inspired by an empirical tradition at the National Institute for Economic Research, developed by Hans Olsson and others. I have received helpful comments from the referee, Svend Hylleberg, Paul Klemperer, Edward Palmer, Torsten Persson, Anders Vredin, Michael Woodford, and seminar participants at the universities of Aarhus, Columbia, Princeton, and Rochester, Uppsala, IMF, Bank of Sweden, the SEDC and EEA meetings and the Econometric Society World Congress. I thank Robert Keller and Kerstin Johansson for

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<sup>21</sup> In this case the trend was excluded. With a trend,  $\sigma$  took the implausibly large value of 1.63 in the unrestricted model and both models were rejected at p-values around 2 percent.

able research assistance. Various stages of research on this project were supported by the National Institute for Economic Research, the Nordic Economic Research Council, the Bank of Sweden Tercentenary Foundation, the Wallander-Hedelius Foundation and the Swedish Council for Research in the Humanities and Social Sciences.

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#### APPENDIX A: DATA DEFINITIONS AND SOURCES

The trade statistics definition of *manufactured goods* which is used by the National Institute for Economic Research is SITC 5-9 except 68 (nonferrous metals) and 793 (ships). (The National Institute excludes nonferrous metals because their prices are very volatile and ships to avoid large outliers.) This definition corresponds to most products included in industrial production (SNI 3) except food, sawnwood, pulp, petroleum products, nonferrous metals and ships. The 14 countries referred to below are Canada, USA, Japan, Belgium, Netherlands, France, United Kingdom, Germany, Switzerland, Austria, Italy, Norway, Denmark and

Finland. *KITS* is the database available at the National Institute for Economic Research. Seasonally unadjusted data is used and seasonal dummies are included in all equations.

$Q$ : value of exports of manufactured goods to 14 countries, deflated by  $P$ . Source: Swedish foreign trade statistics and *KITS*.

$P$ : "hybride" price index for exports of manufactured goods, based on a mixture of unit value and producer price indices, constructed by National Institute for Economic Research. Source: *KITS*.

$P^*$ : weighted average of import price indices for manufactures for 14 countries converted to Swedish currency. Data comes from OECD trade statistics, series A and national statistics. The weights are based on the shares of Swedish exports going to each country. Source: *KITS*.

$Y$ : correspondingly weighted average of imports volumes for manufactures for 14 countries. Volumes are calculated by deflating import values by import prices. Data comes from OECD trade statistics, series A, and national statistics. Weights: as above. Source: *KITS*.

$E$ : weighted exchange rate index. Weights: as above. Source: *KITS*.

$$P^f = P^*/E.$$

$W$ : wage cost per hour divided by production per hour (unit labor cost). Wage cost per hour is calculated as .7 times wage cost per hour for blue-collar workers plus .3 times wage cost per hour for white-collar workers (the weight reflects the share of wages going to each group). The latter was obtained by dividing the wage cost per month by stipulated hours per month for white-collar workers. Production per hour is production divided by working hours for SNI 3. Source: *National Accounts*.

$i$ : short-term nominal interest rate. From 1972-1982 the rate on "special deposits", then the rate on three month statsskuldväxlar. Special deposits were large deposits, usually made by firms, at a negotiated interest rate. These interest rates were unregulated for the whole period and represent a relevant financial investment alternative for firms. Because of regulations of the bond and bank loan markets, rates in these markets do not represent relevant market prices in the first half of the sample (see Gottfries, Persson and Palmer (1989)).

$ir$ : the realised real interest rate for the coming year, calculated as  $(1+i_t) (1+i_{t+1}) (1+i_{t+2}) (1+i_{t+3}) P_{t+4}^* / P_t^*$ . As described in the text, the lagged nominal interest rate, prices etc. were used as instruments.

$b$ : change in net debt in a year divided by equity, SNI 3. Net debt is defined as short and long term debt plus .15 times untaxed reserves minus financial assets. (.15 is a rough estimate of the effective corporate tax rate.) Financial assets is total assets minus inventories, machines, real estate, imaginary assets and shares. The quarterly series is constructed by interpolation from a yearly series. Source: Aggregate accounting data published in *Företagen*, Statistics Sweden.

The strike dummy takes the value unity in the second quarter of 1980 and zero otherwise. The “after strike” dummy takes the value unity in the third quarter of 1980 and zero otherwise. The trend increases one unit each quarter.

APPENDIX B: DERIVATION OF THE PRICE EQUATION, FUNCTIONAL FORMS  
Define  $\beta \equiv (1 + \pi)/(1 + i)$ . We may then write the first order condition (Euler equation):

$$(A1) \quad -\frac{1}{\lambda\eta} X_t^{1/\lambda} X_{t-1}^{1-1/\lambda} + \frac{\alpha}{\eta} - \frac{1}{\eta} X_t^{1/\lambda} X_{t-1}^{1-1/\lambda} - \frac{cW_t}{P_t^*} + \beta \frac{1-\lambda}{\lambda\eta} X_{t+1}^{1+1/\lambda} X_t^{-1/\lambda} = 0$$

where  $cW_t$  is marginal cost;  $W$  being unit labor cost. Consider first a long run equilibrium when  $W$  is constant. Without loss of generality we may normalize so that  $X = W = P = 1$  in the long run equilibrium, and solve for the value of  $c$  which is consistent with this normalization:  $c = (\lambda\eta + \beta(1 - \lambda) - 1) / \lambda\eta$ . Log-linearizing the Euler equation we get:

$$(A2) \quad \left[ 1 - \Lambda L + \frac{1}{\beta} L^2 \right] x_{t-1} = \Phi (w_t - p_t^*)$$

where  $\Lambda = \frac{\beta(1-\lambda)+1+\lambda}{\beta(1-\lambda)(1+\lambda)}$  and  $\Phi = \frac{\lambda^2\eta c}{\beta(1-\lambda)(1+\lambda)}$ .

Factorizing the polynomial  $1 - \Lambda L + L^2 / \beta = (1 - r_1 L)(1 - r_2 L)$  where

$$(A3) \quad r_1 = \frac{\Lambda}{2} - \sqrt{\left(\frac{\Lambda}{2}\right)^2 - \frac{1}{\beta}} \quad \text{and} \quad r_2 = \frac{\Lambda}{2} + \sqrt{\left(\frac{\Lambda}{2}\right)^2 - \frac{1}{\beta}},$$

and solving for the stable solution we get:

$$(A4) \quad \begin{aligned} x_{t+1} &= r_1 x_t - \Phi \frac{x_2^{-1} L^{-1}}{1 - x_2^{-1} L^{-1}} (w_t - p_t^*) \\ &= r_1 x_t - \frac{\Phi}{r_2} \sum_{j=0}^{\infty} r_2^{-j} (w_{t+1+j} - p_{t+1+j}^*) = r_1 x_t - \frac{\Phi}{\lambda_2 - \rho} (w_{t+1} - p_{t+1}^*) \end{aligned}$$

where we made use of equation (6). The same equation applies for period  $t$ . Solving the customer flow equation for the price and log-linearizing we

get  $p_t - p_t^* = [(1 - \lambda)x_{t-1} - x_t] / \lambda\eta$  and thus

$$(A5) \quad p_t - p_t^* = \frac{\Phi}{\lambda\eta(r_1 - \rho)} (w_t - p_t^*) + \frac{1 - \lambda - r_1}{\lambda\eta} x_{t-1}.$$

The functional form of the demand function, with a mixture of linear and log-linear elements, may appear peculiar. As it turns out, the estimates of the long run price elasticity and the adjustment speed obtained from the *quantity* equation are not very sensitive to the choice of functional form. Alternative specifications of the demand curve have dramatically different implications for *pricing behavior*, however. An important property of the linear long run demand curve, postulated above, is that *the price elasticity increases in absolute value with the relative price* and there are two good reasons why this is a desirable property. First, the estimated within quarter price elasticity, evaluated at the mean, is only one quarter. If the price elasticity was one quarter at *all* points of the demand curve, the firm would be able to make infinite profits in one quarter by raising its price to infinity. Thus, the price elasticity *has to be* increasing in absolute value as the price increases. Second, the far from full pass-through of cost and exchange rate shocks into prices, which can be observed in Figure 1, also suggests that demand becomes more elastic - and the markup decreases - when the price increases (c. f. Marston (1990), Feenstra, Gagnon and Knetter (1996), Goldbergh and Knetter (1997)).

Another alternative would be to make equation (1) linear in the relative price and the lagged market share. (This is the form one gets if customers compare all prices with probability  $\lambda$  in each period - see Gottfries (1991).) Solving for the optimal price for this case one finds that the price should depend very much on the lagged market share ( $a_x$  should be large) which is not true in the data. The present specification has the implication that the effect of a price change on the exported quantity increases with the lagged market share. This is a reasonable property since a firm with a large market share should be more "visible" in the market.

Yet another possibility would be to assume that the long run price elasticity is infinite - as in the original Phelps-Winter model. First, this is not what I find when I estimate the export equation; the estimated elasticity is substantial, but not infinite. Second, solving for the optimal price in this case, one finds an extremely cost-oriented pricing behavior. The elasticity of the price with respect to costs ( $a_w$ ) turns out to be larger than unity and the price should *fall* when the foreign price increases. (This theoretical possibility was pointed out in Gottfries (1986).) Again, this is not what we see in the data.

TABLE 1. GMM estimates of the basic model

	1	2	3	4	5	6	7	8	9
Dependent variables	Market share	Market share	Market share	Relative price	Relative price	Relative price	Share & price	Share & price	Share & price
Equations	3	3	3	8	8	8	3,6,8	3,6,8	3,6,8
Period	72:1-96:4	72:1-84:2	84:3-96:4	72:1-96:4	72:1-84:2	84:3-96:4	72:1-96:3	72:1-84:2	84:3-96:3
Instrument set	I	I	I	II	II	II	II	II	II

*Export equation:*

$\eta$	3.016 (.863)	1.494 (.165)	2.550 (.781)				2.881 (.572)	1.642 (.154)	2.613 (.678)
$\lambda$	.0879 (.0316)	.2752 (.0346)	.1024 (.0384)				.0786 (.0212)	.2617 (.0440)	.0976 (.0267)
$\sigma$	.9406 (.1079)	.9304 (.0569)	.9747 (.1657)	.94	.94	.94	.8130 (.0997)	.8514 (.0989)	.5219 (.2843)
strike	-.0782 (.0092)	-.0764 (.0057)	-				-.0818 (.0112)	-.0902 (.0188)	-
after strike trend	.0321 (.0083)	.0256 (.0048)	-				.0299 (.0091)	.0173 (.0185)	-
s.e.	.0282 (.00016)	.0227 (.00026)	.0270 (.00025)				.0260 (.00011)	.0190 (.00036)	.0248 (.00037)
R <sup>2</sup>	.935	.941	.941				.935	.939	.927

*Price equation:*

$a_w$	.2439 (.0158)	.1574 (.0359)	.2336 (.0243)	.4121 (.0346)	.1807 (.0501)	.4990 (.0289)	.3735 (.0217)	.2188 (.0364)	.4249 (.0359)
$a_x$	.1060 (.0241)	.1337 (.0098)	.1216 (.0282)	.1326 (.0484)	-.1021 (.0800)	.2592 (.0628)	.1130 (.0187)	.1263 (.0134)	.1199 (.0269)
$a_i$				.2390 (.0591)	.0593 (.1089)	.1692 (.0437)	.1943 (.0411)	-.1644 (.1059)	.0726 (.0452)
$a_b$				.4588 (.0887)	.7857 (.1288)	.3652 (.1902)	.5507 (.0699)	.8154 (.1435)	.4926 (.2069)
trend				.00075 (.00014)	.00031 (.00044)	.00093 (.00024)	.00062 (.00017)	.0012 (.0004)	-.00014 (.00045)
s.e.				.0294	.0291	.0217	.0260	.0227	.0155
R <sup>2</sup>				.716	.767	.870	.735	.795	.905

p-value	.754	.580	.538	.553	.625	.132	.909	.048	.007
$\rho$	.91	.91	.91				.9966	.9919	1.0223
							.0156	.0580	.0356

*Notes:* Numbers in parenthesis are standard errors. All estimations were done by the GMM procedure in TSP 4.4 allowing for third order moving average errors and conditional heteroscedasticity. Instrument sets I and II are defined in the text. The  $p$ -value refers to the test of overidentifying restrictions. The first four autocorrelations for the errors in the export equation in column 1 are as follows: -.413 (.100), .128 (.116), -.083 (.117), -.004 (.118). The first four autocorrelations for the errors in the price equation in column 4 are as follows: .584 (.100), .206 (.130), -.001 (.133), -.085 (.133). The pattern is very similar for the other estimates.

TABLE 2. Testing for price rigidity

	1	2	3	4	5
Dependent variable	Relative price	Relative price	Share, price	Share, price &	Share, price
	2 steps	& projections	& projections	projections	& projections
Equations	14	15-19	3,6,15-19	3,6,15-19	3,6,15-19
Period	72:1-96:4	72:1-96:4	72:1-96:3	72:1-84:2	84:3-96:3
Instrument set	I	I	I	I	I
<i>Export equation:</i>					
$\eta$			3.494 (1.162)	1.634 (.218)	2.783 (.692)
$\lambda$			.0715 (.0289)	.2294 (.0437)	.1041 (.0287)
$\sigma$	.94	.94	.8534 (.1063)	.9203 (.0865)	.7338 (.1915)
strike			-.0827 (.0222)	-.0934 (.0162)	-
after strike trend			.0265 (.0224) -.00004 (.00012)	.0142 (.0162) -.00061 (.00030)	-  .00014 (.00027)
s.e.			.0259	.0196	.0237
R <sup>2</sup>			.935	.935	.934
<i>Price equation:</i>					
$a_w$	.3737 (.0467)	.2555 (.0577)	.2982 (.0403)	.2154 (.0435)	.3698 (.0645)
$a_x$	.0939 (.0615)	.0003 (.0727)	.0944 (.0269)	.1386 (.0142)	.1110 (.0222)
$a_i$	.1265 (.0414)	.0959 (.0466)	.0608 (.0466)	.1442 (.0441)	.1218 (.0389)
$a_b$	.5265 (.1110)	.8215 (.2041)	.6744 (.1801)	1.0434 (.2285)	1.1737 (.6891)
$m_w$	.3945 (.1383)	.3371 (.2134)	.2778 (.1773)	-.4568 (.2735)	.4103 (.2115)
$m_p$	.8079 (.1191)	.7263 (.1787)	.7487 (.1846)	.6092 (.1074)	1.1385 (.3789)
$m_e'$	.4439 (.0937)	.3372 (.0796)	.3741 (.0837)	.0906 (.0784)	.3837 (.1009)
$m_b$	.6867 (.2057)	.5078 (.1811)	.6561 (.2366)	-.0194 (.0861)	.1536 (.1492)
trend	.00076 (.00016)	.00071 (.00023)	.00082 (.00021)	.00082 (.00048)	-.00006 (.00044)
s.e.	.0211	.0160	.0164	.0101	.0110
R <sup>2</sup>	.858	.898	.893	.960	.952
p-value	.324	-	-	-	-
$\rho$			.9515 .0238	.9884 .0474	.9942 .0395

Notes to table 2: See Table 1 for explanations. The first four autocorrelations for the errors in the price equation in column 2 are as follows: -.650 (s.e.:.100), .450 (.136), .345 (.150), .153 (.158) and the pattern is similar for the other specifications. As discussed in the text, the test of overidentifying restrictions cannot be applied in the case of joint estimation of the price equation and the projection equations.



Figure 1. Export Price (P) and Unit Labor Cost (W)  
Relative to Foreign Import Price (P\*)  
(seasonally adjusted)

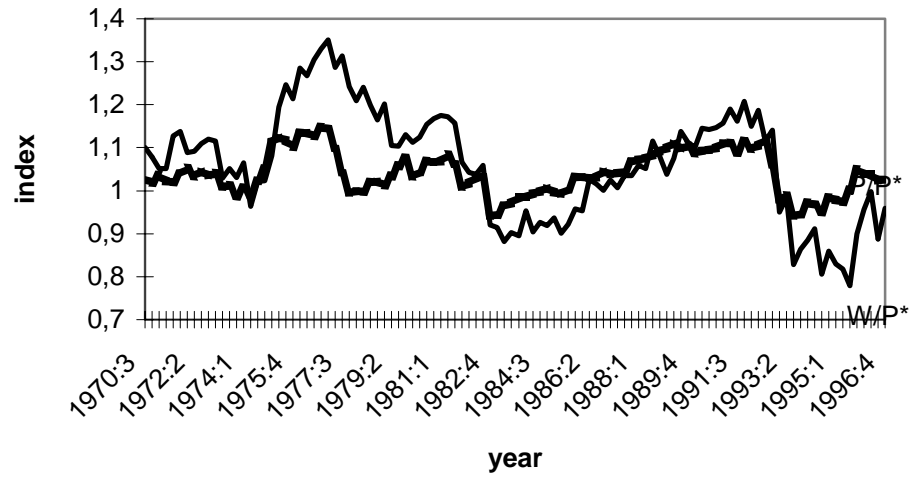
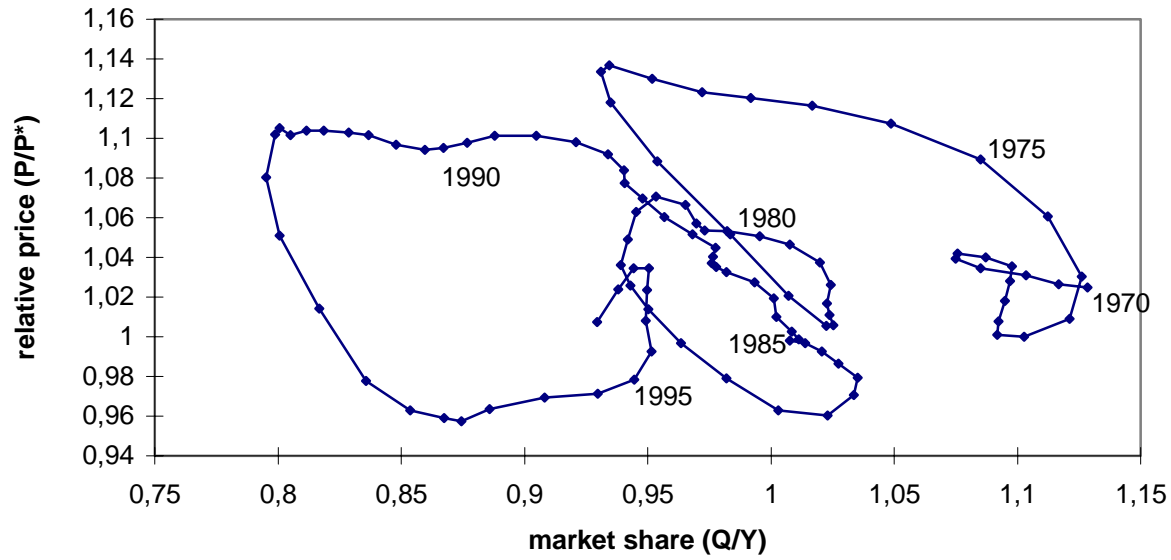


Figure 2. Relative Price and Market Share 1971:1-1996:4  
(moving average)



Note to Figure 2: The figure shows five quarter moving averages, centered on the quarter, for the data used in the estimation. The dates mark the the first quarter of the respective year.