INTERACTION BETWEEN PRICE SETTING AND CAPITAL INVESTMENT IN A CUSTOMER MARKET[*]

by

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ABSTRACT

In this essay a customer market model is constructed, where an entrepreneur-owned firm has two choice variables, namely the customer stock and the capital stock. The firm is assumed to be completely credit rationed and the investment procedure is characterised by time-to-build. The model is solved numerically to yield steady state paths for the ratio of customers to capital, investments and price. A comparative statics analysis is carried out so as to find out how price and investments respond to exogenous shocks. The model is also tested empirically with data for the Swedish manufacturing sector. The results from the theoretical model point to a close relationship between price setting and investment decisions, which is then confirmed by the empirical investigation.

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1. Introduction

According to textbooks in economics, a firm that experiences a rise in demand will immediately raise the price of its product in order to maximise profits. This description of the world is, however, widely questioned. First, there is a great deal of empirical evidence of prices and mark-ups being countercyclical, e. g. Bils (1987), Rotemberg and Woodford (1991) and Chevalier and Sharfstein (1994). Second, authors like Phelps and Winter (1971), Gottfries (1986, 1991) and Bils (1989) have developed theoretical models, where prices and mark-ups react slowly to demand and in some circumstances even countercyclically.

One model of mark-ups is the so called customer market model developed by Phelps and Winter in 1971. The main feature of that model is that the firm has long-term relations with customers and therefore cannot charge as high a price as one would expect from a textbook monopolistic competitor. If it does raise its price too much it will lose customers to the other firms in the market and make lower profits in the future. Thus, the pricing decision of the firm is a dynamic optimisation problem.

This model has been extended to show the possibility of gradual price adjustment and countercyclical prices. In Bils (1989) the monopolist wants to exploit existing customers as well as attract new ones. In periods with high demand and many potential customers the firm gives more weight to attracting new buyers. Therefore it lowers its price in booms. Gottfries (1991) assumes that the firm is credit rationed, for which reason it must always generate enough profits to pay back debt. It cannot compete as intensely as it would if it could borrow freely. In periods of high demand the firm will lower its price in order to gain a larger market share and thereby increase profits in the future.

The various customer market models involve only one choice variable, namely the customer stock. However, it is natural to imagine that a firm must invest in equipment and machines for production. Therefore, the idea in this essay is to develop a customer market model that incorporates not only the customer stock, but also the capital stock as a choice variable. Moreover, a realistic model of investments must allow for the fact that completion of an investment project is a prolonged process. First, the firm decides to make an investment. Then, planning the actual purchase and payment of the new machine takes place, but not immediately in connection to the investment decision. Finally, investments rarely become productive at once when they are bought, but time must be devoted to install them. The importance of this so called time-to-build effect has been stressed in models by e. g. Kydland and Prescott (1982) and Rouwenhorst (1991). Empirical evidence of the existence of time-to-build is reported by, among others, Hall (1977) and Nickell (1978). Hall contends that the whole completion process on average takes 21 months, whereas Nickell has found evidence that investments are completed in 23 months.

The purpose of this essay is to study the interaction of prices and investments in a customer market model with time-to-build effects and a credit constraint. Hence, we construct such a model and solve for the paths of the customer stock, investments and price. For simplicity, we assume that the firm of our model is completely credit rationed, which admittedly may seem somewhat extreme. Nevertheless, given this assumption, the model sheds light on how the firm's pricing and investments decisions interact. Thus, our firm has to resort only to its own cash flow to finance investments. If it is investing heavily in machinery and equipment it will have to raise the price of its products in order to pay for the investments. However, it cannot raise the price too much, since it then may lose revenues due to loss of customers in the future.

Furthermore, we study the effects of temporary and permanent shocks to demand and wage costs on the firm's pricing and investment decisions. Then, assuming that the system is out of steady state we describe how investments in customers and capital are matched by pricing during the period of adjustment to the steady state. In fact, we find that the timing of the investment decision and the pricing decision is closely related.

We also test the model empirically. One may argue that the assumption of complete credit rationing is most relevant for small, entrepreneur-owned firms. For instance, Gertler and Gilchrist (1993) and Hansen and Lindberg (1997) report that the smaller a firm, the more likely it is to be denied bank loans. This finding, however, does not contradict the notion that any enterprise, no matter its size, faces some kind of financial constraint, although not as extreme as in the theoretical model. Therefore, we use data for the whole manufacturing sectors in Sweden and in thirteen competitor countries to estimate a price equation, derived from the solution of the theoretical model. The results of our estimations confirm that investments do play an important role when firms set prices.

This essay is organised as follows. In sections 2.1 and 2.2 the model is outlined and solved. A comparative statics analysis is carried out in section 2.3, continued by a description of the adjustment to the steady state in section 2.4. In section 3.1 an econometric price equation is rationalised, whereas the data used in the estimations are discussed in section 3.2. Section 3.3 illustrates some tendencies as to demand, investments and prices in the Swedish economy during the investigated period. The results of the estimations are reported in sections 3.4. Finally, section 4 concludes.

2. Theory

In this section we first develop a theoretical model of a firm in a customer market that invests in customers and capital. Then we solve the model numerically and perform a comparative statics analysis on the firm's response to shocks to demand and wage costs. Finally, we describe the adjustment to the steady state.

2.1 The model

We consider a small, entrepreneur-owned firm facing a customer market, i. e. a market where customers react slowly to variations in prices. This phenomenon arises when shopping around for various reasons is costly to customers, e. g. when they have imperfect information about the firms' prices or when changing firms imposes switching costs upon them. We postulate the net customer flow equation characterising the customer market: $(x_{t+j} - x_{t+j-1}) / x_{t+j-1} = H\left(p_{t+j} - \overline{p}_{t+j}\right)$, where x denotes the customer stock. Thus, current net customer flows, $(x_{t+j} - x_{t+j-1}) / x_{t+j-1}$, is a function of the price of the firm's product, p_{t+j}, and the prices of the competitors, $\overline{p}_{t+j}$. For rationalisations of the net customer flow equation, see Phelps and Winter (1971), Gottfries (1986, 1991), and Klemperer (1992). The entrepreneur invests in market shares, i. e. in the customer stock, , and in capital, *k*, such as new machinery and equipment. We introduce a financial constraint as simply as possible by assuming that the owner/entrepreneur must finance his investments solely with the profits he makes in the current period.

Empirical evidence, such as Hall (1977) and Nickell (1978), supports the existence of time-to-build effects in investments in capital. In our model the firm will decide to invest during booms, both because of the increased demand and because it will have enough cash-flow to afford the investments. However, due to the phenomenon of time-to-build, the new machinery will be installed only in the period after the decision to invest is made, that is after the peak of the boom. It will become productive still one period later. In other words, we assume that there are lags between the investment decision itself and the payment and the instalment of the new equipment. Put shortly, we assume that the decision to install investments in the next period, $t+1$, is made in the current period, t, and that investments will be productive only in $t+2$.

As to the utility function we assume that utility is a concave function of revenues minus costs and investments. Generally, a concave utility function can be interpreted as if the entrepreneur is inclined to smooth consumption over time. More generally, the owner may have alternative uses of funds outside this particular firm, which have a decreasing marginal return in the current period.

The entrepreneur maximises his discounted current and future utility:

$$\max_{\{x_{t+j},k_{t+j}\}} \sum_{j=0}^{\infty} \beta^j U_{t+j}\left\{p_{t+j}x_{t+j}y_{t+j} - C\left((x_{t+j}y_{t+j})/k_{t+j-1}\right)k_{t+j-1}w_{t+j} - i_{t+j}\right\}$$

s. t.

$$\begin{aligned} & i_{t+j} = k_{t+j} - k_{t+j-1} \\ & \left(x_{t+j} - x_{t+j-1}\right)/x_{t+j-1} = H\left(p_{t+j} - \overline{p}_{t+j}\right), \end{aligned} \tag{1}$$

where β is the entrepreneur's subjective rate of time preference and p_t is the price of the entrepreneur's product. The customers, i. e. the market share, of the firm are denoted x_t, whereas y_t is exogenous demand per customer. Assuming that production equals sales, costs, C, depend on production $x_t y_t$ and the capital stock in the previous period, k_{t-1} and the wage in the current period, w_t. Since we assume that the production function is characterised by constant returns to scale we can write the cost function in the above form. Finally, i_t denotes investment in capital in the current period. Note that the customer stock in the previous period and the capital stock in the previous and the current periods are predetermined, that is $x_{t-1} = \bar{x}_{t-1}$, $k_{t-1} = \bar{k}_{t-1}$ and $k_t = \bar{k}_t$.

The first constraint is trivial and needs no further explanation. For simplicity, depreciation is neglected. The second constraint, however, is the net customer flow equation. For our purposes it will henceforth be better to write it in a slightly different form, namely $p_{t+j} = \bar{p}_{t+j} - H^{-1}\big((x_{t+j} / x_{t+j-1}) - 1\big) \equiv G\big((x_{t+j} / x_{t+j-1}), \bar{p}_{t+j}\big)$, which depicts the price of the firm as a function, G, of net customer flows and the competitors' price. See Gottfries (1986).

Generally, the problem for the entrepreneur in the current period is to maximise his utility over time with respect to the two choice variables, i. e. the customer stock, x_{t+j}, and the capital stock, k_{t+j}. The result of the maximisation for the general case is the following two first order conditions:

x_{t+j}:

$$(\partial U_{t+j} / \partial x_{t+j})\left\{G' x_{t+j} y_{t+j} / x_{t+j-1} + G y_{t+j} - C' y_{t+j} w_{t+j}\right\} - \beta(\partial U_{t+j+1} / \partial x_{t+j})\left\{G' x_{t+j+1}^2 y_{t+j+1} / x_{t+j}^2\right\} = 0$$

k_{t+j}:

$$-(\partial U_{t+j} / \partial k_{t+j}) + \beta(\partial U_{t+j+1} / \partial k_{t+j})\left\{C' x_{t+j+1} y_{t+j+1} w_{t+j+1} / k_{t+j} - C w_{t+j+1} + 1\right\} = 0. \qquad (2)$$

However, as our purpose is to explicitly solve the above outlined general model, we will now assume a logarithmic utility function. The assumption of a homothetic utility function in combination with the assumption of constant returns to scale means that neither the customer stock, x_{t+j}, nor the capital stock, k_{t+j}, will ever converge to a steady state value. On the other hand, for a given market price, $\bar{p}_{t+j}$, and a given wage, w_{t+j}, there will exist steady state paths, where the ratios $x_{t+j} y_{t+j} / k_{t+j}$ and k_{t+j} / k_{t+j-1} are constant, so that the firm can grow or shrink forever. Now, in order to simplify the notation we introduce the new variable z_{t+j} for the ratio of production to capital $\ _{t+j}\ \ _{t+j}\ /\ \ _{t+j}$, which we substitute into the utility function and into the constraints. See *appendi* . Thus, the choice variables for the firm are the ratio of sales to capital, z_{t+j}, and the capital stock, $\ _{t+j}$, and we will solve for the steady state paths of sales relative to the capital stock and for the growth rate of the capital stock, that is for z_{t+j} and $\ _{t+j}\ /\ \ _{t+j-1}$.

The entrepreneur's maximisation problem, with the constraints already substituted into the utility function, is thus a discrete sum of utilities:

$$\max_{\{\tilde{z}_{t+j},\tilde{k}_{t+j}\}}\sum_{j=0}^{\infty}\beta^{j}\left[\ln\left\{G\left(e^{\tilde{z}_{t+j}-\tilde{z}_{t+j-1}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}-\tilde{y}_{t+j}+\tilde{y}_{t+j-1}},e^{\tilde{\tilde{p}}_{t+j}}\right)e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}-C\left(e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}\right)e^{\tilde{w}_{t+j}}+1-e^{\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}\right\}+\tilde{k}_{t+j-1}\right], \qquad (3)$$

where the tildes denote logarithms.

To be able to solve the entrepreneur's non-linear maximisation problem we must linearise it around the stationary points $\tilde{y}^{o}$, $\tilde{\tilde{p}}^{o}$ and $\tilde{w}^{o}$ and around the constant growth rates $\tilde{z}^{o}$ and $(\tilde{k}_{t+j}-\tilde{k}_{t+j-1})^{o}$ (cf. Gottfries (1986)). First, we define the function f as follows:

$$\begin{aligned}&U_{t+j}=f\left(\tilde{z}_{t+j},\tilde{z}_{t+j-1},\tilde{k}_{t+j}-\tilde{k}_{t+j-1},\tilde{y}_{t+j},\tilde{y}_{t+j-1},\tilde{\tilde{p}}_{t+j},\tilde{w}_{t+j}\right)+\tilde{k}_{t+j-1}\equiv\\&\ln\left\{G\left(e^{\tilde{z}_{+j}-\tilde{z}_{t+j-1}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}-\tilde{y}_{t+j}+\tilde{y}_{t+j-1}},e^{\tilde{\tilde{p}}_{t+j}}\right)e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}-C\left(e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}\right)e^{\tilde{w}_{t+j}}+1-e^{\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}\right\}+\tilde{k}_{t+j-1}\ .\end{aligned} \qquad (4)$$

Then, we use a second-order Taylor expansion to linearise f. Finally, we maximise using the linearised version of the function f with respect to $\tilde{z}_{t+j}$ and $\tilde{k}_{t+j}$, which yields the following two Euler equations:

$$(\beta f_{21}+(f_{11}+\beta f_{22})L+f_{21}L^{2})\tilde{z}_{t+j+1}=$$
$$-\left\{\begin{array}{l}-(f_{21}(1+\beta)+f_{11}+\beta f_{22})\tilde{z}^{o}-(\beta f_{32}+f_{31})(\tilde{k}_{t+j+1}-\tilde{k}_{t+j})^{o}\\+(\beta f_{32}+(f_{31}-\beta f_{32})L-f_{31}L^{2})(\tilde{k}_{t+j+1}-\tilde{k}_{t+j})\\+(\beta f_{42}+(f_{41}+\beta f_{52})L+f_{51}L^{2})\tilde{y}'_{t+j+1}+\\+(\beta f_{62}+f_{61}L)\tilde{\tilde{p}}'_{t+j+1}+(\beta f_{72}+f_{71}L)\tilde{w}'_{t+j+1}\end{array}\right\}$$

and

$$
\begin{aligned}
&(-\beta f_{31} + (f_{31} - \beta f_{32})L + f_{32}L^2)\tilde{z}_{t+j+1} = \\
&-\left\{\begin{array}{l}
-(1-\beta)((f_{31} + f_{32})\tilde{z}^o - f_{33}(\tilde{k}_{t+j+1} - \tilde{k}_{t+j})^o) \\
+(-\beta f_{33} + f_{33}(1+\beta)L - f_{33}L^2)(\tilde{k}_{t+j+1} - \tilde{k}_{t+j}) \\
+(-\beta f_{43} + (f_{43} - \beta f_{53})L + f_{53}L)\tilde{y}'_{t+j+1} + \\
+(-\beta f_{63} + f_{63}L)\tilde{\overline{p}}'_{t+j+1} + (-\beta f_{73} + f_{73}L)\tilde{w}'_{t+j+1}
\end{array}\right\},
\end{aligned}
\qquad (5)
$$

where the steady state growth rates are represented by $\tilde{z}^o$ and $\left(\tilde{k}_{t+j+1} - \tilde{k}_{t+j}\right)^o$ and where e. g. $\tilde{y}'_{t+j+1} = \tilde{y}_{t+j+1} - \tilde{y}^o$ denotes the deviation from the steady state.

From the above Euler equations we derive the following difference equations for $\tilde{z}_{t+j+1}$ and $\tilde{k}_{t+j+1}$:

$$
\left\{\begin{array}{l}
(\beta^2 f_{21} f_{33} - \beta^2 f_{31} f_{32}) + \\
(-f_{21} f_{33}(\beta + \beta^2) + \beta f_{11} f_{33} + \beta^2 f_{22} f_{33} + f_{31} f_{32}(\beta + \beta^2) - \beta^2 f_{32}^2 - \beta f_{31}^2)L + \\
(2\beta f_{21} f_{33} - f_{11} f_{33}(1+\beta) - f_{22} f_{33}(\beta + \beta^2) - 2\beta f_{31} f_{32} + f_{32}^2(\beta + \beta^2) + f_{31}^2(1+\beta))L^2 + \\
(f_{11} f_{33} + \beta f_{22} f_{33} - f_{21} f_{33}(1+\beta) + f_{31} f_{32} - \beta f_{32}^2 - f_{31}^2 + \beta f_{31} f_{32})L^3 + \\
(f_{21} f_{33} - f_{31} f_{32})L^4
\end{array}\right\}\tilde{z}_{t+j+1} = T_1
$$

and

$$
\left\{\begin{array}{l}
(\beta^2 f_{21} f_{33} - \beta^2 f_{31} f_{32}) + \\
(-f_{21} f_{33}(\beta + \beta^2) + \beta f_{11} f_{33} + \beta^2 f_{22} f_{33} + f_{31} f_{32}(\beta + \beta^2) - \beta^2 f_{32}^2 - \beta f_{31}^2)L + \\
(2\beta f_{21} f_{33} - f_{11} f_{33}(1+\beta) - f_{22} f_{33}(\beta + \beta^2) - 2\beta f_{31} f_{32} + f_{32}^2(\beta + \beta^2) + f_{31}^2(1+\beta))L^2 + \\
(f_{11} f_{33} + \beta f_{22} f_{33} - f_{21} f_{33}(1+\beta) + f_{31} f_{32} - \beta f_{32}^2 - f_{31}^2 + \beta f_{31} f_{32})L^3 + \\
(f_{21} f_{33} - f_{31} f_{32})L^4
\end{array}\right\}\tilde{k}_{t+j+1} = T_2. \qquad (6)
$$

T_1 and T_2 represent the steady state growth rates and the exogenous variables. For a complete description of the above calculations, see*appendix 2*.

Assuming that the solution of the above difference equations has two stable and two unstable roots, we may characterise it as (cf. Sargent (1979)):

$$
\begin{aligned}
&(1-\lambda_1 L)(1-\lambda_4 L)\tilde{z}_{t+j+1} = \\
&(1/(\lambda_2 - \lambda_3))\left\{-\lambda_2 \sum_{j=1}^{\infty}(1/\lambda_2)^j + \lambda_3 \sum_{j=1}^{\infty}(1/\lambda_3)^j\right\} T_1 / (\beta^2(f_{21} f_{33} - f_{31} f_{32})) + \rho_2 \lambda_2^t + \rho_3 \lambda_3^t
\end{aligned}
$$

and

$$(1-\lambda_1 L)(1-\lambda_4 L)\tilde{k}_{t+j+1} =$$
$$(1/(\lambda_2-\lambda_3))\left\{-\lambda_2\sum_{j=1}^{\infty}(1/\lambda_2)^{j} + \lambda_3\sum_{j=1}^{\infty}(1/\lambda_3)^{j}\right\}T_2/(\beta^2(f_{21}f_{33}-f_{31}f_{32})) + \rho_2\lambda_2^t + \rho_3\lambda_3^t \ . \tag{7}$$

The coefficients ρ_2 and ρ_3 are set to zero to ensure that the transversality condition is satisfied. We have not been able to solve for the roots λ_1, λ_2, λ_3 and λ_4 analytically, except that we in *appendix 3* have shown that λ_4 is unity. This reflects that neither the customer stock, $\tilde{x}_{t+j}$, nor the capital stock, $\tilde{k}_{t+j}$, will ever converge to a steady state value. Rather they converge to constant growth paths, that is the ratios $\tilde{z}_{t+j}$ and $\tilde{k}_{t+j} - \tilde{k}_{t+j-1}$ converge to steady state values. In other words, the firm can grow or shrink indefinitely, since we have assumed constant returns to scale, a homothetic utility function and that the long run demand curve is completely elastic (cf. Rotemberg and Woodford (1991)). Short term demand is inelastic, since customers in a customer market react slowly to price changes.

2.2 Numerical solution

Since we have not managed to solve our model analytically, we have had to resort to solving the difference equations numerically[1].

We postulate a linear demand function $x_{t+j} = (1+\xi-\xi p_{t+j})x_{t+j-1}$, where ξ is the elasticity of customer demand with respect to the firm's price, i. e. $\xi = -(\partial x_{t+j}/\partial p_{t+j})(p_{t+j}/x_{t+j})$, when $p_{t+j} = 1$ (cf. Gottfries (1994)). Rewriting the demand function, we get $p_{t+j} = (1/\xi)\left(1+\xi - e^{\tilde{z}_{t+j}-\tilde{z}_{t+j-1}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}-\tilde{y}_{t+j}+\tilde{y}_{t+j-1}}\right)$.

We assume that the production function is Cobb-Douglas[2] and express costs as $C\left(((z_{t+j}k_{t+j})/k_{t+j-1}),1,w_{t+j}\right) = w_{t+j}\left((z_{t+j}k_{t+j})/k_{t+j-1}\right)^{\gamma}$. Thus, the sum of utilities may be rewritten as

$$\max_{\{\tilde{z}_{t+j},\tilde{k}_{t+j}\}} \sum_{j=0}^{\infty} \beta^j \left\{ \ln \left[\begin{array}{l} (1/\xi)\left(1+\xi - e^{\tilde{z}_{t+j}-\tilde{z}_{t+j-1}+\tilde{k}_{t+j}-\tilde{k}_{t+t-1}-\tilde{y}_{t+j}+\tilde{y}_{t+j-1}}\right) e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}} - \\ -w_{t+j}\left(e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}\right)^{\gamma} + 1 - e^{\tilde{k}_{t+j}-\tilde{k}_{t+j-1}} \end{array} \right] + \tilde{k}_{t+j-1} \right\}, \tag{8}$$

where the competitors' price, $\overline{p}_{t+j}$, is normalised to unity.

To solve the model numerically we choose as our reference case a wage level such that the firm neither grows, nor shrinks. The magnitude of w_{t+j} determines the profitability of the firm and, consequently, whether the firm will expand or diminish in steady state. Thus, in the reference case $\left(\tilde{k}_{t+j} - \tilde{k}_{t+j-1}\right)_{steadystate}$ is set to zero and the wage, w_{t+j}, is calculated to 0.86.

The elasticity of demand, ξ, is set to 0.8. This value has been found in estimations of export equations by Gottfries (1985) and (1994). The parameter γ is set to 1.4, corresponding to a value of α equal to 0.3. The subjective rate of time preference, β, is assigned the value 0.9, so that firms are relatively concerned about the present period. The probability of the market disappearing is thus included in the subjective rate of time preference. Without loss of generality we may normalise demand in steady state to zero. Finally, rather than solving for the general paths of $\tilde{z}_t$, $(\tilde{k}_{t+1} - \tilde{k}_t)$ and $\tilde{p}_t$, we simplify the solution by assuming that the exogenous variables are constant in future periods.

Thus, having assigned values to the elasticity, ξ, the parameter γ, the wage, w_t, and the rate of time preference, β, and assuming that there are no shocks to demand and suppressing the competitors' price, $\tilde{\overline{p}}_t$, we use Newton's method to iterate the steady state solutions to $\tilde{z}_{steadystate}$ and $\left(\tilde{k}_{t+j} - \tilde{k}_{t+j-1}\right)_{steadystate}$ from the Euler equations (5). Among

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[1] The computations were performed in Mathematica™.

[2] The production function is defined as $q_{t+j} = k_{t+j-1}{}^{\alpha} l_{t+j}{}^{1-\alpha}$, where q_{t+j} is the quantity produced and l_{t+j} is labour. Rewrite the production function to $l_{t+j} = k_{t+j-1}\left(q_{t+j} / k_{t+j-1}\right)^{\gamma}$, where γ is the inverse of $1-\alpha$. The costs that accrue to labour are thus $k_{t+j-1}\left(q_{t+j} / k_{t+j-1}\right)^{\gamma} w_{t+j}$. With production equal to sales we get the cost function $C\left(z_{t+j}k_{t+j}, k_{t+j-1}, w_{t+j}\right) = w_{t+j}k_{t+j-1}\left((z_{t+j}k_{t+j}) / k_{t+j-1}\right)^{\gamma}$. Dividing by k_{t+j-1} and then using the assumption of constant returns to scale we get $C\left(((z_{t+j}k_{t+j}) / k_{t+j-1}), 1, w_{t+j}\right) = w_{t+j}\left((z_{t+j}k_{t+j}) / k_{t+j-1}\right)^{\gamma}$.

other things, we then compute the steady state values of the second order derivatives to ensure that there is a maximum to the function. Thereafter, we use our results in *appendix 3* to compute the roots λ_1, λ_2 and λ_3 that we could not solve for analytically. Finally, we solve the entrepreneur's maximisation problem according to *appendix 4*. For the reference case the results are:

$$\tilde{z}_t = 0.88\tilde{z}_{t-1} - 1.99(\tilde{k}_t - \tilde{k}_{t-1}) - 0.18 - 0.154\tilde{W} - 0.88\tilde{y}_{t-1} + 0.84\tilde{y}_t + 0.010\tilde{Y}$$

$$\tilde{k}_{t+1} - \tilde{k}_t = 0.13\tilde{z}_{t-1} - 0.30\left(\tilde{k}_t - \tilde{k}_{t-1}\right) + 0.11 + 0.090\tilde{W} - 0.14\tilde{y}_{t-1} - 0.24\tilde{y}_t + 0.15\tilde{Y}$$

$$p_t = \left(2.25 - 1.25e^{\tilde{z}_t - \tilde{z}_{t-1} + \tilde{k}_t - \tilde{k}_{t-1} - \tilde{y}_t + \tilde{y}_{t-1}}\right) \ , \qquad (9)$$

where capital letters denote the values of the exogenous variables from*t+1* and onwards.

We may interpret the first decision rule as follows. If the predetermined investments, $\left(\tilde{k}_t - \tilde{k}_{t-1}\right)$, are high, the price must be raised in the current period in order to finance them. The prise rise, however, discourages current buyers, which reduces the customer stock. Consequently, the ratio of sales to capital, $\tilde{z}_t$, falls. Furthermore, given the predetermined investments, if the firm comes out of the previous period with a high $\tilde{z}_{t-1}$, it will not want to expand its customer stock in the current period, but rather increase investments. Hence, it raises the price and increases its current revenues thanks to the high customer stock passed on from - .

As to the second decision rule, let us assume that in the previous period sales relative the capital stock, $\tilde{z}_{t-1}$, were high. Consequently, there was reason to increase investments. Hence, current investments, $\left(\tilde{k}_t - \tilde{k}_{t-1}\right)$, are high. Since the firm is credit rationed it has to increase profits in order to finance the investments and therefore it raises the price, which in turn causes some customers to leave the firm. A diminishing customer stock means that the need for new machines and equipment is less urgent and, thus, the next period investments, $\left(\tilde{k}_{t+1} - \tilde{k}_t\right)$, will fall.

Finally, the third decision rule determines a price that is consistent with an optimal choice of the customer stock and of investments.

To find out how the solution of the entrepreneur's maximisation problem is altered by parameter changes we carry out a sensitivity analysis, the results of which are compiled in *5*. It seems that the decision rules are qualitatively very robust to different parameter values, since the coefficients in them never change signs. The quantitative changes are also small for the range of parameter values considered. Furthermore, varying the parameters yields expected changes of the steady state values of $\tilde{z}$ and $\left(\tilde{k}_t - \tilde{k}_{t-1}\right)$. These changes are also rather minor in magnitude.

2.3 Comparative statics

We conduct a comparative statics analysis of how the firm's pricing and investment decisions are affected by temporary and permanent shocks in demand and wage costs. In order to carry out this analysis we differentiate (9). See *6* for the computations. For the results of the reference case, see table 1 below.

Tbl. *Comparative statics for the reference case.*

	Temporary shock	Permanent shock
$\partial\tilde{p}_t / \partial\tilde{y}_t$	0.19421	0.14656
$\partial\tilde{p}_t / \partial\tilde{w}_t$	0.56163	0.75352
$\partial\left(\tilde{k}_{t+1} - \tilde{k}_t\right) / \partial\tilde{y}_t$	-0.023764	0.13502
$\partial\left(\tilde{k}_{t+1} - \tilde{k}_t\right) / \partial\tilde{w}_t$	-0.068723	0.022905

The computations were carried out in Mathematica™. Note that $\partial\tilde{p}_t / \partial\tilde{y}_t$ and $\partial\tilde{p}_t / \partial\tilde{w}_t$ denote how price is affected by shocks to demand and wage costs, whereas $\partial\left(\tilde{k}_{t+1} - \tilde{k}_t\right) / \partial\tilde{y}_t$ and $\partial\left(\tilde{k}_{t+1} - \tilde{k}_t\right) / \partial\tilde{w}_t$ refer to the response of investments.

In the customer market model of Gottfries (1991) the firm lowers its price in response to a temporary demand shock. In our model, however, the firms raises its price, i. e. $\partial\tilde{p}_t / \partial\tilde{y}_t^{Temporary} > 0$. In other words, it behaves qualitatively as in a static model. This somewhat unexpected result probably depends on the choice of utility function. The logarithmic utility function is not concave enough for the entrepreneur to smooth his consumption over time and future customers are hence less valuable to the firm. Consequently, current profits matter more to the entrepreneur than future revenues.

If the increase in demand is permanent the firm will raise its price, i. e. $\partial\tilde{p}_t / \partial\tilde{y}_t^{Permanent} > 0$, thus again acting procyclically. However, the rise in price is smaller than the rise is, when the firm experiences a temporary shock in demand. This implies that setting the price too high may lead to a loss of a substantial amount of customers, which would decrease future profits to such an extent that investments cannot be financed. Thus, the firm has to balance its wish to attract and keep customers and its need for investments by setting reasonably high prices. Put shortly, customers are valuable to the firm, as are future profits.

As to cost shocks, the firm behaves as expected. It reacts to a temporary shock in wages by raising the price, i. e. $\partial\tilde{p}_t / \partial\tilde{w}_t^{Temporary} > 0$. Since it cannot turn to financial intermediaries for credits, it must itself finance the increased costs. Therefore it raises the price of its products in order to generate revenues. This finding is also true for a permanent shock in wage costs, i. e. $\partial\tilde{p}_t / \partial\tilde{w}_t^{Permanent} > 0$. In the latter case, however, the firm will raise its price more than if the shock is only temporary. This is natural, since high future costs make future customers less valuable.

A temporary shock in demand forces the firm to reduce investments: $\partial\left(\tilde{k}_{t+1} - \tilde{k}_t\right) / \partial\tilde{\ }_t^{Temporary}$ <0. A temporary boom makes the entrepreneur raise the current price of his product. Therefore, his current customer stock will decrease, as will the incentives to invest. Hence, the future marginal value of investments is low and there is less need for more capital in the next period.

On the other hand, a permanent increase in demand leads to increased investments, i. e. $\partial\left(\tilde{k}_{t+1} - \tilde{k}_t\right) / \partial\tilde{\ }_t^{Permanent}$ >0, as there will be a need for new machines and equipment in the future to satisfy the future demand. The profits generated by the higher demand will pay for these investments.

A temporary rise in wage costs makes the firm reduce investments, i. e. $\partial\left(\tilde{k}_{t+1}-\tilde{k}_t\right)/\partial\tilde{w}_t^{Temporary}$<0. Since the firm is credit-rationed it raises the current price of its product as wages soar. This will lead to a loss of customers, so that the marginal value of future investments diminishes. In addition, the firm will experience a lower profit in the future and will not be able to finance an expansion of its capital stock.

If the firm experiences a permanent cost shock, it will increase investments slightly, i. e. $\partial\left(\tilde{k}_{t+1}-\tilde{k}_t\right)/\partial\tilde{w}_t^{Permanent}$>0. This is quite surprising - one would expect the opposite result. Actually, the second decision rule in (9) does show that investments will fall in the long run, since permanently higher wage costs will leave the entrepreneur with less customers and hence less future funds to spend. However, investments seem to be reallocated intertemporally, i. e. the firm invests more in the current period, when the customer stock is still relatively large. It is easier to finance investments with the currently larger customer stock than it will be in the periods to come.

We also carry out a sensitivity analysis similar to the one in section 2.2. The effects of shocks are unaltered, i. e. the signs of the derivatives are not changed and the following relations unambiguously still hold $\left|\partial\tilde{p}_t/\partial\tilde{y}_t^{Temporary}\right|>\left|\partial\tilde{p}_t/\partial\tilde{y}_t^{Permanent}\right|$, $\left|\partial\tilde{p}_t/\partial\tilde{w}_t^{Temporary}\right|<\left|\partial\tilde{p}_t/\partial\tilde{w}_t^{Permanent}\right|$, $\left|\partial\left(\tilde{k}_{t+1}-\tilde{k}_t\right)/\partial\tilde{y}_t^{Temporary}\right|<\left|\partial\left(\tilde{k}_{t+1}-\tilde{k}_t\right)/\partial\tilde{y}_t^{Permanent}\right|$ and $\left|\partial\left(\tilde{k}_{t+1}-\tilde{k}_t\right)/\partial\tilde{w}_t^{Temporary}\right|>\left|\partial\left(\tilde{k}_{t+1}-\tilde{k}_t\right)/\partial\tilde{w}_t^{Permanent}\right|$. Therefore, we conclude that the results of this section are stable. The results of the sensitivity analysis are compiled in *appendix 6*.

2.4 An illustration of the adjustment to the steady state[3]

[3] The figures were constructed in Excel 5.0. We assumed that the firm started out with a $\tilde{z}_0$ that is fifty percent higher than the steady state value. Hence we used $\tilde{z}_0$=-0.405 and $\tilde{k}_0-\tilde{k}_{-1}=\tilde{k}_1-\tilde{k}_0$=0 as the initial values for the two first decision rules when computing the paths of figures 1 - 3. In contrast to solving for the decision rules (9) we assumed that the deviations of the exogenous variables from steady state were zero. This is rationalised by our wish to illustrate the adjustment of $\tilde{z}_0$, $\tilde{k}_0-\tilde{k}_{-1}$ and $\tilde{p}_0$ to the steady state given the exogenous variables.

In this section we want to investigate the adjustment to the steady state. We imagine that our firm comes into period *t=1* with a higher ratio of customers to capital, $\tilde{z}_1$, than the steady state value. Thanks to the relatively large customer stock there is a need for more machinery to produce items to satisfy the customers. However, investments are predetermined in the periods *t=0* and *t=1.* Consequently, they remain zero at *t=0*, as well as at *t=1.* Because of time-to-build investments can increase only at *t=2*.

The higher ratio of customers to capital, $\tilde{z}_1$, at *t=1* is passed on from *t=0*. At first it falls at a slow rate due to the increase in price. After *t=1* it decreases faster because of the increased capital stock, but then again falls slower as investments adjust to their steady state path. At *t=7* the firm has reached its steady state path as to $\tilde{z}$, whereas investments adjust at a somewhat slower pace. See *figures 1* and *2*.

Figure 1. *The ratio of customers to capital,* $\tilde{z}_t$.

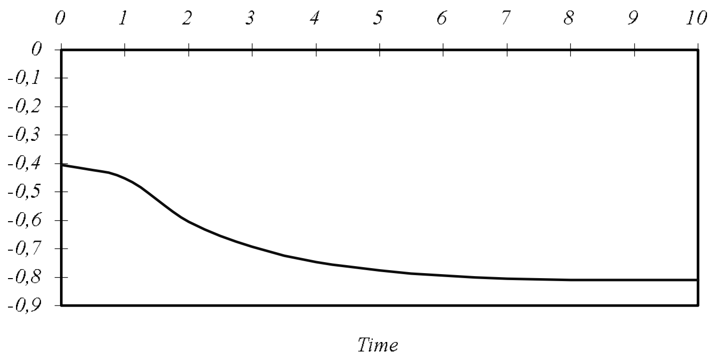
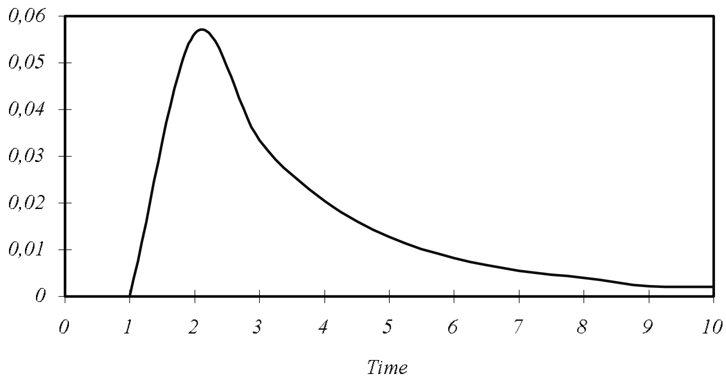
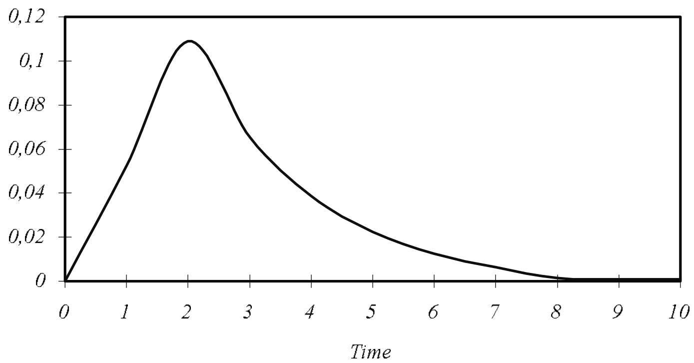


Figure 2. Investments $\tilde{k}_t - \tilde{k}_{t-1}$.



In *figure 3* we see that the shape of the firm's price path to a great extent coheres with that of the investment path, although the price starts to rise already at $t=1$ as a response to the higher ~ . At the same time as investments reach a peak at $t=2$, the firm's price soars in order to finance them. With a falling customer stock, i. e. a decreasing ~ , from $t=1$ and onwards, there is less incentive to invest, though. Therefore the rate of investments is decelerated from $t=2$ towards the steady state path and the firm correspondingly starts to lower its price. The price almost approaches the market price at $t=8$.

Figure 3. Price, $\tilde{p}_t$.



3. Empirical evaluation of the model

In order to find out whether the connection between prices and investments in our theoretical model has its counterpart in the real world, we now empirically investigate the determination of prices in the Swedish manufacturing industry in relation to its competitors in the thirteen OECD-countries Norway, Denmark, Finland, Belgium, France, Germany, Italy, the Netherlands, Switzerland, United Kingdom, Canada, Japan and the United States. We use annual data covering the period 1960 - 1993.

First, we construct the econometric equation. Then, we describe the data and the construction of the variables. Finally, we report the results of the estimations.

3.1 The econometric price equation

Remember that the solution of the theoretical model for $\tilde{z}_t$, $\left(\tilde{k}_t - \tilde{k}_{t-1}\right)$ and p_t was derived assuming that all future exogenous variables are constant. From this solution we derive the following linearised price equation, where future and current variables do not differ:

$$\tilde{p}_t = \alpha_1 \tilde{\bar{p}}_t + \alpha_2 (\tilde{q}_{t-1} - \tilde{k}_{t-1}) + \alpha_3 \Delta \tilde{k}_t + \alpha_4 \tilde{w}_t + \alpha_5 \Delta \tilde{y}_t + \mu_t \qquad (10)$$

The price is denoted $\tilde{p}_t$, $\tilde{\bar{p}}_t$ is the market price, $\tilde{q}_{t-1}$ is lagged production, $\tilde{k}_{t-1}$ is the lagged capital stock, $\tilde{w}_t$ is wage costs, $\Delta \tilde{y}_t$ is a shift variable indicating fluctuations in market demand and, finally, μ_t is a stochastic term reflecting other factors that affect price setting. As before, the tildes denote logarithms.

For a rationalisation of the equation above, see pp . When one compares the equation with that of the price path (9) one sees that the variable $\tilde{}_t$ has been eliminated. This is necessary, since the customer stock is unobserved in data. As Sweden is an open economy, an empirical investigation of price setting behaviour must take into account prices of foreign producers and fluctuations in market demand. Wage costs are naturally an important determinant of price setting, whether the economy is open or not. Note moreover, that according to the theory behind our model, the coefficients α_1 and α_4 sum to unity.

Furthermore, we add three explanatory variables to (10), in order to capture effects that are disregarded in the theoretical model, but may be important in reality. First, the firm of our model is perfectly informed about the competitors' prices, an assumption that may not hold in the real world. Hence, unpredictable components of the movements in the competitors' prices, $\tilde{\bar{p}}_t^u$, must be taken into account (cf. Gottfries (1994)). Second, in our model we refrain from studying technological development. However, there has been an actual growth in factor productivity during the investigated period (cf. Bergman and Hansson (1991)). In order to capture the level of technical development we therefore construct a variable named "factor productivity", $\tilde{a}_t$. Finally, the real interest rate has to be taken into consideration, although we in the theoretical part of this essay assume that the firm faces a perfect credit constraint. As mentioned in section 1, we find it plausible that real firms are to some extent credit rationed. However, we do not believe that all firms of the Swedish manufacturing sector are completely so, for which reason the real interest rate, r_t, should be important for pricing behaviour in a customer market.

Thus imposing the restriction $\alpha_1 + \alpha_4 = 1$ and adding $\tilde{\bar{p}}_t^u$, $\tilde{a}_t$ and r_t to (10) yields the following basic equation to be estimated:

$$(\tilde{p}_t - \tilde{\bar{p}}_t) = const + \alpha_1(\tilde{w}_t - \tilde{\bar{p}}_t) + \alpha_2(\tilde{q}_{t-1} - \tilde{\bar{k}}_{t-1}) + \alpha_3\Delta\tilde{\bar{k}}_t + \alpha_4\Delta\tilde{y}_t + \alpha_5\tilde{\bar{p}}_t^u + \alpha_6\tilde{a}_t + \alpha_7 r_t + \mu_t \ .$$

(11)

It deserves to be noticed that the theoretical model and consequently the equations (10) and (11) are derived for a single firm, whereas the estimations, of course, apply to the whole manufacturing sector. In other words, we assume that one single firm behaves exactly as all other firms. This strong assumption means that we disregard aggregation problems, the consequences of which are hard to evaluate.

3.2 Data and variable construction

For a comprehensive description of the sources, a precise treatment of the data set and a thorough description of how the series and the variables were constructed, see *pp* .

The domestic and foreign prices are constructed from producer price indices for the manufacturing sector. These prices refer to gross output. The data on wage costs include wages to employees as well as other forms of compensation, e. g. payroll taxes. Production, capital stock and investments are also in gross terms and fixed prices and, as well as the wage costs, refer to the whole manufacturing sector.

The shift variable, $\tilde{\Delta}_t$, which reflects the fluctuations in market demand, was constructed by taking a weighted sum of foreign production and domestic absorption. The weights reflect the share of deliveries from the manufacturing sector that is exported from Sweden and the share that remains within the country. Foreign production is used as a proxy for foreign market demand.

Swedish firms set their prices using information of predictable movements in the market price that are based on known, lagged information. The unpredictable component of the market price, $\tilde{\tilde{p}}_t^u$, is thus the difference between actual outcomes and predictions. Hence, we ran a regression of $\tilde{\tilde{p}}_t$ on a constant and two lags of $\tilde{\tilde{p}}_t$ and created a foreign price forecast series. This series was subtracted from the original market price series. Thus, the series of unexpected movements in the market price was created.

In order to capture the level of technical development we have constructed the variable "factor productivity", $\tilde{a}_t$. Differentiating the production function and considering that the manufacturing sector is characterised by imperfect competition yields $\tilde{a}_t = \tilde{q}_t - m\left\{s_k \tilde{k}_t + s_l \tilde{l}_t\right\}$. Tildes denote logarithms, the terms s_k and s_l represent the factor shares for capital and labour and *m* is the mark-up. The factor shares are simply the arithmetical averages for the period 1960 - 1990, whereas the mark-up in our reference case is 1.14 (cf. *a5*).

The real interest rate used in the estimations is the short real interest rate computed according to the formula $r_t = i_t - \pi^{predicted}$, where is the real interest rate, i is the nominal interest rate and $\pi^{predicted}$ is the predicted inflation. The latter was constructed by running the change in consumer price index, i. e. $\left((CPI_{t+1} - CPI_t)/CPI_t\right)$, on a constant and two lags of this variable itself.

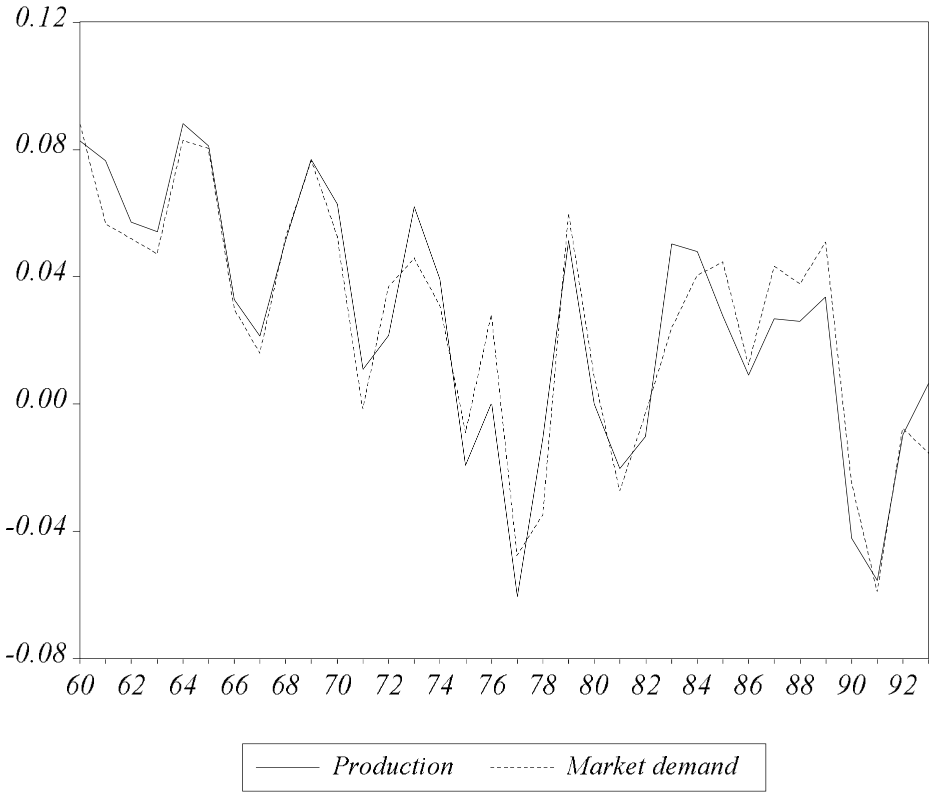
3.3 Customer demand, investments and prices in Sweden 1960 - 1993

In this section we show a few graphs[4] to illustrate some characteristics of the data. During the investigated period the most notable features of the Swedish economy are a falling rate of productivity growth (cf. Bergman and Hansson (1991)) and rising wage costs.

In *i r 4* we see the close correlation between production, $\tilde{q}_t$, and market demand, $\tilde{y}_t$. The variables are very synchronic and contrary to what might be expected production does not lag market demand. The slowdown in the production growth during most of the period is clearly visible.

[4] The graphs were constructed in Econometric Views 1.1.

i r 4 First differences of logarithmed production and market demand

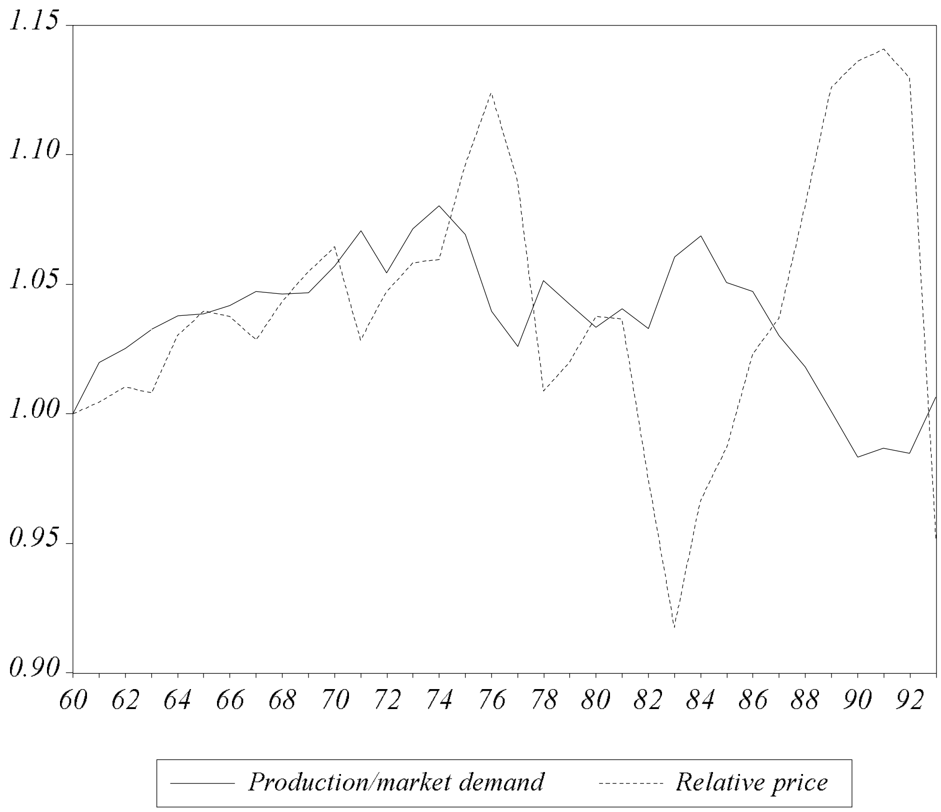


In *figure 5* the relationship between the ratio of production to market demand, q_t / y_t , and the relative price, $p_t / \overline{p}_t$, is shown. In terms of our theoretical model, *figure 5* depicts the interaction between price and customer stocks. Both production relative to market demand and relative price show a positive trend until 1974, from which year there is a decreasing trend in production relative to market demand. This is explained by an overall fall of the productivity growth rate. The increase in relative price in 1976 reflects that wage costs started to rise at a higher rate in Sweden than in the competing countries.

The temporary increase of production relative to market demand in 1983 and 1984, reflects a production increase and an overall increase in demand for Swedish exported goods caused by the 1983 devaluation of the Swedish krona, seen as a fall in the relative price due to reductions in relative producer costs.

The wage negotiations in the latter part of the 1980's resulted in a sharp increase in relative wage costs, consequently leading to an increase in relative price. The downward trend in production relative to market demand is broken in 1992, because of the depreciation of the Swedish krona from November that year.

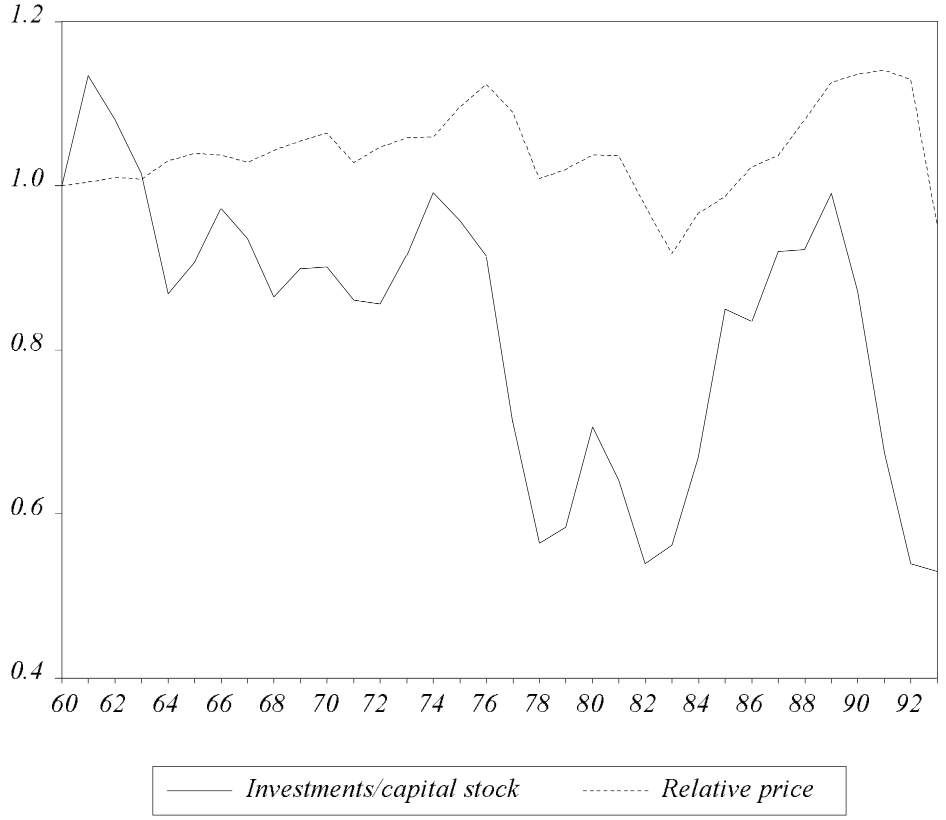
Figure 5. Production/market demand and relative price



Furthermore, in correspondence with our theoretical model, a positive correlation between investments relative to capital stocks and relative price is shown in *figure 6*. During almost the entire investigated period both variables show a similar upward trend, although weaker as to the relative price.

Figure 6.

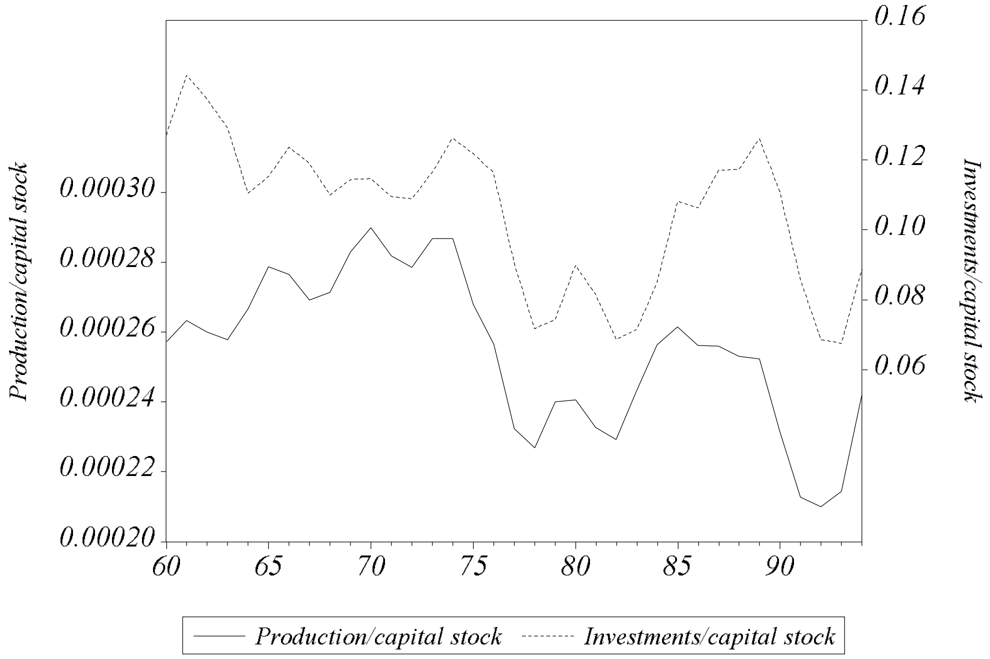
Investments relative to capital stock and relative price



Finally, *figure 7* shows the relationship between production and investments, both divided by the capital stock, i. e. ${}_t / k_t$ and $\Delta k_t / k_t$. The correlation between production and investments is apparent, although the increase in production until the late 1960s is met by a slowdown in investments. A notable feature is the delay in investments compared to production, which probably reflects time-to-build effects.

The strong correlation of production and investments may be interpreted as a high degree of self-financing, confirming one of the tenets behind our theoretical model. Only with high production generating a large cash flow dare firms take decisions to invest. The correlation may, however, also be interpreted in another way, namely that firms invest in periods characterised by high demand, because future expected demand and hence profitability will also be high.

Figure 7. The ratios of production to capital stock and investments to capital stock



3.4 Results

We have estimated three specifications of the following equation by 2SLS and OLS (cf. (11) in section 3.1):

$$(\tilde{p}_t - \tilde{\bar{p}}_t) = const + \alpha_1(\tilde{w}_t - \tilde{\bar{p}}_t) + \alpha_2(\tilde{q}_{t-1} - \tilde{\bar{k}}_{t-1}) + \alpha_3\Delta\tilde{\bar{k}}_t + \alpha_4\Delta\tilde{y}_t + \alpha_5\tilde{\bar{p}}_t^u + \alpha_6\tilde{a}_t + \alpha_7 r_t + \mu_t \quad .$$

(12)

In specification 1 we straightforwardly estimate the above equation. Specification 2 reports the result of estimating it without the real interest rate. This specification is chosen, since the theoretical model rests on the supposition that the firm is financially constrained. Furthermore, we have tried an alternative measure of technical progress but $\tilde{a}_t$, since it may be subjected to some measurement error. Therefore, in specification 3 we use a smoothed version of ”factor productivity”, namely a polynomial. That is, we run

”factor productivity” on a linear, a quadratic and a cubic trend and then use the predictions of that regression to create a smoothed series of $\tilde{a}_t$.

Gottfries (1994) found that prices are preset. Therefore, we let the disturbances follow a MA(1)-process when estimating by OLS[5] . Imagine that the firms in the autumn of the previous period are to publish price lists for the current period. These prices will be marred with errors, since costs, competitors’ prices and other factors that affect price setting neither for the previous, nor for the current period are known. On the other hand, the costs of the period before the previous are completely known, for which reason the pricing error has a memory only for the current and the previous periods, thus generating a MA(1)-process. When estimating by 2SLS we accordingly use independent variables lagged two periods as instruments.

3.4.1 Estimation with instrumental variables

We have estimated specifications 1 - 3 with instrumental variables, since there are possible measurement errors to the explanatory variables. For instance $\tilde{q}_{t-1} - \tilde{k}_{t-1}$ may not measure the exact customer demand. If that is the case, it cannot explain the relative price, because it is correlated with the disturbance μ_t. In addition, the variables $\Delta\tilde{y}_t$ and $\tilde{a}_t$ are also probably subjected to measurement errors. As to $\Delta\tilde{}_t$, its construction is rather involved and proxies for some of its components are used. The productivity growth, $\tilde{a}_t$, is in itself difficult to measure.

In order to circumvent these problems we have estimated specifications 1 - 3 with a set of instruments, namely: $\tilde{w}_{t-2} - \tilde{\tilde{p}}_{t-2}$, $\tilde{q}_{t-2} - \tilde{\tilde{p}}_{t-2}$, $\tilde{a}_{t-2}$, , t^2, $\tilde{u}_{t-2}$, $\Delta\tilde{y}_{t-2}^{OECD}$ and $\tilde{e}_{t-2}$, where $\tilde{u}_{t-2}$, $\Delta\tilde{y}_{t-2}^{OECD}$ and $\tilde{e}_{t-2}$ denote unemployment, the foreign component of market demand and the nominal exchange rate. Note that we use the second lags of the instruments in

[5] We have also carried out the 2SLS-estimations with MA(1)-terms. As we have come to terms with the measurement errors by using instrumental variables, the coefficients of the MA(1)-terms in these estimations are expectedly insignificant.

accordance with the finding of Gottfries (1994) that prices may be predetermined. When the firms set their prices for the next period it is possible that they do not know the current outcome of e. g. the relative wage, for which reason this, and the other instruments, must be lagged two periods. Thus, $\tilde{w}_{t-1} - \tilde{\tilde{p}}_{t-1}$ is correlated to the disturbance μ_t, whereas $\tilde{w}_{t-2} - \tilde{\tilde{p}}_{t-2}$ is not.

The 2SLS-estimations are reported in table 2. We have carried out Sargan-tests on the instrument set and not in one single case were the instruments rejected. The results of these tests are reported in *pp x 9*. The OLS-estimations, which yield very similar results to the 2SLS-estimations, are reported and discussed in *ppx9* *b2Dpb* $\left(\tilde{p}_t - \tilde{\tilde{p}}_t\right)$

	Spec. 1	Spec. 2	Spec. 3
Constant	-1.0650	-1.5849	-0.6856
	(-1.3092)	(-2.0932)	(-0.8267)
$\tilde{w}_t - \tilde{\tilde{p}}_t$	0.2901	0.2558	0.3238
	(3.2622)	(2.8842)	(3.5068)
$\tilde{q}_{t-1} - \tilde{k}_{t-1}$	-0.2105	-0.3216	-0.2733
	(-1.4643)	(-2.5103)	(-2.0906)
$\Delta\tilde{k}_t$	0.1928	0.2275	0.2054
	(3.7273)	(4.7422)	(4.3621)
$\Delta\tilde{y}_t$	0.04795	0.2050	-0.2658
	(0.1631)	(0.7299)	(-0.9709)
$\tilde{\tilde{p}}_t^u$	-0.07821	-0.09340	-0.04243
	(-1.4966)	(-1.7575)	(-0.7719)
$\tilde{a}_t$		-0.3730	-0.3427
		(-4.4025)	(-4.0490)
r_t	0.3917		0.4469
	(1.4106)		(1.7049)
”Smoothed” $\tilde{\ }_t$			-0.4706
			(-4.5736)
R^2	0.8390	0.8203	0.8626
Durbin-Watson	1.8340	1.8018	1.7209

SLS y E V w 1 1 -
pp .

We now dwell somewhat on specification 2, since this is the most straightforward one. A ten percent increase in the relative wage forces the firms to raise the price by approximately 2.6 per cent. This result is significant at the five percent level and is in accordance with section 2.3, where the firm will raise its price, regardless of whether the shock to wage costs is temporary or permanent.

The estimate of $\tilde{\ }_{t-1} - \tilde{k}_{t-1}$ comes in with the wrong sign and is significant. Theoretically, the firms should raise their prices, since they can take advantage of the already high customer stock from the previous period. However, this discouraging result is a classical one in estimations of price equations (cf. Forslund and Lindh (1991) and Gottfries (1991)). As to the magnitude of the estimated coefficient it may be noted that theoretically, with the values of the reference case, it should be approximately 0.15[6].

As to investments, $\Delta\tilde{k}_t$, the result of estimating specification 2 confirms the tenet of our model, namely that investments are an important determinant of the firms' price setting in a customer market. The sign of the coefficient is positive and the t-value is strongly significant. If the capital stock increases by ten percent in the current period the firms of the sample raise the price by 2.3 percent. This is low in comparison to the theoretical reference case, where a ten percent increase of the capital stock leads to a 12 percent increase in price[7]. However, the theoretical firm faces an absolute credit constraint, whereas the firms of the empirical investigation can borrow some part of the needed funds.

The role of market demand, $\Delta\tilde{\ }_t$, with respect to price setting is not clear. According to table 2 the response to a ten percent demand shock is a price rise of 2.1 per cent. This result is not statistically significant, however. In section 2.3 an increase in exogenous market demand indeed raises the price, regardless of whether the shock is permanent or temporary.

The unexpected component of the foreign price, $\tilde{\tilde{p}}_t^u$, behaves as expected in specification 2. An increase by ten percent in this component indicates that the firms' price differs by 0.9 per cent from what the price would be if the firms had had perfect information. The result is significant at the five percent level.

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[6] According to *appendix 7* $\alpha_2 = -\left((\beta_1 - 1)/\xi\right) = -\left((0.88 - 1)/0.8\right) = 0.15$.

[7] According to *appendix 7* $\alpha_3 = -\left((\beta_{12} + 1)/\xi\right) = -\left((-1.99 + 1)/0.8\right) = 1.2$.

A ten percent increase in ”factor productivity”, $\tilde{}_t$, reduces the price more than three percent, a finding that is statistically significant. It is clear that the growth of productivity plays an important role during the period and that this trend is captured by the variable $\tilde{}_t$.

When one compares the estimation results of specifications 1 - 3 it is noteworthy that they are qualitatively and quantitatively similar. The only change of sign accrues to the coefficient of $\Delta\tilde{y}_t$ in specification 3, which is negative, but insignificant. Moreover, the magnitude of this parameter estimate varies within a considerable range in the estimated specifications. It is noteworthy that the variable $\tilde{q}_{t-1} - \tilde{k}_{t-1}$ always comes in with the wrong sign and, moreover, significantly so in the specifications 2 and 3. The real interest rate, r_t, comes in with the correct sign, but is insignificant in both specifications. In specification 3 we replace $\tilde{}_t$ by a ”smoothed” version of $\tilde{}_t$ (see section 3.2 and *pp* *8*), the parameter estimate of which neither qualitatively, nor quantitatively differs from the ”non-smoothed” one in the other specifications.

4. Concluding remarks

The purpose of this essay has been to study the interaction between price setting and investment in capital. Therefore, we have constructed, solved and empirically tested a customer market model with two choice variables, namely customers and capital. To our knowledge, the literature on customer market models up to this point deals with the customer stock as the only determinant of price.

The model was constructed so as to take time-to-build effects and credit restrictions into account. The solution yielded three steady state paths, characterising the ratio of sales to capital, investments and price. A comparative statics analysis was carried out to find out how the firm responds to exogenous shocks in demand and wage costs. Using data for the Swedish manufacturing industry the model was tested estimating a price equation, derived from the solution of the model.

The main finding is that there is a clear connection between price setting and investments. Actually, the intuition is evident: a profit-maximising firm needs customers to make profits. In turn, machines and equipment are needed to produce the items customers want. Thus, investments are required and funds must be raised. The only way for a credit constrained firm to raise funds is to increase profits by adjusting the price.

The steady state paths show a close interaction between prices and investments: the firm balances high prices and current profits with lower prices and future profits. Since the firm cannot take loans and because of time-to-build, investments decided upon in the current period can be financed only by the firm's own future cash-flow. When exposed to exogenous shocks in demand and wage costs, the firm adjusts its price and investments to make the best of the shocks. The empirical investigation confirms that investments influence price setting to a great extent. As a matter of fact, in all specifications estimated, investments do help to explain prices.

As in Gottfries (1994) the main findings in this essay are that investments and prices are closely related and that investments exert a positive influence on prices. Contrary to Gottfries (1991) and Chevalier and Scharfstein (1994) we find that in the theoretical model demand shocks cause the financially constrained firm to raise its price. This finding, however, may hinge on our need to simplify the computations by using a logarithmic utility function, which appears not to be concave enough to replicate the results obtained by those authors. Therefore, an interesting topic for further research would be to explore the behaviour of the model of this essay by using alternative utility functions. Moreover, considering that our empirical investigation is rather rudimentary, more elaborate empirical tests of the model would also be of interest.

Appendix 1. Logarithmic utility

First, we assume that production equals sales, i. e. $q_{t+j} = x_{t+j} y_{t+j}$, where x_{t+j} is the customer stock and y_{t+j} is demand per customer. Then, let us introduce the new variable z_{t+j}, which is defined by $z_{t+j} = x_{t+j} y_{t+j} / k_{t+j}$. We substitute z_{t+j} for x_{t+j} into the utility function. For instance, costs are rewritten to $C\left(z_{t+j}k_{t+j},k_{t+j-1}\right)w_{t+j}$. Assuming constant returns to scale, the cost function can be expressed as $C\left(((z_{t+j}k_{t+j})/k_{t+j-1}),1\right)k_{t+j-1}w_{t+j}$. As to the second constraint, it is rewritten as $p_{t+j}=G\left((z_{t+j}k_{t+j}y_{t+j-1})/(z_{t+j-1}k_{t+j-1}y_{t+j}),\bar{p}_{t+j}\right)$ and together with the first constraint substituted into the objective function to get

$$\sum_{j=0}^{\infty}\beta^{j}ln\left\{G\left((z_{t+j}k_{t+j}y_{t+j-1})/(z_{t+j-1}k_{t+j-1}y_{t+j}),\bar{p}_{t+j}\right)z_{t+j}k_{t+j}-C\left((z_{t+j}k_{t+j})/k_{t+j-1}\right)k_{t+j-1}w_{t+j}+k_{t+j-1}-k_{t+j}\right\}$$

$$\equiv\sum_{j=0}^{\infty}\beta^{j}\left[ln\left\{G\left((z_{t+j}k_{t+j}y_{t+j-1})/(z_{t+j-1}k_{t+j-1}y_{t+j}),\bar{p}_{t+j}\right)((z_{t+j}k_{t+j})/k_{t+j-1})-C\left((z_{t+j}k_{t+j})/k_{t+j-1}\right)w_{t+j}+1-(k_{t+j}/k_{t+j-1})\right\}+lnk_{t+j-1}\right]$$

This expression is identical to (4) in section 2.1.

Appendix 2. Derivation of the Euler equations and the difference equations

We define f as $U_{t+j}=f\left(\tilde{z}_{t+j},\tilde{z}_{t+j-1},\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right),\tilde{y}_{t+j},\tilde{y}_{t+j-1},\tilde{\bar{p}}_{t+j},\tilde{w}_{t+j}\right)+\tilde{k}_{t+j-1}\equiv$

$$\equiv\ln\left\{G\left(e^{\tilde{z}_{t+j}-\tilde{z}_{t+j-1}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}-\tilde{y}_{t+j}+\tilde{y}_{t+j-1}},e^{\tilde{\bar{p}}_{t+j}}\right)e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}-C\left(e^{\tilde{z}_{t+j}+\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}\right)e^{\tilde{w}_{t+j}}+1-e^{\tilde{k}_{t+j}-\tilde{k}_{t+j-1}}\right\}+\tilde{k}_{t+j-1}\;.$$

Using Young's theorem, we linearise f around the steady state growth of customers to capital, $\tilde{z}^{o}$, and of capital, $(\tilde{k}_{t+j}-\tilde{k}_{t+j-1})^{O}$, and around the stationary points $\tilde{y}^{o},\tilde{\bar{p}}^{o}$ and $\tilde{w}^{o}$. The discounted utility is then:

$$(1+\beta)f\left(\tilde{z}^{o},\tilde{z}^{o},(\tilde{k}_{t+j+1}-\tilde{k}_{t+j})^{o},\tilde{y}^{o},\tilde{y}^{o},\tilde{\bar{p}}^{o},\tilde{w}^{o}\right)+\tilde{k}_{t+j-1}+\beta\tilde{k}_{t+j}+f_1\tilde{z}'_{t+j}+f_2\tilde{z}'_{t+j-1}+f_3(\tilde{k}_{t+j}-\tilde{k}_{t+j-1})'+f_4\tilde{y}'_{t+j}+f_5\tilde{y}'_{t+j-1}+$$
$$+f_6\tilde{\bar{p}}'_{t+j}+f_7\tilde{w}'_{t+j}+\beta(f_1\tilde{z}'_{t+j+1}+f_2\tilde{z}'_{t+j}+f_3(\tilde{k}_{t+j+1}-\tilde{k}_{t+j})'+f_4\tilde{y}'_{t+j+1}+f_5\tilde{y}'_{t+j}+f_6\tilde{\bar{p}}'_{t+j+1}+f_7\tilde{w}'_{t+j+1})+$$

$$+½\left[f_{11}\tilde{z}'^{2}_{t+j}+f_{22}\tilde{z}'^{2}_{t+j-1}+f_{33}\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right)'^{2}+f_{44}\tilde{y}'^{2}_{t+j}+f_{55}\tilde{y}'^{2}_{t+j-1}+f_{66}\tilde{\bar{p}}'^{2}_{t+j}+f_{77}\tilde{w}'^{2}_{t+j}\right]+$$
$$+½\beta\left[f_{11}\tilde{z}'^{2}_{t+j+1}+f_{22}\tilde{z}'^{2}_{t+j}+f_{33}\left(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}\right)'^{2}+f_{44}\tilde{y}'^{2}_{t+j+1}+f_{55}\tilde{y}'^{2}_{t+j}+f_{66}\tilde{\bar{p}}'^{2}_{t+j+1}+f_{77}\tilde{w}'^{2}_{t+1}\right]+$$
$$+\left[\begin{array}{l}f_{21}\tilde{z}'_{t+j}\tilde{z}'_{t+j-1}+f_{31}\tilde{z}'_{t+j}\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right)'+f_{32}\tilde{z}'_{t+j-1}\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right)'+f_{41}\tilde{z}'_{t+j}\tilde{y}'_{t+j}+f_{42}\tilde{z}'_{t+j-1}\tilde{y}'_{t+j}+f_{43}\tilde{y}'_{t+j}\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right)'+\\ f_{51}\tilde{z}'_{t+j}\tilde{y}'_{t+j-1}+f_{52}\tilde{z}'_{t+j-1}\tilde{y}'_{t+j-1}+f_{53}\tilde{y}'_{t+j-1}\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right)'+f_{54}\tilde{y}'_{t+j}\tilde{y}'_{t+j-1}+\\ f_{61}\tilde{z}'_{t+j}\tilde{\bar{p}}'_{t+j}+f_{62}\tilde{z}'_{t+j-1}\tilde{\bar{p}}'_{t+j}+f_{63}\tilde{\bar{p}}'_{t+j}\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right)'+f_{64}\tilde{y}'_{t+j}\tilde{\bar{p}}'_{t+j}+f_{65}\tilde{y}'_{t+j-1}\tilde{\bar{p}}'_{t+j}+\\ f_{71}\tilde{z}'_{t+j}\tilde{w}'_{t+j}+f_{72}\tilde{z}'_{t+j-1}\tilde{w}'_{t+j}+f_{73}\tilde{w}'_{t+j}\left(\tilde{k}_{t+j}-\tilde{k}_{t+j-1}\right)'+f_{74}\tilde{y}'_{t+j}\tilde{w}'_{t+j}+f_{75}\tilde{y}'_{t+j-1}\tilde{w}'_{t+j}+f_{76}\tilde{\bar{p}}'_{t+j}\tilde{w}'_{t+j}\end{array}\right]+$$

$$
+\beta\begin{bmatrix} f_{21}\tilde{z}'_{t+j+1}\tilde{z}'_{t+j}+f_{31}\tilde{z}'_{t+j+1}\left(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}\right)'+f_{32}\tilde{z}'_{t}\left(\tilde{k}_{t+1}-\tilde{k}_{t+j}\right)'+f_{41}\tilde{z}'_{t+j+1}\tilde{y}'_{t+j+1}+f_{42}\tilde{z}'_{t+j}\tilde{y}'_{t+j+1}+f_{43}\tilde{y}'_{t+j+1}\left(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}\right)'+ \\ f_{51}\tilde{z}'_{t+j+1}\tilde{y}'_{t+j}+f_{52}\tilde{z}'_{t+j}\tilde{y}'_{t+j}+f_{53}\tilde{y}'_{t+j}\left(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}\right)'+f_{54}\tilde{y}'_{t+j+1}\tilde{y}'_{t+j}+ \\ f_{61}\tilde{z}'_{t+j+1}\tilde{\tilde{p}}'_{t+j+1}+f_{62}\tilde{z}'_{t+j}\tilde{\tilde{p}}'_{t+j+1}+f_{63}\tilde{\tilde{p}}'_{t+j+1}\left(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}\right)'+f_{64}\tilde{y}'_{t+j+1}\tilde{\tilde{p}}'_{t+j+1}+f_{65}\tilde{y}'_{t+j}\tilde{\tilde{p}}'_{t+j+1}+ \\ f_{71}\tilde{z}'_{t+j+1}\tilde{w}'_{t+j+1}+f_{72}\tilde{z}'_{t+j}\tilde{w}'_{t+j+1}+f_{73}\tilde{w}'_{t+j+1}\left(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}\right)'+f_{74}\tilde{y}'_{t+j+1}\tilde{w}'_{t+j+1}+f_{75}\tilde{y}'_{t+j}\tilde{w}'_{t+j+1}+f_{76}\tilde{\tilde{p}}'_{t+j+1}\tilde{w}'_{t+j+1} \end{bmatrix}+\ldots
$$

where e. g. $\tilde{z}'_{t+j}=\tilde{z}_{t+j}-\tilde{z}^{o}$.

The Euler equations are derived from the following first order conditions:

$$
\frac{\partial U}{\partial \tilde{z}_{t+j}}=0=f_1+\beta f_2+(\beta f_{21}+\left(f_{11}+\beta f_{22}\right)L+f_{21}L^2)\tilde{z}'_{t+j+1}+
$$
$$
+(\beta f_{32}+(f_{31}-\beta f_{32})L-f_{31}L^2)(\tilde{k}_{t+j+1}-\tilde{k}_{t+j})'+(\beta f_{42}+(f_{41}+\beta f_{52})L+f_{51}L^2)\tilde{y}'_{t+j+1}+
$$
$$
+(\beta f_{62}+f_{61}L)\tilde{\tilde{p}}'_{t+j+1}+(\beta f_{72}+f_{71}L)\tilde{w}'_{t+j+1}
$$

(1)

$$
\frac{\partial U}{\partial \tilde{k}_{t+j}}=0=\beta+f_3\;-\beta f_3+(-\beta f_{31}+\left(f_{31}-\beta f_{32}\right)L+f_{32}L^2)\tilde{z}'_{t+j+1}+
$$
$$
+(-\beta f_{33}+f_{33}(1+\beta)L-f_{33}L^2)\left(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}\right)'+(-\beta f_{43}+(f_{43}-\beta f_{53})L+f_{53}L)\tilde{y}'_{t+j+1}+
$$
$$
+(-\beta f_{63}+f_{63}L)\tilde{\tilde{p}}'_{t+j+1}+(-\beta f_{73}+f_{73}L)\tilde{w}'_{t+j+1}\quad .
$$

(2)

The deviations from the steady state are denoted ‘. Since we are at the stationary point, where $\tilde{z}'_{t+j+1}=\tilde{z}'_{t+j}=\tilde{z}'_{t+j-1}=(\tilde{k}_{t+j+1}-\tilde{k}_{t+j})'=(\tilde{k}_{t+j}-\tilde{k}_{t+j-1})'=0$ we have that $f_1+\beta f_2=0$ and $\beta+\left(1-\beta\right)f_3=0$.

From the first order conditions (1) and (2) we derive two Euler equations:

$$
(\beta f_{21}+\left(f_{11}+\beta f_{22}\right)L+f_{21}L^2)\tilde{z}_{t+j+1}=
$$
$$
-\begin{Bmatrix} -(f_{21}(1+\beta)+f_{11}+\beta f_{22})\tilde{z}^{o}-(\beta f_{32}+f_{31})(\tilde{k}_{t+j+1}-\tilde{k}_{t+j})^{o} \\ +(\beta f_{32}+(f_{31}-\beta f_{32})L-f_{31}L^2)(\tilde{k}_{t+j+1}-\tilde{k}_{t+j}) \\ +(\beta f_{42}+(f_{41}+\beta f_{52})L+f_{51}L^2)\tilde{y}'_{t+j+1}+ \\ +(\beta f_{62}+f_{61}L)\tilde{\tilde{p}}'_{t+j+1}+(\beta f_{72}+f_{71}L)\tilde{w}'_{t+j+1} \end{Bmatrix}
$$

and

$$
(-\beta f_{31} + \left(f_{31} - \beta f_{32}\right) L + f_{32} L^2)\tilde{z}_{t+j+1} =
-\left\{ \begin{array}{l}
-(1-\beta)(f_{31} + f_{32})\tilde{z}^o - f_{33}(\tilde{k}_{t+j+1} - \tilde{k}_{t+j})^o) \\
+(-\beta f_{33} + f_{33}(1+\beta) L - f_{33} L^2)\left(\tilde{k}_{t+j+1} - \tilde{k}_{t+j}\right) \\
+(-\beta f_{43} + (f_{43} - \beta f_{53}) L + f_{53} L)\tilde{y}'_{t+j+1} + \\
+(-\beta f_{63} + f_{63} L)\tilde{\bar{p}}'_{t+j+1} + (-\beta f_{73} + f_{73} L)\tilde{w}'_{t+j+1}
\end{array} \right\}.
$$

These Euler equations in turn give us the difference equations for $\tilde{z}_{t+j+1}$ and $\tilde{k}_{t+j+1}$ below

$$
\left\{ \begin{array}{l}
\left(\beta^2 f_{21} f_{33} - \beta^2 f_{31} f_{32}\right) + \\
\left(-f_{21} f_{33}(\beta + \beta^2) + \beta f_{11} f_{33} + \beta^2 f_{22} f_{33} + f_{31} f_{32}(\beta + \beta^2) - \beta^2 f_{32}^2 - \beta f_{31}^2\right) L + \\
\left(2\beta f_{21} f_{33} - f_{11} f_{33}(1+\beta)\right) - f_{22} f_{33}(\beta + \beta^2) - 2\beta f_{31} f_{32} + f_{32}^2(\beta + \beta^2) + f_{31}^2(1+\beta)) L^2 + \\
\left(f_{11} f_{33} + \beta f_{22} f_{33} - f_{21} f_{33}(1+\beta) + f_{31} f_{32} - \beta f_{32}^2 - f_{31}^2 + \beta f_{31} f_{32}\right) L^3 + \\
\left(f_{21} f_{33} - f_{31} f_{32}\right) L^4
\end{array} \right\} \tilde{z}_{t+j+1} = T_1
$$

and

$$
\left\{ \begin{array}{l}
\left(\beta^2 f_{21} f_{33} - \beta^2 f_{31} f_{32}\right) + \\
\left(-f_{21} f_{33}(\beta + \beta^2) + \beta f_{11} f_{33} + \beta^2 f_{22} f_{33} + f_{31} f_{32}(\beta + \beta^2) - \beta^2 f_{32}^2 - \beta f_{31}^2\right) L + \\
\left(2\beta f_{21} f_{33} - f_{11} f_{33}(1+\beta)\right) - f_{22} f_{33}(\beta + \beta^2) - 2\beta f_{31} f_{32} + f_{32}^2(\beta + \beta^2) + f_{31}^2(1+\beta)) L^2 + \\
\left(f_{11} f_{33} + \beta f_{22} f_{33} - f_{21} f_{33}(1+\beta) + f_{31} f_{32} - \beta f_{32}^2 - f_{31}^2 + \beta f_{31} f_{32}\right) L^3 + \\
\left(f_{21} f_{33} - f_{31} f_{32}\right) L^4
\end{array} \right\} \tilde{k}_{t+j+1} = T_2 \ ,
$$

where

$$
\begin{aligned}
T_1 = {} & (\beta f_{32} + (f_{31} - \beta f_{32}) L - f_{31} L^2)((\beta f_{43} - (f_{43} - \beta f_{53}) L - f_{53} L^2)(\tilde{y}_{t+j+1} - \tilde{y}^o) + \\
& (\beta f_{63} - f_{63} L)(\tilde{\bar{p}}_{t+j+1} - \tilde{\bar{p}}^o) + (\beta f_{73} - f_{73} L)(\tilde{w}_{t+j+1} - \tilde{w}^o)) - \\
& (-\beta f_{33} + f_{33}(1+\beta) L - f_{33} L^2)((-\beta f_{42} - (f_{41} + \beta f_{52}) L - f_{51} L^2)(\tilde{y}_{t+j+1} - \tilde{y}^o) + \\
& (-\beta f_{62} - f_{61} L)(\tilde{\bar{p}}_{t+j+1} - \tilde{\bar{p}}^o) + (-\beta f_{62} - f_{61} L)(\tilde{w}_{t+j+1} - \tilde{w}^o))
\end{aligned}
$$

and

$$
\begin{aligned}
T_2 = {} & (1 - \beta((f_{31} + f_{32})(\beta f_{32} + f_{31}) - f_{33}((f_{21}(1+\beta) + f_{11} + \beta f_{22}))(\tilde{k}_{t+j+1} - \tilde{k}_{t+j})^o + \\
& (-\beta f_{31} + (f_{31} - \beta f_{32}) L + f_{32} L^2)((-\beta f_{42} - (f_{41} + \beta f_{52}) L - f_{51} L^2)(\tilde{y}_{t+j+1} - \tilde{y}^o) + \\
& (-\beta f_{62} - f_{61} L)(\tilde{\bar{p}}_{t+j+1} - \tilde{\bar{p}}^o) + (-\beta f_{72} - f_{71} L)(\tilde{w}_{t+j+1} - \tilde{w}^o)) - \\
& ((\beta f_{21} + (f_{11} + \beta f_{22}) L + \beta f_{21} L^2)((\beta f_{43} - (f_{43} - \beta f_{53}) L - f_{53} L^2)(\tilde{y}_{t+j+1} - \tilde{y}^o) + \\
& (\beta f_{63} - f_{63} L)(\tilde{\bar{p}}_{t+j+1} - \tilde{\bar{p}}^o) + (\beta f_{73} - f_{73} L)(\tilde{w}_{t+j+1} - \tilde{w}^o)) \ .
\end{aligned}
$$

Appendix 3. Proof that λ_4 is a unit root

We simplify the difference equations of *appendix 2*, first by assuming that $T_1 = T_2 = 0$, then by dividing them with $\beta^2(f_{21}f_{33} - f_{31}f_{32})$, which yields $(1 + aL + bL^2 + cL^3 + dL^4)\tilde{z}_{t+j+1} = 0$ and $(1 + aL + bL^2 + cL^3 + dL^4)\tilde{k}_{t+j+1} = 0$, where

$c = (\beta^2(f_{21}f_{33} - f_{31}f_{32}))^{-1}(f_{11}f_{33} + \beta\ f_{22}f_{33} - f_{21}f_{33}(1+\beta) + f_{31}f_{32}(1+\beta) - f_{31}^2 - \beta\ f_{32}^2)$,

$a = \beta c$, $b = -((1+\beta^2)/\beta^2) - (1+\beta)c$ and, finally, $d = 1/\beta^2$.

Factorising the left hand side of the difference equations yields (cfSargent (1979))

$(1-\lambda_1 L)(1-\lambda_2 L)(1-\lambda_3 L)(1-\lambda_4 L) = 0$ or

$$\left\{\begin{matrix} 1-(\lambda_1+\lambda_2+\lambda_3+\lambda_4)L + (\lambda_1\lambda_2+\lambda_1\lambda_3+\lambda_1\lambda_4+\lambda_2\lambda_3+\lambda_2\lambda_4+\lambda_3\lambda_4)L^2 - \\ (\lambda_1\lambda_2\lambda_3+\lambda_1\lambda_3\lambda_4+\lambda_1\lambda_2\lambda_4+\lambda_2\lambda_3\lambda_4)L^3 + \lambda_1\lambda_2\lambda_3\lambda_4 L^4 \end{matrix}\right\} = 0 .$$

Thus, the terms *a, b, c* and *d* can be expressed as

$a = -\lambda_1 - \lambda_2 - \lambda_3 - \lambda_4$

$b = \lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_2\lambda_3 + \lambda_1\lambda_4 + \lambda_2\lambda_4 + \lambda_3\lambda_4$

(1)

$c = -\lambda_1\lambda_2\lambda_3 - \lambda_1\lambda_2\lambda_4 - \lambda_1\lambda_3\lambda_4 - \lambda_2\lambda_3\lambda_4$

$d = \lambda_1\lambda_2\lambda_3\lambda_4$.

To show that we have a unit root let us assume that $\lambda_4 = 1$. Consecutive substitutions of (1) then yields $a + b + c + d = -1$ (2). Now, replace the coefficients *a, b*, *c* and *d* on the left hand side of (2) with their actual definitions to get $\beta c\ -((1+\beta^2)/\beta^2) - (1+\beta)c + c\ +1/\beta^2$ (3). Since (3) equals -1, we have proven that $\lambda_4 = 1$.

Appendix 4. The numerical solution of the model

Using the results of *appendix 2* and *3* we have

$(1-\lambda_1 L)(1-\lambda_2 L)(1-\lambda_3 L)(1-L)\tilde{z}_{t+j+1} = T_1/(\beta^2(f_{21}f_{33} - f_{31}f_{32}))$ and

$(1-\lambda_1 L)(1-\lambda_2 L)(1-\lambda_3 L)(1-L)\tilde{k}_{t+j+1} = T_2/(\beta^2(f_{21}f_{33} - f_{31}f_{32}))$.

We assume that the roots λ_2 and λ_3, which are the inverses of the characteristic roots, exceed unity and therefore are unstable. A solution of e. g. the first of the equations above would be of the following form (cf.Sargent (1979)):

$$(1-\lambda_1 L)(1-L)\tilde{z}_{t+j+1} = (\lambda_2 - \lambda_3)^{-1}\left\{-\lambda_2 \sum_{j=1}^{\infty}(1/\lambda_2)^j + \lambda_3 \sum_{j=1}^{\infty}(1/\lambda_3)^j\right\} T_1 / (\beta^2 (f_{21}f_{33} - f_{31}f_{32})) .$$

In other words, the difference equations for $\tilde{z}_{t+j+1}$ and $\tilde{k}_{t+j+1}$ can be written as below

$$(1-\lambda_1 L)(1-L)\tilde{z}_{t+j+1} = \left(\beta^2 (f_{21}f_{33} - f_{31}f_{32})(1-\lambda_2)(1-\lambda_3)\right)^{-1}$$
$$\left\{\begin{array}{l} (-\beta f_{33} + f_{33}(1+\beta)L - f_{33}L^2)((-\beta f_{42} - (f_{41} + \beta f_{52})L - f_{51}L^2)\tilde{y}'_{t+j+1} + \\ +(-\beta f_{62} - f_{61}L)\tilde{\tilde{p}}'_{t+j+1} + (-\beta f_{72} - f_{71}L)\tilde{w}'_{t+j+1}) - \\ -(\beta f_{32} + (f_{31} - \beta f_{32})L - f_{31}L^2)((\beta f_{43} - (f_{43} + \beta f_{53})L - f_{53}L^2)\tilde{y}'_{t+j+1} + \\ +(\beta f_{63} - f_{63}L)\tilde{\tilde{p}}'_{t+j+1} + (\beta f_{73} - f_{73}L)\tilde{w}'_{t+j+1}) \end{array}\right\}$$

and

$$(1-\lambda_1 L)(\tilde{k}_{t+j+1} - \tilde{k}_{t+j}) = \left(\beta^2 (f_{21}f_{33} - f_{31}f_{32})(1-\lambda_2)(1-\lambda_3)\right)^{-1}$$

$$\left\{\begin{array}{l} (1-\beta)((f_{31} + f_{32})(f_{31} + \beta f_{32}) - f_{33}(f_{21}(1+\beta) + f_{11} + \beta f_{22}))(\tilde{k}_{t+j+1} - \tilde{k}_{t+j})^{o} + \\ +(\beta f_{21} + (f_{11} + \beta f_{22})L + f_{21}L^2)((\beta f_{43} - (f_{43} - \beta f_{53})L - f_{53}L^2)\tilde{y}'_{t+j+1} + \\ +(\beta f_{63} - f_{63}L)\tilde{\tilde{p}}'_{t+j+1} + (\beta f_{73} - f_{73}L)\tilde{w}'_{t+j+1}) - \\ -(-\beta f_{31} + (f_{31} - \beta f_{32})L + f_{32}L^2)((-\beta f_{42} - (f_{41} + \beta f_{52})L - f_{51}L^2)\tilde{y}'_{t+j+1} + \\ +(-\beta f_{62} - f_{61}L)\tilde{\tilde{p}}'_{t+j+1} + (-\beta f_{72} - f_{71}L)\tilde{w}'_{t+j+1})) \end{array}\right\} .$$

(1)

Let us now for simplicity denote the right hand sides of (1) K^1_{t+j+1} and K^2_{t+j+1}, so that we express the difference equations as $(1-\lambda_1 L)(1-L)\tilde{z}_{t+j+1} = K^1_{t+j+1}$ and $(1-\lambda_1 L)(\tilde{k}_{t+j+1} - \tilde{k}_{t+j}) = K^2_{t+j+1}$ (2). Furthermore, we use the two Euler equations from *appendix 2*. However, when using these Euler equations we have to take into account the time-to-build effect, i. e. that the choice in *t=0* of $\tilde{z}$ is made for both *t=0* and *t=1*, whereas the choice of investments merely applies in *t=1* and onwards, since they are paid only then. Moreover, keep in mind that the function f of *appendix 2* include both $\tilde{y}_{t+j}$ and $\tilde{y}_{t+j-1}$. Hence, K^1_{t+j+1} and K^2_{t+j+1} and the exogenous variables in the Euler equations are constant only from 3 and onwards. Therefore, the Euler equations for $\tilde{z}_{t+j}$ for the periods , , and for $(\tilde{k}_{t+j+1} - \tilde{k}_{t+j})$ for the periods , are used for the solution of the maximisation problem. They are combined with (2) for the period 3 and onwards to yield the system of equations below.

$$\tilde{z}_3 = (1+\lambda_1)\tilde{z}_2 - \lambda_1\tilde{z}_1 + K^1_{t=3}$$
$$(\tilde{k}_3 - \tilde{k}_2) = \lambda_1(\tilde{k}_2 - \tilde{k}_1) + K^2_{t=3}$$
$$\beta f_{22}\tilde{z}_1 + (f_{11} + \beta f_{22})\tilde{z}_0 + f_{21}\tilde{z}_{-1} = -\beta f_{23}\tilde{k}_1 - (f_{31} - \beta f_{32})\tilde{k}_0 + f_{31}\tilde{k}_{-1} + K^3_{t=0}$$
$$\beta f_{22}\tilde{z}_2 + (f_{11} + \beta f_{22})\tilde{z}_1 + f_{21}\tilde{z}_0 = -\beta f_{32}\tilde{k}_2 - (f_{31} - \beta f_{32})\tilde{k}_1 + f_{31}\tilde{k}_0 + K^3_{t=1}$$
$$\beta f_{22}\tilde{z}_3 + (f_{11} + \beta f_{22})\tilde{z}_2 + f_{21}\tilde{z}_1 = -\beta f_{32}\tilde{k}_3 - (f_{31} - \beta f_{32})\tilde{k}_2 + f_{31}\tilde{k}_1 + K^3_{t=2}$$
$$-\beta f_{31}\tilde{z}_2 + (f_{31} - \beta f_{22})\tilde{z}_1 + f_{32}\tilde{z}_0 = \beta f_{33}\tilde{k}_2 - (f_{33} + \beta f_{33})\tilde{k}_1 + f_{33}\tilde{k}_0 + K^4_{t=1}$$
$$-\beta f_{31}\tilde{z}_3 + (f_{31} - \beta f_{22})\tilde{z}_2 + f_{32}\tilde{z}_1 = \beta f_{33}\tilde{k}_3 - (f_{33} + \beta f_{33})\tilde{k}_2 + f_{33}\tilde{k}_2 + K^4_{t=2} \ .$$

$K^1_{t=3}$ and $K^2_{t=3}$ denote the growth rate and the exogenous variables of (2) and $K^3_{t=0}, K^3_{t=1}, K^3_{t=2}$ and $K^4_{t=1}, K^4_{t=2}$ represent the exogenous variables in the Euler equations. The system is solved using the steady state values of the second order derivatives. This gives us the following solution to the entrepreneur's maximisation problem

$$\tilde{z}_0 = 0.88\tilde{z}_{-1} - 1.99(\tilde{k}_0 - \tilde{k}_{-1}) - 0.18 - 0.45\tilde{w}_0 - 0.15\tilde{W} - 0.88\tilde{y}_{-1} + 0.84\tilde{y}_0 + 0.01\tilde{Y}$$
$$\tilde{k}_1 - \tilde{k}_0 = 0.13\tilde{z}_{-1} - 0.30(\tilde{k}_0 - \tilde{k}_{-1}) + 0.11 - 0.069\tilde{w}_0 + 0.090\tilde{W} - 0.14\tilde{y}_{-1} - 0.24\tilde{y}_0 + 0.15\tilde{Y}$$
$$e^{\tilde{p}_0} = \left(2.25 - 1.25e^{\tilde{z}_0 - \tilde{z}_{-1} + \tilde{k}_0 - \tilde{k}_{-1} - \tilde{y}_0 + \tilde{y}_{-1}}\right),$$

where capital letters denote the values from $t=1$ and onwards. Letting the exogenous variables take on constant values only from $t=4$ and onwards, we have carried out a similar computation with seven Euler equations and two characteristic equations valid for $t=4$. The results were identical, which confirmed that the problem has been solved correctly.

Appendix 5. Sensitivity analysis

We have carried out several computations with different values assigned to the various variables and parameters. In all these computations the initial value for the iteration of $\tilde{z}_{steadystate}$ and $\left(\tilde{k}_t - \tilde{k}_{t-1}\right)_{steadystate}$ are arbitrarily set to zero. The results are compiled below. Capital letters denote constant exogenous variables from and onwards.

w = 0.8:

$$\tilde{z}_t = 0.89\tilde{z}_{t-1} - 1.90(\tilde{k}_t - \tilde{k}_{t-1}) - 0.18 - 0.48\tilde{w}_t - 0.14\tilde{W} - 0.89\tilde{y}_{t-1} + 0.86\tilde{y}_t + 0.030\tilde{Y}$$
$$(\tilde{k}_{t+1} - \tilde{k}_t) = 0.15\tilde{z}_{t-1} - 0.33(\tilde{k}_t - \tilde{k}_{t-1}) + 0.12 - 0.082\tilde{w}_t + 0.080\tilde{W} - 0.15\tilde{y}_{t-1} - 0.024\tilde{y}_t + 0.18\tilde{Y}$$

w = 0.9:

$$\tilde{z}_t = 0.88\,\tilde{z}_{t-1} - 2.04\,(\tilde{k}_t - \tilde{k}_{t-1}) - 0.18 - 0.43\,\tilde{w}_t - 0.15\,\tilde{W} - 0.88\,\tilde{y}_{t-1} + 0.84\,\tilde{y}_t + 0.050\tilde{Y}$$
$$(\tilde{k}_{t+1} - \tilde{k}_t) = 0.13\,\tilde{z}_{t-1} - 0.29\,(\tilde{k}_t - \tilde{k}_{t-1}) + 0.10 - 0.062\tilde{w}_t + 0.080\,\tilde{W} - 0.13\,\tilde{y}_{t-1} - 0.023\,\tilde{y}_t + 0.15\tilde{Y}$$

γ = 1.35

$$\tilde{z}_t = 0.89\tilde{z}_{t-1} - 1.99(\tilde{k}_t - \tilde{k}_{t-1}) - 0.19 - 0.47\tilde{w}_t - 0.18\tilde{W} - 0.89\tilde{y}_{t-1} + 0.85\tilde{y}_t + 0.040\tilde{Y}$$
$$\tilde{k}_{t+1} - \tilde{k}_t = 0.13\tilde{z}_{t-1} - 0.29(\tilde{k}_t - \tilde{k}_{t-1}) + 0.10 - 0.070\tilde{w}_t + 0.10\tilde{W} - 0.13\tilde{y}_{t-1} - 0.022\tilde{y}_t + 0.15\tilde{Y}$$

γ = 1.45:

$$\tilde{z}_t = 0.87\tilde{z}_{t-1} - 1.99(\tilde{k}_t - \tilde{k}_{t-1}) - 0.17 - 0.43\tilde{w}_t - 0.14\tilde{W} - 0.87\,\tilde{y}_{t-1} + 0.84\tilde{y}_t + 0.040\,\tilde{Y}$$
$$(\tilde{k}_{t+1} - \tilde{k}_t) = 0.14\tilde{z}_{t-1} - 0.31(\tilde{k}_t - \tilde{k}_{t-1}) + 0.12 - 0.067\tilde{w}_t + 0.080\tilde{W} - 0.14\tilde{y}_{t-1} - 0.025\tilde{y}_t + 0.17\tilde{Y}$$

β = 0.85:

$$\tilde{z}_t = 0.85\tilde{z}_{t-1} - 1.76(\tilde{k}_t - \tilde{k}_{t-1}) - 0.29 - 0.44\tilde{w}_t - 0.18\tilde{W} - 0.85\tilde{y}_{t-1} + 0.81\tilde{y}_t + 0.040\tilde{Y}$$
$$(\tilde{k}_{t+1} - \tilde{k}_t) = 0.13\tilde{z}_{t-1} - 0.28(\tilde{k}_{t+1} - \tilde{k}_t) + 0.032 - 0.070\tilde{w}_t + 0.080\tilde{W} - 0.13\tilde{y}_{t-1} - 0.030\tilde{y}_t + 0.17\tilde{Y}$$

β = 0.95:

$$\tilde{z}_t = 0.93\tilde{z}_{t-1} - 2.32(\tilde{k}_t - \tilde{k}_{t-1}) - 0.028 - 0.50\tilde{w}_t - 0.095\tilde{W} - 0.93\tilde{y}_{t-1} + 0.90\tilde{y}_t + 0.030\tilde{Y}$$
$$(\tilde{k}_{t+1} - \tilde{k}_t) = 0.14\tilde{z}_{t-1} - 0.35(\tilde{k}_t - \tilde{k}_{t-1}) + 0.20 - 0.071\tilde{w}_t + 0.10\tilde{W} - 0.14\tilde{y}_{t-1} - 0.015\tilde{y}_t + 0.15\tilde{Y}$$

ξ = 0.75:

$$\tilde{z}_t = 0.89\tilde{z}_{t-1} - 1.97(\tilde{k}_t - \tilde{k}_{t-1}) - 0.18 - 0.42\tilde{w}_t - 0.14\tilde{W} - 0.89\tilde{y}_{t-1} + 0.85\tilde{y}_t + 0.040\tilde{Y}$$
$$(\tilde{k}_{t+1} - \tilde{k}_t) = 0.14\tilde{z}_{t-1} - 0.31(\tilde{k}_t - \tilde{k}_{t-1}) + 0.12 - 0.066\tilde{w}_t + 0.10\tilde{W} - 0.14\tilde{y}_{t-1} - 0.023\tilde{y}_t + 0.17\tilde{Y}$$

ξ = 0.85:

$$\tilde{z}_t = 0.\quad \tilde{z}_{t-1} - 2.02(\tilde{k}_t - \tilde{k}_{t-1}) - 0.1\quad - 0.47\tilde{w}_t - 0.17\tilde{W} - 0.\quad \tilde{y}_{t-1} + 0.\quad 4\tilde{y}_t + 0.040\tilde{Y}$$
$$(\tilde{k}_{t+1} - \tilde{k}_t) = 0.13\tilde{z}_{t-1} - 0.30(\tilde{k}_t - \tilde{k}_{t-1}) + 0.11 - 0.071\tilde{w}_t + 0.070\tilde{W} - 0.13\tilde{y}_{t-1} - 0.024\tilde{y}_t + 0.16\tilde{Y}$$

	$\tilde{z}_{t\ steadystate}$	$(\tilde{k}_t - \tilde{k}_{t-1})_{steadystate}$	*Price*	*Mark-up*
Reference case	-0.81093	0	1	1.14286
w =0.8	-0.68143	0.01287	0.98381	1.14771
w =0.9	-0.88032	-0.00063902	1.00796	1.14054
γ =1.35	-0.78643	-0.0066837	1.00833	1.14044
γ =1.45	-0.82771	0.00063939	0.99198	1.14524
β =0.85	-0.72655	-0.052613	1.06408	1.12007

β=0.95	-0.88162	0.051399	0.93407	1.16185
ξ=0.75	-0.82393	-0.0030930	1.00279	1.15298
ξ=0.85	-0.79910	0.0019449	0.99771	1.13398

We have also performed computations with initial values ranging from -0.54 to 0.025. These computations gave us the same results as above. For initial values outside this range the computation cannot be performed using the same number (30) of iterations.

Appendix 6. Comparative statics

To compute the firm's response to temporary and permanent shocks in demand and wages we use the solution of the entrepreneur's maximisation problem. For the reference case the solution is:

$$\tilde{z}_0 = 0.88\tilde{z}_{-1} - 1.99(\tilde{k}_0 - \tilde{k}_{-1}) - 0.18 - 0.45\tilde{w}_0 - 0.15\tilde{W} - 0.88\tilde{y}_{-1} + 0.84\tilde{y}_0 + 0.040\tilde{Y}$$

(1)

$$\tilde{k}_1 - \tilde{k}_0 = 0.13\tilde{z}_{-1} - 0.30\left(\tilde{k}_0 - \tilde{k}_{-1}\right) + 0.11 - 0.069\tilde{w}_0 + 0.090\tilde{W} - 0.14\tilde{y}_{-1} - 0.24\tilde{y}_0 + 0.15\tilde{Y} \qquad (2)$$

$$e^{\tilde{p}_0} = \left(2.25 - 1.25e^{\tilde{z}_0 - \tilde{z}_{-1} + \tilde{k}_0 - \tilde{k}_{-1} - \tilde{y}_0 + \tilde{y}_{-1}}\right).$$

(3)

Let us start by analysing the effects on the price. First, assume that the shocks occur in $t=0$ and differentiate (3) w. r. t. $\tilde{p}_0$, $\tilde{z}_0$ and $\tilde{y}_0$. This yields $d\tilde{p}_0 = -1.25e^{(\tilde{z}_0 - \tilde{z}_{-1} + (\tilde{k}_0 - \tilde{k}_{-1}) - \tilde{y}_0 + \tilde{y}_{-1} - \tilde{p}_0)}(d\tilde{z}_0 - d\tilde{y}_0)$ (4). Then, to analyse the price response to a temporary demand shock, i. e. $\partial\tilde{p}_0 / \partial\tilde{y}_0$, we differentiate (1) w. r. t. $\tilde{z}_0$ and $\tilde{}_0$ and substitute into (4), which is evaluated at the steady state. When we investigate the effects of a permanent demand shock that lasts from and into infinity, we set $\tilde{y}_0 + \tilde{Y} = \tilde{Y}^p$ in (1) and differentiate it w. r. t. $\tilde{Y}^p$. This derivative is substituted into (4) to yield $\partial\tilde{p}_0 / \partial\tilde{Y}^p$, which is evaluated at the steady state.

For a temporary cost shock, we differentiate (3) w. r. t. $\tilde{z}_0$ and multiplicate the result with the derivative of (1) w. r. t. $\tilde{w}_0$ .Then $\partial\tilde{}_0 / \partial\tilde{w}_0$ is evaluated at the steady state. A permanent cost shock lasts from and onwards, for which reason we set $\tilde{w}_0 + \tilde{W} = \tilde{W}^p$ in (1). We differentiate (1) w. r. t. $\tilde{W}^p$, multiplicate it with the derivative of (3) w. r. t. $\tilde{}_0$ and evaluate at the steady state to get the sign and magnitude of $\partial\tilde{p}_0 / \partial\tilde{W}^P$.

In order to study how the shocks affect the investment decision of the firm we simply differentiate (2) w. r. t. $\tilde{y}_0$, $\tilde{Y}^p$, $\tilde{w}_0$ and $\tilde{W}^p$. The results of our comparative statics analysis are compiled in the following tables, where the first table reports the results on price setting and the second on investments.

	Temporary demand shock $\partial\tilde{p}_0 / \partial\tilde{y}_0$	*Permanent demand shock* $\partial\tilde{}_0 \quad \partial\tilde{Y}^p$	*Temporary cost shock* $\partial\tilde{p}_0 / \partial\tilde{w}_0$	*Permanent cost shock* $\partial\tilde{p}_0 / \partial\tilde{W}^p$
Reference case	0.19421	0.14656	0.56163	0.75352
$w = 0.8$	0.18274	0.13817	0.61562	0.80443
$w = 0.9$	0.20050	0.15115	0.53498	0.72946
$\gamma = 1.35$	0.18445	0.13305	0.58285	0.78410
$\gamma = 1.45$	0.20310	0.15919	0.54187	0.72507
$\beta = 0.85$	0.21453	0.16379	0.49569	0.69921
$\beta = 0.95$	0.13704	0.10277	0.66166	0.80239
$\xi = 0.75$	0.19724	0.14557	0.56294	0.75363
$\xi = 0.85$	0.19132	0.14734	0.55979	0.74603

	Temporary demand shock $\partial(\tilde{k}_1 - \tilde{k}_0) / \partial\tilde{y}_0$	*Permanent demand shock* $\partial(\tilde{k}_1 - \tilde{k}_0) / \partial\tilde{Y}^p$	*Temporary cost shock* $\partial(\tilde{k}_1 - \tilde{k}_0) / \partial\tilde{w}_0$	*Permanent cost shock* $\partial(\tilde{k}_1 - \tilde{k}_0) / \partial\tilde{W}^p$
Reference case	-0.023764	0.13502	-0.068723	0.022905
$w = 0.8$	-0.024465	0.15380	-0.082420	0.031501
$w = 0.9$	-0.023334	0.12581	-0.062260	0.019268
$\gamma = 1.35$	-0.022206	0.13224	-0.070269	0.036619
$\gamma = 1.45$	-0.025272	0.137800	-0.067423	0.013005
$\beta = 0.85$	-0.030193	0.13381	-0.060763	0.015708
$\beta = 0.95$	-0.014661	0.13973	-0.070788	0.029984
$\xi = 0.75$	-0.023156	0.13868	-0.066091	0.036310
$\xi = 0.85$	-0.024331	0.13151	-0.071189	0.010034

Appendix 7. Rationalisation of the econometric equation

In section 2.2 of this essay we postulated the demand function $x_t = (1 + \xi - \xi p_t)x_{t-1}$. We now rewrite it to get the price as a function of the elasticity and the customer stock in the current and previous period $p_t = 1 - (1/\xi)(x_t / x_{t-1} - 1)$. However, since Swedish enterprises compete in international markets, the relative price, rather than the nominal one, is of interest. Therefore, we must take into account the price of foreign firms, $\bar{p}_t$, i. e. $p_t / \bar{p}_t = 1 - (1/\xi)(x_t / x_{t-1} - 1)$. We rewrite this equation in logarithmic form and, using a first order Taylor-expansion, linearise the left hand side around $\tilde{p}_t - \tilde{\bar{p}}_t = 0$ and the right hand side around $\tilde{x}_t - \tilde{x}_{t-1} = 0$, to get $\tilde{p}_t = \tilde{\bar{p}}_t - 1/\xi(\tilde{x}_t - \tilde{x}_{t-1})$ (1). Tildes denote logarithms.

We have defined the variable z_t as $x_t y_t / k_t$, which yields $\Delta\tilde{x}_t = \Delta\tilde{z}_t + \Delta\tilde{k}_t - \Delta\tilde{y}_t$ (2), where e. g. $\Delta\tilde{x}_t$ denotes $\tilde{x}_t - \tilde{x}_{t-1}$. Assuming that all exogenous variables are constant, according to *appendix 4* the path of ${}_t$ should have the form $\tilde{z}_t = \beta_{11}\tilde{z}_{t-1} + \beta_{12}\Delta\tilde{k}_t + \beta_{13}\tilde{\bar{p}}_t + \beta_{14}\tilde{w}_t + \beta_{15}\Delta\tilde{y}_t$. Adding $(1 - \beta_{11})\tilde{z}_{t-1}$ to both sides results in $\Delta\tilde{z}_t = (\beta_{11} - 1)\tilde{z}_{t-1} + \beta_{12}\Delta\tilde{k}_t + \beta_{13}\tilde{\bar{p}}_t + \beta_{14}\tilde{w}_t + \beta_{15}\Delta\tilde{y}_t$ (3).

Inserting (3) into (2) gives the expression $\Delta\tilde{x}_t = (\beta_{11} - 1)\tilde{z}_{t-1} + (\beta_{12} + 1)\Delta\tilde{k}_t + \beta_{13}\tilde{\bar{p}}_t + \beta_{14}\tilde{w}_t + (\beta_{15} - 1)\Delta\tilde{y}_t$, which inserted into (1) results in $\tilde{p}_t = \tilde{\bar{p}}_t - 1/\xi\{(\beta_{11} - 1)\tilde{z}_{t-1} + (\beta_{12} + 1)\Delta\tilde{k}_t + \beta_{13}\tilde{\bar{p}}_t + \beta_{14}\tilde{w}_t + (\beta_{15} - 1)\Delta\tilde{y}_t\}$ (4). Thus, we have eliminated the unobservable variable $\tilde{x}_t$. However, nor $\tilde{z}_t$ can be observed, but under the assumption that $q_t = x_t y_t$, $\tilde{z}_{t-1}$ is defined as $\tilde{z}_{t-1} = \tilde{q}_{t-1} - \tilde{k}_{t-1}$. Using this definition in (4) we end up with the following econometric price equation:

$$\tilde{p}_t = (1 - \beta_{13}/\xi)\tilde{\bar{p}}_t - ((\beta_{11} - 1)/\xi)(\tilde{q}_{t-1} - \tilde{k}_{t-1}) - ((\beta_{12} + 1)/\xi)\Delta\tilde{k}_t - (\beta_{14}/\xi)\tilde{w}_t - ((\beta_{15} - 1)/\xi)\Delta\tilde{y} \ .$$

Hence, the basic econometric equation is $\tilde{p}_t = \alpha_1 \tilde{\tilde{p}}_t + \alpha_2(\tilde{q}_{t-1} - \tilde{k}_{t-1}) + \alpha_3 \Delta\tilde{k}_t + \alpha_4 \tilde{w}_t + \alpha_5 \Delta\tilde{y}_t + \mu_t$ (5), where $\tilde{p}_t$ is the price, $\tilde{\tilde{p}}_t$ is the weighted sum of export prices of the thirteen foreign countries in the empirical investigation, $\tilde{q}_{t-1}$ is lagged production, $\tilde{k}_{t-1}$ is the lagged capital stock, $\tilde{w}_t$ is the wage cost, $\Delta\tilde{y}_t$ is the shift variable indicating fluctuations in market demand and, finally, μ_t is a stochastic term reflecting other factors that affect price setting. All variables are in logarithms and all of them, except $\tilde{\tilde{p}}_t$, refer to the Swedish manufacturing sector.

Preliminary least squares estimations of (5) led to a quite low Durbin-Watson statistic, probably due to misspecification. Therefore, the variables $\tilde{\tilde{p}}_t^u$, $\tilde{a}_t$ and r_t were included[8], which yielded the equation in section 3.1:

$$(\tilde{p}_t - \tilde{\tilde{p}}_t) = const + \alpha_1(\tilde{w}_t - \tilde{\tilde{p}}_t) + \alpha_2(\tilde{q}_{t-1} - \tilde{k}_{t-1}) + \alpha_3 \Delta\tilde{k}_t + \alpha_4 \Delta\tilde{y}_t + \alpha_5 \tilde{\tilde{p}}_t^u + \alpha_6 \tilde{a}_t + \alpha_7 r_t + \mu_t$$

Appendix 8. Data

The focal point of the empirical investigation is the manufacturing industry, denoted SNI 3, formerly SNR 3000. However, this sector is not defined in the trade statistics, where the SITC-codes prevail. ”Manufactured goods”, SITC 5 - 8 except 68 and 793 , which is most compatible to SNI 3 does not take into account food, beverages, non-ferrous metals, pulp, chemicals, products of petroleum, plastic products and rubber products. However, we have had to use ”manufactured goods” as a proxy of ”manufacturing” for variables constructed partly from trade data.

The countries chosen for the study are those, with which Sweden traditionally trade and compete, namely Norway, Denmark, Finland, Belgium, France, Germany, Italy, the Netherlands, Switzerland, United Kingdom, Canada, Japan and the United States. The Swedish data are either taken from publications of Statistics Sweden or from the National Institute of Economic Research. As to the international data, they mainly originate from various OECD-publications. The exceptions are the oldest data and some recent data on Denmark. The first comes from publications by B. R. Mitchell and for the latter we have had to resort to using data from the Nordic Council of Ministers.

Prices of goods of the Swedish manufacturing sector

The series of producer price indices used in the estimations consists of four separate series, which have been linked together. Since the producer price indices are not published before 1963, we for the earliest years have created a series of producer price indices by deflating value added in current prices with value added in the prices of 1959. This series was linked with a series for the years 1963 to 1968 (1963=100), with a series from 1968 to 1990 (1968=100) and with the most recent series covering the years 1990 to 1993 (1990=100).

Sources:
Statistics Sweden. ”Statistiska meddelanden”: N 1975:98 App. 4, P 1969:12, P 1970:5, P 1974:3, P 1975:5, P 1976:2.2, P 1977:3.2, P 1978:2.2, P 1979:2.2, P 1980:2.2, P 1981:4.2, P 1981:4.2, P 1982:2.2, P 1983:2.1, P1984:2.3, P 10 8503, P 10 8603, P 10 8703, P 10 8803, P 10 8902 , P 10 9002 , P 10 9102. ”Statistical Yearbook '97”: Table 241.

Capital stocks and gross investments

The series for capital stocks and gross investments have been kindly provided by Bengt Hansson at Svenska Handelsbanken, Stockholm. They were generated from data from the National Accounts of Sweden, Statistics Sweden, by the method of perpetual inventory.

Source:
Disc provided by Bengt Hansson, Svenska Handelsbanken, Stockholm. The data originate from his essay ”Capital Stock Estimates for Sweden, 1960 - 88: An Application of the Hulten-Wykoff Studies”, Department of Economics, Uppsala university, 1991. The years 1989 - 93 have been added by Bengt Hansson.

Wage costs

To compute the wage costs we have divided a series of compensation to employees including employers' contributions to social security to a series of hours worked. The series for compensation to employees was created by linking four such series in current

[8] However, including a variable that captures the unknown component of wage costs, created in the same manner as $\tilde{\tilde{p}}_t^u$, barely changes the results. Furthermore, this variable does not behave as expected.

prices, covering the years 1960 - 1963, 1963 - 1970, 1970 - 1980 and 1980 - 1993. The same procedure was used to create the series for hours worked.

Sources for compensation to employees:
Statistics Sweden. "Statistiska meddelanden": N 1975:98 App 4, N10 8501 App. 5, N 10 9501 App. 1
Sources for hours worked:
Statistics Sweden. "Statistiska meddelanden": N 1970:21, N 1975:98 , N 1985: 10,
N 10 9501 App. 2

Foreign prices

Since we were unable to find the export prices of the goods of the manufacturing industries in the OECD countries, we as a proxy had to resort to the OECD export price indices (1990=100) for total exports. The export price indices were first recalculated to Swedish kronor and then normalised to unity in 1976. Finally the price indices were summed, using the 1976 competition weights below.

Country	Norway	Denmark	Finland	Belgium	Germany	France	Italy
Competition weight	1.54	2.97	1.64	7.59	25.8	10.2	7.07

Country	Netherlands	Switzerland	United Kingdom	Canada	Japan	United States
Competition weight	7.38	4.10	9.54	3.49	7.28	11.4

Sources:
Maj Nordin, Swedish National Institute of Economic Research, Stockholm. OECD Main Aggregates Vol. 1, 1960 - 1994, Part 5 and Appendix

Production

The series for Swedish production was created by linking three series of volume indices of the production of the manufacturing sector, ranging from 1960 to 1970 (1968=100), from 1970 to 1990 (1980=100) and from 1990 to 1994 (1990=100).

Sources:
Statistics Sweden. "Statistiska meddelanden": I 1972:7, I 1973:1, I 12 8512, IB 12 8612, IB 8712, IB 8812 , IB 8912, I 12 9009, I 12 9112. "Statistical Yearbook '97": Table 112

Market demand

This variable supposedly reflects variations in Swedish and foreign customers' demand of the goods of the Swedish manufacturing industry. The market demand index therefore consists of a Swedish and a foreign component and it captures the booms and slowdowns of the market.

The Swedish part of the market demand index was calculated by summing the Swedish production and imports to Sweden and then subtracting a series of Swedish exports. This newly created series was normalised to unity in 1976.

However, it was first necessary to manipulate the three original series somewhat. The series for Swedish production was recalculated to the prices of 1976. As to the series of imports and exports, they were created from two separate series. Since the SNI 3-sector cannot be found in the Swedish trade statistics we had to use proxies. For the years 1959 to 1970 not even ”manufactured goods”, SITC 5 - 8 except 68 and 793, could be extracted so we had to resort to using the total imports of goods to and the total exports of goods from Sweden. This is rationalised by the fact that about 80 percent of the Swedish imports and exports consists of ”manufactured goods” or goods from the manufacturing sector. These series, themselves created by linking two series in the prices of 1959 and 1968, were each linked to a series of imports or exports of ”manufactured goods” in the prices of 1991. Those series were directly sent to us from the Swedish National Institute of Economic Research. After linking the series together we recalculated the new series to the prices of 1976 and renormalised them to unity that year. Finally, we summed the series of production and imports, from which we then subtracted the series for exports.

The foreign component of the market demand index consists of a weighted series of volume indices of the production of the manufacturing industry in the OECD countries. Ideally, of course, a series of imports of goods from manufacturing firms would have been preferred, but such a series could unfortunately not be found in the available statistics. For the period 1959 to 1969 not even disaggregated information of production could be found, so as a proxy we had to use indices of total industrial production. In the case of the United Kingdom we had to resort to using that proxy even for the years 1959 to 1988. As to Denmark, however, the proxy was used only for the years 1959 to 1965. For the United States and Canada it was not necessary to use the proxy at all, since series of production of the manufacturing sector were found for the entire period. Except for Denmark, the series for the OECD countries from 1969 and onwards originate from various OECD-publications. As to Denmark, the OECD-statistics were incomplete and we used a linked series of volume indices of the manufacturing industry extracted from various issues of the Yearbook of Nordic Statistics.

Using the abovementioned data, we constructed a complete series of production of the manufacturing industry in each OECD country, which we then normalised to unity in 1976. Finally, we summed the normalised observations for each year using weights on export share given below.

Country	Norway	Denmark	Finland	Belgium	Germany	France	Italy
Export share weight	15.4	14.8	11.3	3.8	11.9	5.8	3.1

Country	Netherlands	Switzerland	United Kingdom	Canada	Japan	United States
Export share weight	4.6	2.5	13.5	2.8	1.3	9.2

Source. Gottfries, Nils (1985), App.1

Thus the foreign part of the market demand, $\tilde{y}_t^{OECD}$, was constructed. Note that we have also used the variable $\tilde{y}_t^{OECD}$ separately, as an instrument, in section 3.4.2.

The final step of the computations of the market demand indices was to calculate a weighted sum of the Swedish and the foreign demand series, where the weights given below reflect the share of deliveries from the manufacturing industry, SNI 3, that is exported from Sweden, and the share that remains within the country. The rather low value of the exported share is due to the fact that some of the gross output is used as inputs in the SNI 3 sector itself. Thus a new series was generated, i. e. the series of market demand indices (1976=100), which is the one used in the estimations.

	Weight)
Exported share	35
Remaining share	65

Source: Statistics Sweden. ”Statistiska meddelanden”: SM I 1977:1.3

Sources of Swedish data:
Statistics Sweden. ”Statistiska meddelanden”: N 10 8601 App. 4, N 1975:98 App. 3

Statistics Sweden. Disc with the 1976 nominal values of Swedish imports and exports of SNI 3-goods provided by Ulrica Åkerman. The Swedish National Institute of Economic Research. Disc provided by Jan Alsterlind.

Sources of foreign data:
Mitchell, B. R.: ”International Historical Statistics: Europe 1750 - 1988”, Table D1,
”International Historical Statistics: Africa, Asia and Oceania 1750 - 1988”, Table E1,
”International Historical Statistics: The Americas 1750 - 1988”, Table E1
OECD Statistics Directorate: ”Main Economic Indicators: Historical Statistics 1964 - 1983”, pp. 52, 94, 206, 262, 290, 326, 416, 450, 480, 572
”Main Economic Indicators: Historical Statistics 1969 - 1988”, pp. 12, 54, 102, 12, 54, 102, 228, 292, 322, 360, 458, 504, 536, 640
”Main Economic Indicators: December 1992”, pp. 48, 96, 102, 116, 122, 126, 130, 140, 144, 148, 160, 164
”Main Economic Indicators: December 1995”, pp. 60, 72, 80, 102, 112, 116, 122, 142, 150, 154, 174, 184
”Main Economic Indicators: November 1996”, pp. 60, 68, 90, 98, 106, 112, 120, 142, 154, 158, 178, 188
Nordic Council of Minister, ed. by the Nordic Statistical Secretariat, Copenhagen. ”Yearbook of Nordic Statistics” : 1971 Table 46, 1974 Table 60, 1978 Table 71, 1981 Table 74, 1985 Table 81, 1989/90” Table 77, 1992 Table 77, 1995 Table 76

Factor productivity

Traditionally the Solow-residual measures the rate of technical change. However, the assumption behind this measure is perfect competition in the output market (see e. g. Hansson (1991b)). This requirement is not met neither in our theoretical model, nor in reality in the manufacturing sector. We have therefore calculated a variable, denoted ”factor productivity”, $\tilde{a}_t$, taking imperfect competition into account. This variable supposedly captures the level of technical development over time.

The rate of technical change can be calculated either from the supply side using gross values or from the demand side using net values, i. e. value added. The first method is preferred when dealing with single industries, since then the value added constitutes a relatively small part of the gross output. However, if one studies a whole sector, e. g. the manufacturing sector, one may use the value added in constant prices. In this case, one only has to consider the inputs labour and capital, whereas in the former case material and energy also has to be taken into account. (See Bergman and Hansson (1991)).

We have used the latter approach so as to construct the variable ”factor productivity” as simply as possible. This simplification can be justified by the fact that we are studying the whole manufacturing sector. Furthermore, data on material and energy inputs were not readily available.

The derivation of ”factor productivity” is shown below[9] . The data on value added were picked from the National Accounts of Sweden. Six series in the prices of 1959, 1968, 1980, 1985 and 1991 were linked together. For the data on labour input, see the section Wage costs in this *appendix*. As to capital input, see under Capital stocks and investments in this *appendix*.

The value of the mark-up that we computed when solving the theoretical model is 1.14 (see *appendix 5*), which does not equal the scale elasticity for the period (according to Bergman and Hansson (1991) it was 1.23 during the period 1953 - 1988). The factor shares were taken from Bergman and Hansson (1991, table A2). The arithmetical averages for the factor shares over the years 1960 to 1990 are for labour 0.773 and for capital 0.227, which are the values used when creating the series ”factor productivity”. The development of ”factor productivity” is shown in the figure below. There is a notable break in the trend in 1974.

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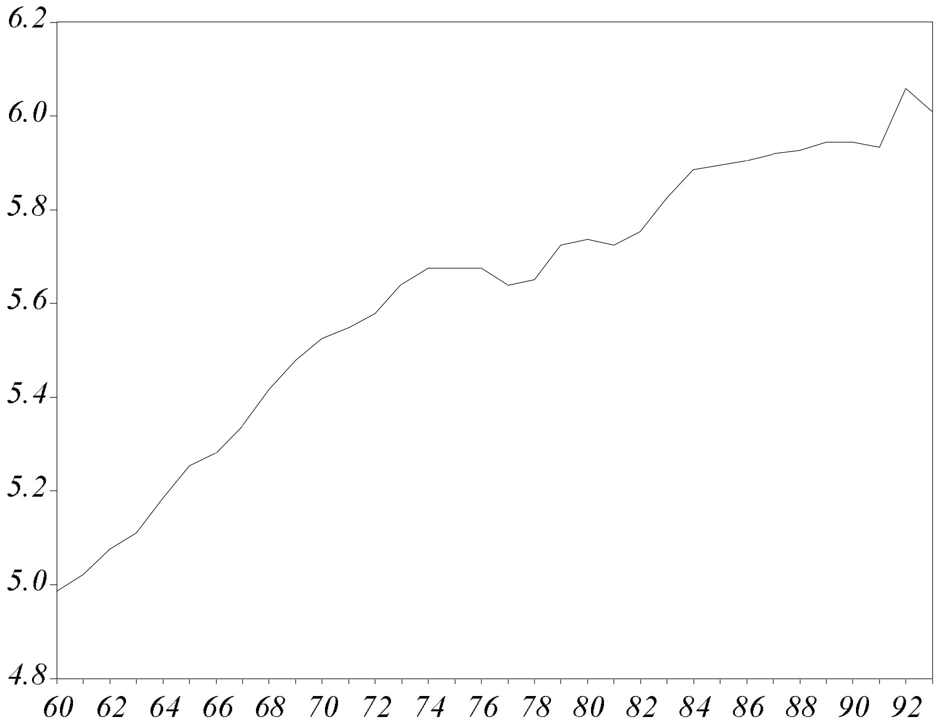
[9] Our production function with the technical factor, a_t, included is $q_t = a_t F(k_t, l_t) = a_t k_t^{\alpha} l_t^{1-\alpha}$. By totally differentiating it and dividing by q_t we get $da_t / a_t = dq_t / q_t - \alpha dk_t / k_t + (1-\alpha) dl_t / l_t$ (*). Since the firm is a monopolistic competitor the price includes a mark-up factor, *m*, and profit maximisation yields $\alpha = m r_t k_t / p_t q_t$ and $(1-\alpha) = m w_t l_t / p_t q_t$. Inserting these into (*) gives us $da_t / a_t = dq_t / q_t - m(r_t k_t / p_{k,t} q_t) dk_t / k_t + m(w_t l_t / p_{l,t} q_t) dl_t / l_t$. (**). Logarithming the production function yields $\tilde{a}_t = \tilde{q}_t - \alpha \tilde{k}_t + (1-\alpha)\tilde{l}_t$, which according to (**) may be written as $\tilde{a}_t = \tilde{q}_t - m\{s_k \tilde{k}_t + s_l \tilde{l}_t\}$, where s_k and s_l represent the factor shares $r_t k_t / p_t q_t$ and $w_t l_t / p_t q_t$. Comparing (**) with e.g. equation (5) in Bergman and Hansson (1991) we see that our mark-up parameter corresponds to the parameter of scale economies (or diseconomies) $\varepsilon_{Qx} = (\partial Q / \partial X)(X / Q)$, where Q is production and X are input factors. This measure shows the deviations from the scale elasticity of the production functions. Unfortunately, we have not been able to derive a connection between the mark-up of (**) and the scale elasticity of the production function. However, contrary to Bergman and Hansson we focus on the level of technical change, rather than the rate.

Factor productivity



Sources:
Statistics Sweden. ”Statistiska meddelanden”: 1975:98 App. 4, N10 8601 App.4, N 10 9501 App 2 &3
Bergman, L. and B. Hansson: ”Vad säger måtten på produktivitetsutvecklingen?” in ed. L. Bergman: ”Ekonomiska rådets årsbok 1991: Produktivitet och tillväxt”, Swedish National Institute of Economic Research, Stockholm 1991

Real interest rates

The series of the real interest rate is created from a series of the short nominal interest rate and a series of predicted inflation, using the formula $r_t = i_t - \hat{\pi}_{t+1}$, where r_t is the real interest rate, i_t is the nominal interest rate and $\hat{\pi}_{t+1}$ is the predicted inflation. In order to construct the latter series, we used the predicted values of the regression of the equation below

$$\left((CPI_{t+1} - CPI_t) / CPI_t\right) = const + \alpha_1\left((CPI_t - CPI_{t-1}) / CPI_{t-1}\right) + \alpha_2\left((CPI_{t-1} - CPI_{t-2}) / CPI_{t-2}\right),$$

where CPI is the consumer price index. Note that because of time-to-build effects the payment of investments decided upon in the current period takes place only in the next period. Therefore, the firms focus on the change in the consumer price index over this and the next period.

The series of the short nominal interest rate for the years 1963 to 1990 cover short-term loans from commercial banks. In order to transform these quarterly data into yearly we simply took the arithmetical averages. This series was linked with a series over the years 1960 to 1963. Furthermore, the series of predicted inflation was constructed by using data on the consumer price index *(CPI)* according to the procedure described above.

Sources on short term interest rates:
The data for the years 1963 to 1990 originate from Lennart Berg, Department of Economics, Uppsala university
The data covering 1960 to 1963 were published in Sveriges Riksbank 1971 Årsbok, Stockholm 1972
Sources of consumer price indices (CPI):
Lennart Berg, Department of Economics, Uppsala university

The nominal exchange rate

The data over the nominal exchange rates were taken from an OECD-publication. They were recalculated to SEK/USD, SEK/CAD and so on and then weighted together with the same competition weights as the foreign prices (see under Foreign prices in this *appendix*).

Sources:
OECD Main Aggregates Vol. 1, 1960 - 1993, Appendix
Maj Nordin, Swedish National Institute of Economic Research, Stockholm

Unemployment

The data on unemployment cover both openly unemployed persons and those in labour market policy programs.

Source:
Anders Forslund, Department of Economics, Uppsala university

Appendix 9. Sargan tests, heteroscedasticity tests and OLS-estimation[10]

Sargan tests

[10] The tests and estimations of this appendix were carried out in Econometric Views, version 1.1.

To find out whether the instrument set $\tilde{w}_{t-2} - \tilde{\tilde{p}}_{t-2}$,$\tilde{q}_{t-2} - \tilde{k}_{t-2}$, $\tilde{a}_{t-2}$, $trend$, $trend^2$, $\tilde{u}_{t-2}$, $\Delta\tilde{y}_{t-2}^{OECD}$ and $\tilde{e}_{t-2}$ is valid, we have carried out a Sargan test, the results of which are compiled in the table below. The most right-hand column refer to the χ^2 critical value at the five percent level. In all three specifications the Sargan statistic is below the critical value and, therefore, the 2SLS estimates are valid.

	Sargan statistic	χ^2 *critical value*
Specification 1	2.9708	11.0705
Specification 2	3.5513	9.4877
Specification 3	4.3839	11.0705

Heteroscedasticity tests and estimation by OLS

We have run the White heteroscedasticity test on the specifications 1 - 3 in section 3.4, which yielded the following result:

	F-statistic
Specification 1	13.4942
Specification 2	20.2446
Specification 3	2.7952

In specifications 1 and 2 the F-statistic is well above the five percent level critical value. Therefore we conclude that heteroscedasticity is present and, when estimating these specifications with OLS, we run them with a White-estimator so as to not underestimate the standard errors. The results of the OLS regressions with MA(1)-terms are shown in the table below[11] .

[11] We have also estimated specifications 1 - 3 by OLS without MA(1)-terms. In that case, the most notable difference is that $\tilde{\tilde{p}}_t^u$ is always insignificant.

Dependent variable is $\left(\tilde{p}_t - \tilde{\tilde{p}}_t\right)$.

	Spec. 1	Spec. 2	Spec. 3
Constant	-2.3851	-2.9137	0.5557
	(-5.8700)	(-9.8289)	(0.7161)
$\tilde{w}_t - \tilde{\tilde{p}}_t$	0.1242	0.0791	0.4479
	(2.5846)	(1.8991)	(5.3346)
$\tilde{q}_{t-1} - \tilde{k}_{t-1}$	-0.3200	-0.4292	-0.09271
	(-4.2401)	(-9.0007)	(-0.7744)
$\Delta\tilde{k}_t$	0.1376	0.2671	0.1277
	(11.3586)	(16.6782)	(2.7685)
$\Delta\tilde{y}_t$	-0.2091	-0.1111	0.001220
	(-1.2290)	(-0.6723)	(0.009038)
$\tilde{\tilde{p}}_t^u$	-0.1444	-0.1663	0.01869
	(-5.8263)	(-7.7426)	(0.3213)
$\tilde{a}_t$	-0.2252	-0.1844	
	(-4.9106)	(-4.7518)	
r_t	0.3102		0.4113
	(1.7980)		(2.0058)
”Smoothed” $\tilde{}_t$			-0.5396
			(-5.8393)
MA(1)	-0.9480	-0.9464	0.3631
	(-19.9868)	(-22.5870)	(1.7141)
R^2	0.8816	0.8675	0.8845
Durbin-Watson	1.5996	1.5823	1.7766

The estimations are OLS. They are conducted in Econometric Views 1.1. T-values are reported in parentheses.

The results of the OLS-estimations are rather similar to the 2SLS-estimations. The exceptions are a significant parameter estimate of $\tilde{\ }_{t-1} - \tilde{k}_{t-1}$ in specification 1 and an insignificant one in specification 3. In the specifications 1 and 2 the parameter $\Delta\tilde{y}_t$ comes in negatively. However, it is still insignificant in all specifications. The parameter estimate of $\tilde{\tilde{p}}_t^u$ has the wrong sign in specification 3 and is insignificant. In specifications 1 and 2 it is rather strongly significant. In

contrast to the 2SLS-estimations, the real interest rate, $_t$, is significant, although weakly in specification 1.

Running the specifications 1 - 3 with MA(1)-processes in the disturbances to allow for prices being predetermined yields the expected result that the autocorrelation coefficient is strongly significant in specifications 1 and 2. In specification 3 it is also significant, but comes in with the wrong sign.

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