Industriens Utredningsinstitut

THE INDUSTRIAL INSTITUTE FOR ECONOMIC AND SOCIAL RESEARCH

A list of Working Papers on the last pages

No. 355, 1992

INSIDER TRADING, MICRO DIVERSITY AND THE LONG–RUN MACRO EFFICIENCY

by

Mikhail Antonov and Georgi Trofimov

December 1992

Postadress
Box 5501
114 85 Stockholm

Gatuadress
Industrihuset
Storgatan 19

Telefon
08-783 80 00
Telefax
08-661 79 69

Bankgiro
446-9995

Postgiro
19 15 92-5

2.92 10.000

INSIDER TRADING, MICRO DIVERSITY AND THE LONG-RUN MACRO EFFICIENCY

Antonov M., Trofimov G.

Abstract. It is now widely recognized that financial markets are the critical allocation mechanisms behind economic growth. The efficiency of that allocation depends on the state of information in the market. Information asymmetries become especially important when it comes to evaluating the assets of firms. We demonstrate - using a firm based macro model of the Swedish economy - that when the most informed actors, the insiders, are allowed to trade in the stock market and the investment behavior of firms is responsive to the market evaluation of firm assets, macroeconomic growth becomes more stable and the long-run efficiency of investment increases.

1. Introduction.

This paper examines the influence of an imperfect stock market on long-run economic development. Imperfections of capital markets are due to information asymmetries and differences in competence among traders. Such imperfections are responsible for many phenomena peculiar to the market economy, such as persistent fluctuations and unemployment. In the short run information asymmetries lead to mistakes in the market valuation of firm assets, with a consequent inefficiency of the investment allocation and negative effects on welfare. Imperfections in capital markets can therefore reinforce macroeconomic fluctuations and decrease the long-run efficiency of growth.

However it is also obvious that under appropriate conditions capital markets can support a favourable regime of economic development. The paper analyses this question on the Micro-Macro model of a national economy formulated on the idea of the experimentally organized economy [Eliasson 1985,1991]. As shown in the paper, long-run macroeconomic efficiency can be improved, despite imperfections in the stock market, if the following conditions are fulfilled.

1) Insider trading is not prohibited, i.e. well informed traders in the stock market that can influence asset prices are allowed to trade.

2) The stock market is characterized by noise trading, but is efficient in the semi-strong sense.

3) Non-informed traders are sufficiently risk-averse.

4) Investment behavior of firms is sensitive to stock market prices.

The question about insider trading has been debated for many years. There are forcible arguments *pro* and *contra*. On the one hand, insider trading brings true information about asset values into the stock market and reduces the risks of participants and improves welfare. Insiders can, however, also use their privileged position to make profits at the expense of "outsiders" - uninformed stock market traders through engaging in strategic behavior.

Some recent theoretical papers discuss these arguments in detail. In [Glosten, Milgrom 1985] it is demonstrated how insiders' information is disseminated to market specialists and uninformed traders in a pure dealership market. In the dynamic model of sequential auctions by Kyle [Kyle 1985] a risk neutral insider confronts risk neutral market makers, who set efficient prices, and irrational (noise) traders. Although the insider information is reflected by prices, the insider makes positive profits by exploiting his monopoly power. In the finite number of trading dates information is transmitted by prices only gradually, but as the frequency of auctions tends to infinity, all inside information is incorporated into prices by the end of the trading period. As suggested in [Eliasson 1990, p.293-294], restrictions on insider trading in the stock market prevent important information from being embodied in the market evaluation of a firm and efficient allocation of competence among firms. At the same time a market that does not identify and evaluate insiders as holders of competence is not an efficient market.

However in [Laffont and Maskin 1990] it is argued, that it may be reasonable for the insider to ensure that the market price does not convey the private information. This is the case, if the variability of asset returns is sufficiently small to allow the insider to choose a "pooling" equilibrium in a two-stage signalling game. Fishman and Hagerty (1992) show that although insider trading increases the total amount of information possessed by participants, it may happen that it leads to less efficient stock prices, since the presence of insiders in the market deters outsiders from acquiring new information.

In contrast to other works, Ausubel (1990) places emphasis on investment decisions adopted by outsiders before trading in the stock market. The model is a two-stage game, consisting of an investment and trading stage. If outsiders in the first stage do not expect insiders to take advantage of them in trading, they will expect a better return on their investment and increase it. Government regulation of insider trading in the second stage can give benefits to insiders to the extent they can gain from increased investment.

Leland (1992) examines welfare in markets with insider trading and with production investment, financed by an endogenous supply of new shares. Since the amount of investment depends on the issuing price per share, a higher current stock price will increase the issuance of shares and raise real investment. Welfare will increase, when share issues are highly responsive to current stock prices. In this case the benefits from efficient investment exceed direct losses of outsiders from disadvantageous positions in the market.

This result contributes to the recent analysis of insider trading, that ignores investment in production. The work of Leland, however, is based on the highly stylized static model of production (firms maximize profit from a share issues). It is therefore interesting to examine the effects of insider trading in an economy where investment behavior of firms responds to the stock market valuations. This is possible in the dynamic micro firm-based simulation model of the Swedish economy MOSES. The cornerstone of this model is the iterative process of decision-making inside a firm, based on realistic and empirically verified assumptions, corresponding to the principles of bounded rationality. The model makes long-run simulation experiments possible, that are suitable for analyzing the macroeconomic growth consequences of different regimes of investment behavior, with and without insider trading in the stock market.

To organize the experiments, we installed a model of the stock market with insiders into the micro-macro model. The stock market model [Antonov-Trofimov 1992] generalizes the above Kyle model of sequential auctions [Kyle 1985]. We used this model in our simulations, because it can be easily algorithmized and adapted to the quarterly iterative regime of the micro-macro model. The stock market model and its installation into MOSES are presented below (sections 3 and 4). We simulated different regimes of investment behavior of MOSES firms, corresponding to different degrees of investment sensitivity to stock market prices. We also varied the degree of risk aversion of non-informed traders (outsiders), which turns out to be an important factor influencing the efficiency of sequential auctions [Antonov-Trofimov 1992].

The simulation results (section 5) confirm the idea, that insider activity in the stock market can improve macroeconomic performance, if investments are highly responsive to prices. First, investments are more efficiently allocated by capital markets in MOSES in the long-run. Simulations reveal the convergence of real rates of return for the manufacturing sector to the average (among manufacturing firms) real rate of return on equity. This, however, does not take place when firms do not react to stock market prices. The long-run productivity of capital (output-capital ratio) is significantly higher in the case of price sensitive investment behavior.

Second, a stock market with active insiders stabilizes economic growth in the long-run, eliminating cyclical movement of the economy which is persistent, if investments are non-flexible to the stock market prices. This stabilization effect is explained in line with earlier results of Eliasson (1984) by a higher degree of diversity among firms in their rates of return and investment decisions.

2. Firms' objectives and investment decisions in the micro-to-macro model.

Firms in MOSES neither maximize present values, no optimize in the common sense. They are boundedly rational decision units with diversified internal organizational structures acting in line with the "maintain or improve profitability" (MIP) principle of Eliasson [1976, 1991]. Decisions within a firm are adopted on different organizational levels and coordinated according to the routinized procedures, which are algorithmically formalized in MOSES. Long-term objectives of a firm are formed in terms of the MIP principle as a result of confrontation and coordination between top managers, owners and operating departments.

Firms and their divisions are controlled through the rate of return requirements imposed by the capital market and corrected in quarterly intrafirm negotiations. The *nominal rate of return* is the fundamental control function of a MOSES firm, related both to the creation and distribution of profits. On the one hand, it is the sum of growth of net worth growth rate and the dividend share in the net worth. On the other hand, it can be decomposed into several items each representing departments and divisions as sources of profit [Eliasson 1976, 1984]. Top managers are responsible for search and information exchange within a firm, forcing higher levels of profits given organizational and market constraints.

Investment decisions are adopted interactively by selecting investment projects with expected returns satisfying the local interest rate requirement. Quarterly investment desired at the top level is directly determined by the quarterly expected rate of return. However, the preliminary investment plan is coordinated by top managers with the financing department, production divisions, labor management and so on. It is adjusted as certain requirements (e.s. the degree of capacity utilization and on accepted borrowing) are not satisfied ex post. The resulting investments are determined iteratively in the capital market, where firms and financial institutions (banks) compete and correct preliminary plans.

The micro-macro model gives a good opportunity for numerical modelling of capital markets working in different regimes and under varios exogenous institutional restrictions. Simulations on MOSES can reveal their allocative efficiency, both in the short- and in the long-run. The allocative efficiency depends on the informational properties of these markets and their ability to improve economic development. We checked the efficiency properties of the experimentally organized economy with an installed (into MOSES) stock market model, which affects the (MOSES) economy through the investment decisions of firms.

3. The stock market model.

The stock market model is a generalized version of the sequential trade model proposed by Kyle [Kyle, 1985]. In that model, referred here as KM, two infinitely divisible assets - risky and riskless - are exchanged between three kinds of traders: an insider having access to private information and influencing asset prices, market makers who set efficient asset prices and irrational (liquidity) noise traders. In our model uninformed, portfolio-based risk averse small investors (outsiders) also participate.

Trading occurs over one trading period consisting of N sequential auctions or trading dates: 0,1,...,N. At each date trading takes place in two steps. In the first step insiders and noise traders independently place orders to market makers who set a price *schedule*. In the second step they spread the orders among outsiders, set a price and clear the market.

Insiders know at the beginning of a trading period the correct *ex post* liquidation value of the risky asset *q* normally distributed with mean p_0 and variance Σ_0. They do not observe quantaties currently supplied by noise traders. An insider is a risk neutral maximizer of the expected (speculative) profit $\pi_0 = E_0 \Sigma_{n=1}^{N}(q - p_n)\Delta x_n$, where p_n is the risky asset price at date n and $\Delta x_n = x_n - x_{n-1}$ is the insider's order to market makers, x_n - a quantaty purchased at date n. The return from the safe asset (money) is normalized to one. The insider acts as an intertemporal monopolist taking into account the effect of his current actions on beliefs and behaviour of other participants.

Market makers do not know the asset value and cannot distinguish between order flows coming from insiders and noise traders. They set an efficient price p_n, $n=1,...,N$, equal to the expected asset value conditional on the information available from current and past trading. Although market makers are not explicit maximizers, they expect to earn zero profits from any auction, where they implicitly compete in a Bertrand fashion.

Outsiders are uninformed about the asset value but use trade information from current and past dates. They are endowed at the begining of the trade period by initial estimates of the asset value which are normally distributed with mean q_0 and variance Σ_0. They maximize a time-variance expected utility of the terminal wealth $W_N = W_0 + \Sigma_{n=1}{}^N(q_n - p_n)\Delta z_n$, where W_0 is the initial wealth, q_n is the current mean estimate of the asset value, $\Delta z_n = z_n - z_{n-1}$ is the net purchase of the risky asset at date n. Outsiders accept prices p_n as information signals of the asset value and update their estimates q_n in the Bayesian fashion.

Noise traders effect the stock market by random purchases Δu_n, $n=1,...,N$, that are normally and identically distributed with zero mean and variance σ^2 and independent of quantities traded in other dates and by other participants.

In line with KM, trading and pricing rules are considered as functions of the relevant observations. When choosing the traded volume x_n, the insider knows the asset value q and the history of prices $p^{(n-1)} = \{p_1,...,p_{n-1}\}$. His position at the n-th auction is given by a function $x_n = X_n(p^{(n-1)}, q)$. Outsiders base their trade on the current value estimate q_n and the price history $p^{(n)}$: $z_n = Z_n(p^{(n)}, q_n)$. Market makers remember the history of first step trades $h^{(n-1)} = \{x_1+u_1,..., x_{n-1}+u_{n-1},\}$ and observe the current first step order flow $\Delta x_n + \Delta u_n$. The efficient price schedule p_n is determined as $p_n = P_n(h^{(n)})$.

Denote trading strategies of the insider and outsiders as $X = \langle X_1,...,X_N \rangle$ and $Z = \langle Z_1,...,Z_N \rangle$ resp. and the pricing rule applied by market makers as $P = \langle P_1,...,P_N \rangle$. Let $\pi_n = \pi_n(X, Z, P) = \Sigma_{k=n}{}^N(q - p_k)\Delta x_k$ stands for the profit acquired by insider at auctions n,...,N as a function of trading strategies and a pricing rule. The certainty mean-variance equivalent of the end-of-period wealth of outsiders expected at date n is $U_n(X, Z, P) = E[W_N|p^{(n)}] - (a/2)\ Var[W_N|p^{(n)}]$, where a is the degree of risk-aversion.

A Sequential Auctions Equilibrium is defined as: 1) a pair of trading strategies X and Z, 2) a pricing rule P and 3) a family of conditional beliefes $g_n(q|p^{(n)}, q_0, \Sigma_0)$ that provide:

i) *Profit maximization:* for all X' such that $X_1'=X_1,...,X_{n-1}'=X_{n-1}$ it is fulfilled: $E[\pi_n(X, Z, P)|p^{(n-1)}, q] \geq E[\pi_n(X',Z,P)|p^{(n-1)},q]$, n = 1,...,N.

ii) *Expected utility maximization:* for all Z' it is fulfilled: $U_n(X,Z,P) \geq U_n(X,Z',P)$, n = 1,...,N.

iii) *Rationality of expectations:* At each trading date n=1,...,N the conditional probability $g_n(q|p^{(n)}, q_0, \Sigma_0)$ is updated by outsiders in a Bayesian fashion.

iv) *Market efficiency:* For all n=1,...,N prices are set by market makers equal to: $p_n' = E(q|h^{(n)})$.

Define, following KM, a *recursive linear equilibrium* as a sequential auctions equilibrium in which parties use linear trading strategies and the pricing rule is given recursively:

$$p_n = p_{n-1} + \lambda_n(\Delta x_n + \Delta z_n + \Delta u_n), \tag{1}$$

where $\lambda_1,\dots,\lambda_N$ are parameters determined from the market efficiency condition. They characterize the depth of the market: the smaller λ_n, the larger the trade volume required for the percentage change of the asset price. The market at date *n* is deeper when λ_n is lower. As can be shown, the recursive linearity of equilibrium follows from the normality of both noise trading and market makers' beliefs.

The following theorem characterizes the linear recursive equilibrium as the solution to a difference equations system subject to some terminal conditions.

Theorem. *There exists a recursive linear equilibrium such that*

$$\Delta x_n = \beta_{1n}(q - p_{n-1}) + \beta_{2n}(q_{n-1} - p_{n-1}), \tag{2}$$

$$\Delta z_n = \gamma_n(q_{n-1} - p_{n-1} - \lambda_n(\Delta x_n + \Delta u_n)), \tag{3}$$

$$\Delta p_n = p_n - p_{n-1} = \lambda_n(\Delta x_n + \Delta z_n + \Delta u_n), \tag{4}$$

$$E\{\pi_n | p^{(n-1)}, q\} = \alpha_{1n-1}(q - p_{n-1})^2 + \alpha_{2n-1}(q - p_{n-1})(q_{n-1} - p_{n-1}) + \alpha_{3n-1}(q_{n-1} - p_{n-1})^2 + \delta_{n-1}, \tag{5}$$

$$q_n = \xi_n p_n + (1-\xi_n)q_{n-1}, \tag{6}$$

where ξ_n is the relative accuracy of price signal, $0 < \xi_n < 1$.

Given the terminal conditional variance Σ_N and the terminal zero-profit condition on the parameters: $\alpha_{1N} = \alpha_{2N} = \alpha_{3N} = \delta_N = 0$, the set of endogeneous parameters $T = \{\beta_{1n}, \beta_{2n}, \alpha_{1n}, \alpha_{2n}, \alpha_{3n}, \lambda_n, \gamma_n, \Sigma_n, \xi_n, \delta_n\}_{n=1}^N$ is the solution to the backward induction system:

$$\beta_{1n} = \frac{1 - C_n(2\alpha_{1n} + \alpha'_{2n})}{2C_n(1 - C_n\alpha_n)} \qquad (7)$$

$$\beta_{2n} = -\frac{\gamma_n\lambda_n}{2C_n} + \frac{\lambda_n\gamma_n\alpha_n - (2\alpha'_{3n} + \alpha'_{2n})}{2(1 - C_n\alpha_n)} \qquad (8)$$

$$\alpha_{1n-1} = \alpha_{1n} A_n^2 + \alpha_{3n}'(1-A_n)^2 + \beta_{1n}A_n - \alpha_{2n}'A_n(1-A_n), \qquad (9)$$

$$\alpha_{2n-1} = -2\alpha_{1n}A_nB_n - 2\alpha_{3n}'(1-A_n)(1-B_n) + \beta_{2n}A_n - \beta_{1n}B_n +$$

$$\alpha_{2n}'B_n(1-A_n) + \alpha_{2n}'A_n(1-B_n), \qquad (10)$$

$$\alpha_{3n-1} = \alpha_{1n}B_n^2 + \alpha_{3n}'(1-B_n)^2 - \beta_{2n}B_n - \alpha_{2n}'B_n(1-B_n), \qquad (11)$$

$$C_n = \beta_{1n}\Sigma_n / \sigma^2, \qquad (12)$$

$$\gamma_n = 1/(a\Sigma_{n-1} + \lambda_n), \qquad (13)$$

$$\xi_n = C_n\beta_{1n}, \qquad (14)$$

$$\Sigma_n = (1 - \xi_n)\Sigma_{n-1}, \qquad (15)$$

$$\delta_{n-1} = \delta_n + \alpha_n\lambda_n^2\sigma^2, \qquad (16)$$

subject to the second order condition:

$$C_n(1 - C_n\alpha_n) > 0, \qquad (17)$$

where $A_n = 1 - C_n\beta_{1n}$, $B_n = C_n\beta_{2n} + \lambda_n\gamma_n$, $C_n = \lambda_n(1 - \lambda_n\gamma_n)$;

$\alpha_{2n}' = (1 - \xi_n)\alpha_{2n}$, $\alpha_{3n}' = (1 - \xi_n)^2\alpha_{3n}$, $\alpha_n = \alpha_{1n} + \alpha_{2n}' + \alpha_{3n}'$.

Proof: in [Antonov-Trofimov 1992].

Equations (2) through (6) determine the forward induction for prices, expectations and trade volumes given the set of endogenous parameters T, which is computed from the backward induction system (7)-(17). Parameters β_{1n}, β_{2n} (n = 1,...,N) characterize the behavior of insiders at the n th auction: they measure the intensity of their trade subject to the *ex post* square errors of market makers $(q - p_{n-1})^2$ and small shareholders $(q_{n-1} - p_{n-1})^2$. Parameters α_{1n}, α_{2n}, α_{3n} determine the date n expected profit as a square form of the errors. Parameters α_{1n} and α_{3n} relate the expected profit to the squere errors, while α_{2n} indicates how much insiders will gain from the divergence of other parties beliefs. Parameter δ_n ascertains the value of future trading opportunities for an insider.

Parameter γ_n indicates the intensity of outsiders' trade. The product of parameters $\lambda_n\gamma_n$ shows, if insider trading stabilizes or destabilizes the stock market. As it follows from (3), outsiders are less flexible to insider's trade if $\lambda_n\gamma_n < 1$. Conversely, they are more flexible, if $\lambda_n\gamma_n > 1$. Insider trade destabilizes the market, when an additional share supplied (demanded) by an insider causes outsiders to buy (sell) more than one share, i.e. $\lambda_n\gamma_n > 1$. Parameter C_n determines the sensitivity of market prices to the insider trade. It is positive if the insider trade is stabilising prices.

The set of endogeneous parameters T characterizes the *technology of insider trade* in the finite number of stock market auctions. It is computed in the backward induction given the terminal value of conditional variance Σ_N subject to the zero-profit condition $\alpha_{1N} = \alpha_{2N} = \alpha_{3N} = \delta_N = 0$. The technology of trade is specified by two exogeneous parameters: the degree of risk aversion a and the variance of noise trade σ^2, and by the initial variance of expectations Σ_0. Since conditional variances Σ_n are computed in the backward fashion, it is more convinient to consider the terminal variance $\Sigma_N > 0$ as an exogenous constant instead of Σ_0. If the backward induction for the system (7)-(17) has a unique solution, the trading technology is determined by the exogenous parameters: $T = T(a, \sigma^2, \Sigma_N)$.

However this system does not generally provide a unique solution. If at some trading date there are two or more solutions, the insider has to choose among them using (5) according to the Bellman principle. However this problem is recursively unsolvable since he is not able to do it, unless the forward induction data is available. This means that the insider cannot choose the *best* technology of trade before the stock market starts to work in the forward induction. The problem becomes recursively solvable, if one applies an idea of the *second best* solution. The insider can build in the backward fashion a tree of hypothetical trade technologies with the root at date N and the top at date 1. Then he can choose at date 0 the branch of the tree providing maximum expected profit at the beginning of trade, given initial conditions on prices and expectations.

4. Installation of the stock market model into MOSES.

The stock market in MOSES serves as a device to determine market-based rates of return and as a mechanism that supports borrowing decisions of firms and efficient investment allocations. Simulations with the SM model are organized in the quarterly regime to be consistent with MOSES quarterly iterations. At the beginning of each quarter SM traders receive new information about firms' values and trade until the end of the quarter. The quarterly SM information is in turn accepted (or not) by firms top managers as a signal which matters for investment decisions. The quarterly trading procedure in the SM is run independently of the quarterly MOSES iteration. The SM model is only linked to the rest of MOSES economy via information transmitted at the beginning and at the end of a quarterly trading period.

Insiders can operate on one, several or all firms. In this paper there are no insider or there are insiders in all firms. They act in the MOSES stock market as speculators informed about technological opportunities of firms and decisions adopted by top managers. They are able to estimate more or less correctly expected dividend flows and net present values. Insiders update their private information according to new data quarterly generated by MOSES firms. Outside traders and market makers do not have access to fresh inside information about firms and gain insight into it indirectly through asset prices. Besides, they receive, at the beginning of each quarter an exogeneous noise signal about firm values.

At the start of a quarter insiders apply backward induction (7)-(17) to compute the parameters of the trading tree and to choose the best, or the second-best trading technology (trading branch), that maximizes expected speculative quarterly profit. Insiders know the current asset value q, initial expectations of outsiders q_0 and the market price p_0 observable at the end of the preceding quarter. Once a trading technology has been determined, the quarterly trading process in the MOSES stock market comes into play. It works 12 (weekly) trading dates according to the forward recursion (2)-(6).

A firm's present value q is specified as the marginal expected return on a unit of net worth (Tobin's q). It is computed at the quarter t beginning as a ratio between expected value SH_t dated to the end of the quarter t and the net worth NW_{t-1} dated to the end of the quarter t-1. The latter is equal to : $NW_{t-1} = K_{t-1} - BW_{t-1}$, where K_{t-1} is total capital (assets) of a firm, and BW_{t-1} - its total borrowing.

The expected market value is computed as the sum of all discounted future (quarterly) dividends which is approximated in the simpliest way:

$$SH_t = DIV_t^e \;/\; r_t,$$

where DIV_t^e - expected quarterly dividend payments, r_t - discount factor of a firm. Both these variables contain the inside information about the firm.

Expected dividends are determined on the basis of price-wage-sales expectations, the quarterly profit-margin target, and the current balance sheet of a firm (see Appendix 1). The internal discount factor r_t accounts for both the economy-wide tendency of the nominal interest rate R_t and the firm's leverage ratio $\phi_{t-1} = BW_{t-1} \;/\; NW_{t-1}$:

$$r_t = R^{sm}{}_t \; y(\phi_{t-1}), \tag{18}$$

where $R^{sm}{}_t$ is a moving average for R_t, obtained from current and past observations and $y(\phi)$ satisfies: $y(0) > 0$, $y'(\phi) \geq 0$, $y(\infty) = 1$. We use a simple specification for this function:

$$y(\phi) = \min\,[c_1\phi + c_0,\, 1], \tag{19}$$

c_0, c_1 - exogeneous parameters. According to (18), whenever the leverage ratio is not high: $\phi \leq (1\text{-}c_0)/c_1$, the internal discount factor is lower than the market nominal interest rate, but it cannot be lower than $c_0 R^{sm}{}_t$.

The initial outsiders' quarterly expectation of Tobin's q is determined from the currently observable stock market price p_{t-1} and quarterly dividend payments DIV_{t-1}:

$$q_{t0} = \frac{p_{t-1} + \theta'_{t-1}}{1 + RIR^e_{t-1}} + \varepsilon_t \qquad (20)$$

where $\theta'_{t-1} = DIV_{t-1} / NW_{t-1}$ - dividends as a share of current networth, RIR_t^e - the expected quarterly real interest rate, ϵ_t is an exogenous noise signal with mean 0 and variance Σ_0.

The market price of a share p_t differs in our experimental setup from commonly used asset price indices. It is a market-based measure of Tobin's q effected by exogenous intraquarter shocks (noise trade, noise beliefs of outsiders) and insider trade. Such normalization of asset prices is quite natural, since it simplifies the installation of the SM model into MOSES and allows comparable simulated time series for Tobin's q and stock market prices.

In our simulation setup the stock market has a real effect on the MOSES economy only via investment decisions quarterly adopted by firms. Investment behavior of firms, which is given algorithmically in MOSES code [Albrecht et al.(1989)], determines a quarterly ratio between the *ex-post* rate of return from productive activity and investment in total assets.

We apply two measures of the rate of return depending on the purpose of the simulation. Both of them were used in [Eliasson 1985, 1992] for a comparative empirical and simulative analysis of capital market efficiency. Both these measures relate net revenue of a firm to its net assets (net worth). The first one is the nominal, balance sheet-based rate of return. It does not account for the stock market evaluation of firm's net worth:

$$RR_t = \Delta NW_t / NW_{t-1} + \theta_t, \qquad (21)$$

where $\Delta NW_t = NW_t - NW_{t-1}$, $\theta_t = DIV_t / NW_{t-1}$ is the ratio of current dividend payments to past quarter net worth. The second measure of rate of the return is market-based, since it incorporates a quarterly change of the stock price:

$$ER_t = \Delta ME_t / ME_{t-1} + \theta^*_t, \qquad (22)$$

where $ME_t = p_t NW_t$ is the market value of networth, $\theta^*_t = DIV_t / ME_{t-1}$.

We apply both these measures to model two regimes of firms' investment behavior. In the first regime top managers are assumed to be extremely irresponsive to stock market prices and compute net worth using only balance sheet data. Investment decisions in this case are determined by the book measure (21) and are not influenced by stock prices (see Appendix 2). In the second regime investment behavior of firms is highly sensitive to stock market signals. In this case the market-based rate of return (22) is used. Both these regimes are compared in different simulation runs and the results are discussed below.

5. Simulation results.

Simulations were designed to demonstrate how firm investment behavior effects macroeconomic dynamics, if insider trading in the stock market is allowed. We use the current version of the MOSES model initiated on a complete dataset 1982, and calibrated on historic data as described in the database book [Taymaz 1992]. The so calibrated model is described in [Eliasson 1991]. We have run the model up to 1990 and begin our analysis that year. The series of experiments have been completed for different exogenous parameters of the stock market model, such as the degree of risk aversion a, the variance of noise trading σ^2 and the terminal (end of a quarter) conditional variance of outsiders' expectations Σ_N. The simulation results, discussed in what follows, hold for a statistically significant domain of the exogenous parameters. We have chosen a "standard" set of these parameters: $a = 0.1$, $\sigma^2 = \Sigma_N = 100$, under which there is a unique solution to the backward induction system (7)-(16), and trade technology T is well-defined.

The parameters of (19) which determine the local discount rate of a firm as a function of leverage factor (18) have been chosen as: $c_0 = 1/2$, $c_1 = 1/4$. It means, that the discount rate is assumed to be equal to the smoothed nominal interest rate $R^{sm}{}_t$, if the leverage ratio is higher or equal to 2, but it cannot be lower than the half of $R^{sm}{}_t$.

Noise trading is independent across firms and from the noise increment ϵ_t in the initial quarterly valuations (20) of outsiders. The amount of a firm's stock traded in the market is constant over time (new shares are not issued) and normalized to one. The number of dates in the trading period has been set equal to 12, i.e. a trading date corresponds to a week in terms of real time. We also simulated the stock market in MOSES with more frequent intra quarter trades, where N = 30 and 60.

1) The stock market with insiders performs efficiently in MOSES: prices transmit inside information to uninformed participants during quarterly computations. The stock market does not create large asset bubbles. The aggregate price index (the average asset price for the 30 currently largest firms) fluctuates around average net present value (aggregate Tobin's q for the same set of firms) and converges to the latter during a quarter. One can

observe in the figures 1-2, that even 12 trading dates may be enough for prices to incorporate a large volume of insider information and to approach the asset value. This is due, in particular, to the stabilizing effect of insider trade in the last two trading dates, which is explained in turn by the zero-profit terminal condition (see Theorem 1). The higher the frequency of intraquarter trade, the more evident is the convergence. Hence simulations support the efficiency hypothesis in the strong sense, which, however, may fail, if the degree of risk aversion a is too low. In this case insiders can destabilize the stock market.

2) The average market-based rate of return converges in the long run to the rate of return on the unit of net worth. One can see this comparing Tobin's q and the average market-based rate of return $1+ER$ computed for the same set of the 30 largest firms (fig.3). Although the rate of return is more volatile than the Tobin's q, their time averages become closer as the simulation period increases. The Tobin's q time average is 1.100 for 15 years of simulation and the $1+ER$ time average is 1.082 for the same period. In the average the stock market underestimates the net present value, but the average deviation is not significant.

This is not the case in reality. As Eliasson [1992, p.34] points out, the stock market exhibits a strong tendency to undervalue firm assets, compared to incurred costs for accumulating them. The most obvious explanation of this deviation is that the real stock market is less efficient than that modelled in our simulations, due to some restrictions and institutional rules. Probably the abscence of insiders in the stock market contributes to the undervaluation of capital.

The non-market measure of the quarterly rate of return 1+RR is less volatile than the Tobin's q, as figure 4 shows, but its time average is lower. It is equal to 1.053 for the 15 years simulations in the regime of non-responsive investment behavior of firms.

3) If investment behavior of firms is responsive to the movement of stock prices and in the abscence of significant barriers to investment activity (e.s. credit rationing), the stock market with insiders has a positive effect on macroeconomic growth. Figures 5 through 13 give a comparison of macroeconomic performance simulated for 20 years in the cases of responsive and rigid investment behavior. (The reference case with no insider trading is described in [Eliasson 1991]. It generates a significant long-run recession in the quarters 40 to 60 (see Figure 5) due to the inherent dynamics of the system and cumulative government deficits as described in [Eliasson 1992 and Eliasson-Taymaz 1992].)

One can see, that diverging investment cycles of 6-8 years periodicity are generated, if investments are not sensitive to stock market signals. But these cycles are obviouly smoothed, if firms are responsive to the stock market evaluation. Besides, the long-run productivity of investment (the output-investment ratio) is significantly higher if they are sensitive, as it is seen from figures 5-6. At the same time employment and the total number of operating firms are also higher, when firms react to the stock market (fig. 12, 13). A possible interpretation for this effect is that sensitive investment behavior creates the market regime favourable for entry activity in the long run. Note that the quarterly rate of return from production activity in the manufacturing sector, that is shown in figure 9, is calculated differently than the above indicators RR and ER. It measures a firm's rate of return directly through a contribution of its operating departments.

As it was suggested by Eliasson [1984, p.263], a conflict exists between short-term static efficiency and long-term dynamic efficiency. An investment allocation, that is efficient in a static (short-term) sense, can destabilise macroeconomic growth in the long-run and cause self-enforcing swings, such as those shown in figures 6-12. Earlier simulations with MOSES [Eliasson 1984] demonstrated, that an important prerequisite for stable macro growth is diversity at the micro level. Diversity also explains our experimental results. If MOSES firms are sensitive to stock market prices, they exhibit much more diversity in their investment decisions, than is the case with rigid investment behavior. This is so, because the variance of the market-based rate of return among firms is notably higher than the variance of the non-market-based rate of return. On the average, the variance for the former measure is 8.2 times higher, than the variance for the latter. (Figure 14 shows, how the reciprocal of the ratio of their standard deviations changes over time.) This is not surprising, since the stock market valuation adds some noise to the nominal rate of return, both due to noise trading in the stock market and noise in outsiders' expectations. Besides, MOSES firms embody more diversity in their present values (Tobin's q) than in quarterly rates of return from productive activity. Thus imperfections of capital markets in the short-run can sometimes be a positive factor, improving the long-run economic efficiency.

Note that if outsiders are too risk-tolerant, the long-run macroeconomic performance can be adversely affected by the stock market. Figure 15 compares manufacturing outputs in the regime of sensitive investment behavior for "normal" and low values of risk aversion parameter (a = 1 and 0.0035). The decline of production in the latter case is caused by the abnormal trade in the stock market. As numerical experiments show, insiders create speculative bubbles at the end of quarterly trades. But outsiders in our experiments base initial quarterly expectations in a myopic way on currently observable data (20) and thus enforce the growth of these bubbles. They become so large, that exogenous noise signals ϵ_t do not matter. As a result the stock market creates a long-run persistent asset bubble that is responsible for the decline of production.

It is also important, that significant barriers to investment activity are lacking in the current modification of MOSES. Banks in the current version apply a moderate form of credit rationing, cutting proportionally firms' claims in the case of an excess demand for loans. MOSES banks do not demonstrate a pattern of risk-averse behavior, when the supply of credit is dramatically contracted, which is actually peculiar for recession phases. As argued by Stiglitz [Stiglitz 1992], banks, which behave too cautiosly under asymmetric information and bankruptcy risks, are mainly responsible for aggregate economic fluctuations. We ignored this and other barriers to investment, in order to reveal the pure effect of the stock market with insiders on economic growth.

Appendix 1. Determination of dividend expectations.

Quarterly dividend expectations are not computed in the quarterly decision making block of MOSES. Therefore we organized a simple procedure that allows insiders to estimate expected dividend flows. Given that both dividend shares in net profits and corporate tax rates are simulated parameters in the micro-macro model, the expected quarterly dividend flow is:

$$DIV^e = RTD \cdot TXC \cdot \max[0, QREV^e - QDEPRBOOK],$$

where the notation of MOSES code [Albrecht et al. 1989] is used:

RTD - ratio between firms' dividend payments and corporate taxes;

TXC - the exogenous corporate-tax rate;

$QREV^e$ - quarterly expected gross revenue of a firm: sales less wages and purchases of input materials, plus and minus interests;

QDEPRBOOK - quarterly depreciation of a firm's production equipment at book value.

The expected gross revenue depends on the inside information including: 1) balance sheet of a firm - its total assets and borrowing; 2) yearly profit-margin target TARGM, that is the desirable ratio of gross revenue to value added; 3) quarterly price and sales expectations; 4) production possibility frontier QFR as a short-run function of the labor force.

The expected quarterly gross revenue is

$$QREV^e = QM^e + K2 \cdot RIK2/4 - BW \cdot RIF/4,$$

where QM^e is expected quarterly profit margin of a firm, K2 - its current assets, RIK2 - the (annual) rate of interest on its deposits; BW - total borrowing of the firm; RIF - the (annual) rate of interest on its borrowing. It is assumed that the quarterly profit margin is determined by the profit-margin target and constrained from above by the sales expectation and the production frontier:

QM^e = TARGM$\cdot$ min[QEXPS$\cdot$ QEXPPNET/QEXPP, QEXPPNET$\cdot$ QFR],

where QEXPS - expected sales for the quarter, QEXPPNET - an expected net sales price with reductions for purchases of input goods, QEXPP - an expected sales price for the quarter.

Appendix 2. Investment decisions of a MOSES firm.

In the current version of MOSES quarterly desired investments of a firm QDESINV are supposed to grow in a linear proportion to the quarterly rate of return QRR if the degree of capacity utilization is above some admissable (from top managers view) level. No investments are planned, whatever the rate of return, as long as a sufficient share of capacities remains unutilized. This simple behavioral rule is formalized by the equation

$$\text{QDESINV} = \text{K}\cdot \max[0, 1 - \text{ELINV}\cdot (\text{UTREF} - \text{QUTIL})]\cdot (\alpha_k + \beta_k\, \text{QRR}),$$

where K are the total balance assets of a firm, ELINV - an elasticity, reducing firm's desired investments whenever capacity utilization is low, UTREF - a normal ("reference") level of capacity utilization, QUTIL - a quarterly planned level of capacity utilization, α_k, β_k - positive constants. The quarterly rate of return is computed either as the nominal (balance sheet-based) rate (21) or as the market based rate (22).

REFERENCES

1. Albrecht, J. et al, 1989, *MOSES code*, IUI Research Report No. 36, Stockholm.

2. Albrecht, J. et al, 1992, *MOSES database*, IUI Research Report No. 40, Stockholm.

3. Antonov, Trofimov, 1993, *Insider Trading Anomalities: Some Numerical Results*, IUI Working Paper (forthcoming), Stockholm.

4. Ausubel, L., 1990, *Insider Trading in a Rational expectations Economy*, American Economic Review, 80, 1022-41.

5. Blanchard, O., Rhee, Ch., Summers, L., 1990, *The Stock Market, Profit and Investment*, NBER Working Paper No. 3370.

6. Eliasson, G., 1976, *Business Economic Planning - Theory, Practice and Comparison*, John Wiley & Sons, London.

7. Eliasson, G., 1984, *Micro Heterogeneity of Firms and the Stability of Industrial Growth*, Journal of Economic Behavior and Organization, Vol. 5, 249-274.

8. Eliasson, G., 1985, *The Firm and Financial Markets in the Swedish Micro-to-Macro Model*, IUI, Stockholm.

9. Eliasson, G., 1990, *The Firm as a Competent Team*, Journal of Economic Behavior and Organization, Vol. 13, 275-298.

10. Eliasson, G., 1991, *Modeling the Experimentally Organized Economy: Complex Dynamics in an Empirical Micro-Macro Model of Endogenous Economic Growth*, Journal of Economic Behavior and Organization, Vol.16, 153-182.

11. Eliasson, G., 1992, *The MOSES Model - Database and Applications*, in: [2], 5-135.

12. Eliasson, G., Taymaz, E., 1992, *The Limits of Policy Making: An Analysis of the consequences of Boundedly Rational Government using the Swedish Micro-to-Macro Model (MOSES)*, IUI Working Paper, No. 333, Stockholm.

13. Fishman, M., Hagerty, M., 1992, *Insider trading and the efficiency of stock prices*, RAND Journal of Economics, Vol. 23, 106-122.

14. Glosten, L., Milgrom, P., 1985, *Bid, Ask and Transaction Prices in a Specialist Market with Heterogenously Informed Traders*, Journal of Financial Economics, Vol. 14, 71-100.

15. Laffont, J.-J., Maskin E., 1990, *The Efficient Market Hypothesis and Insider Trading on the Stock Market, Journal of Political Economy*, Vol. 98, 70-93.

16. Leland, H., 1992, *Insider Trading: Should It Be Prohibited? Journal of Political Economy*, Vol. 100, 859-887.

17. Kyle, A., 1985, *Continuous Auctions and Insider Trading*, Econometrica, Vol. 53, 1315-1335.

18. Stiglitz J., 1992, *Capital Markets and Economic Fluctuations in Capitalist Economies*, European Economic Review, Vol. 36, 269-306.

19. Taymaz, E., 1992, *A Description of the Initial 1982 and the Synthetic 1990 Database*, in: [2], 137-180.

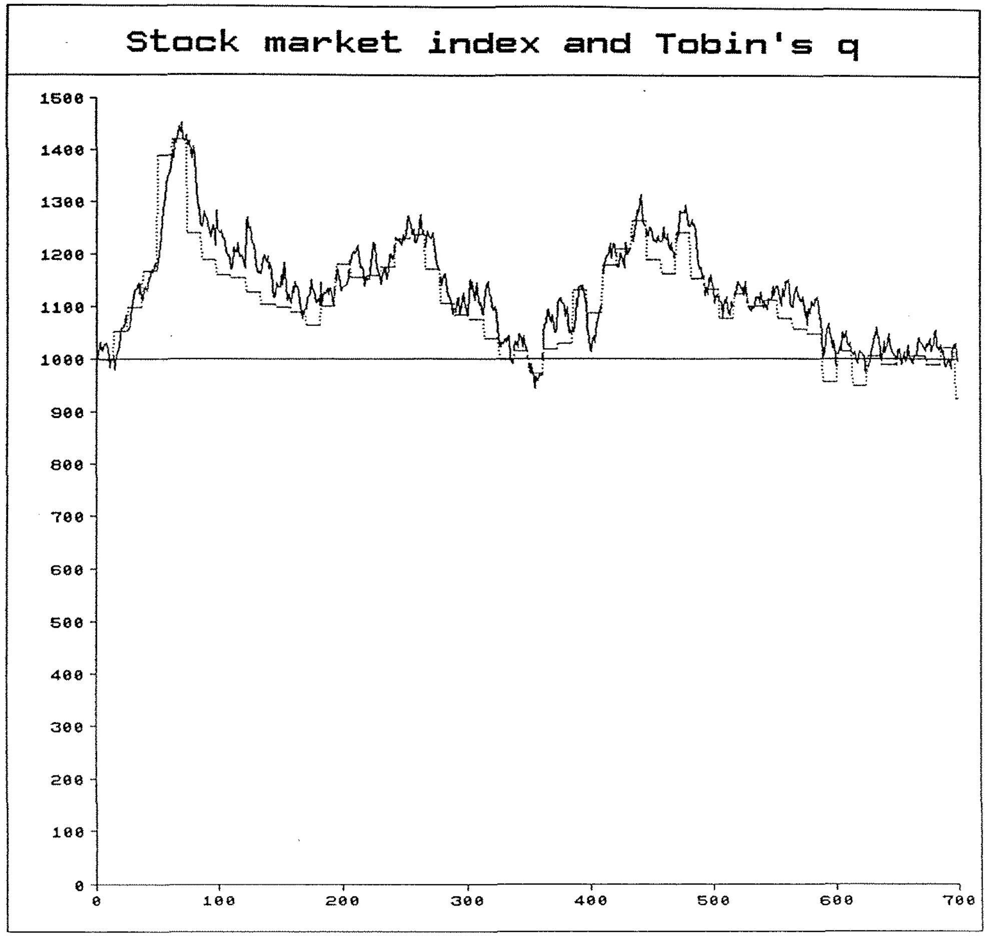

Figure 1. For 700 trading dates (about 15 years):

——— - Stock market index;

.... - Tobin's q.

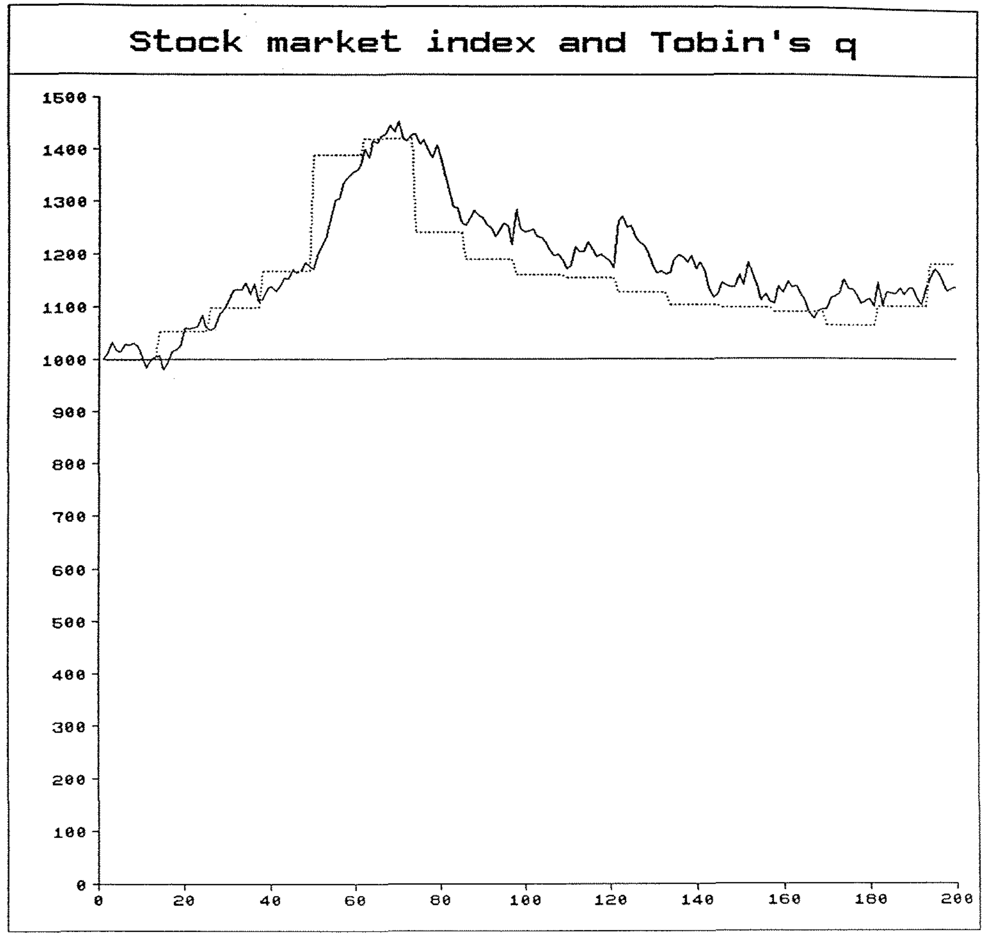

Figure 2. For 200 trading dates (about 4 years):

——— - Stock market index;

.... - Tobin's q.

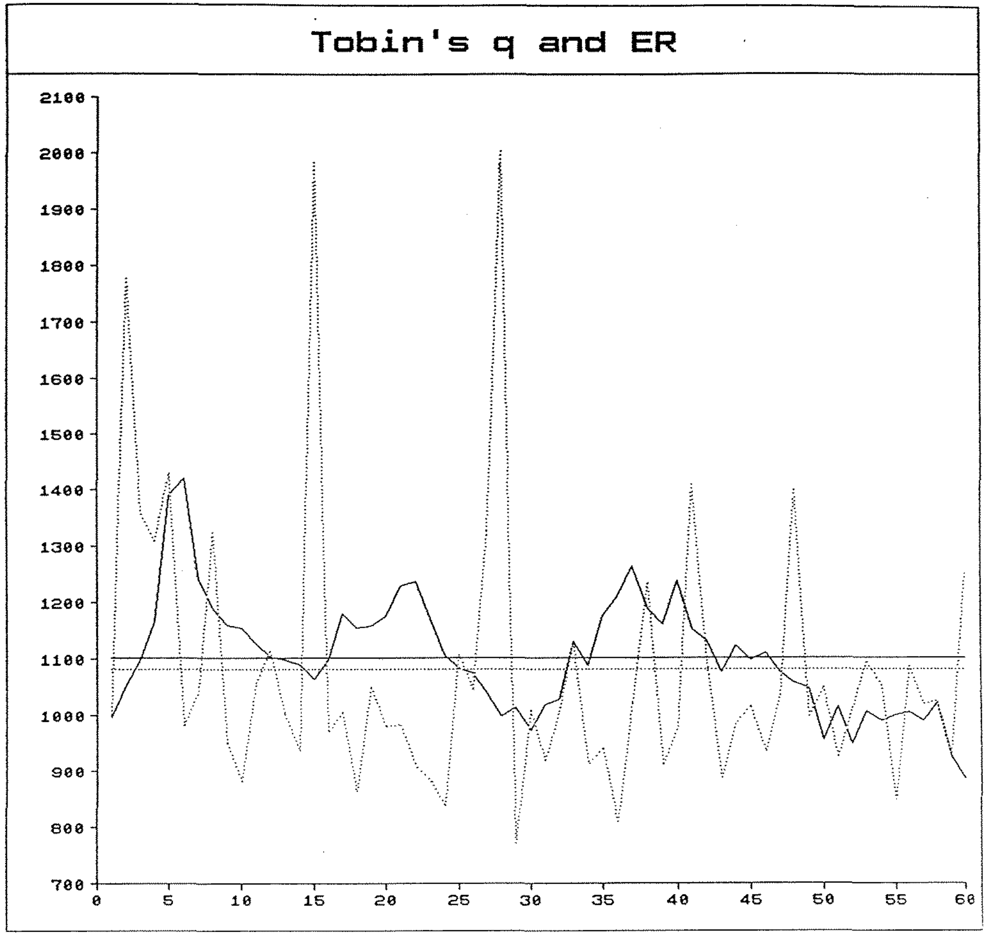

Figure 3. Quarterly observations and time avereges for 15 years:

——— - Tobin's q;

.... - ER.

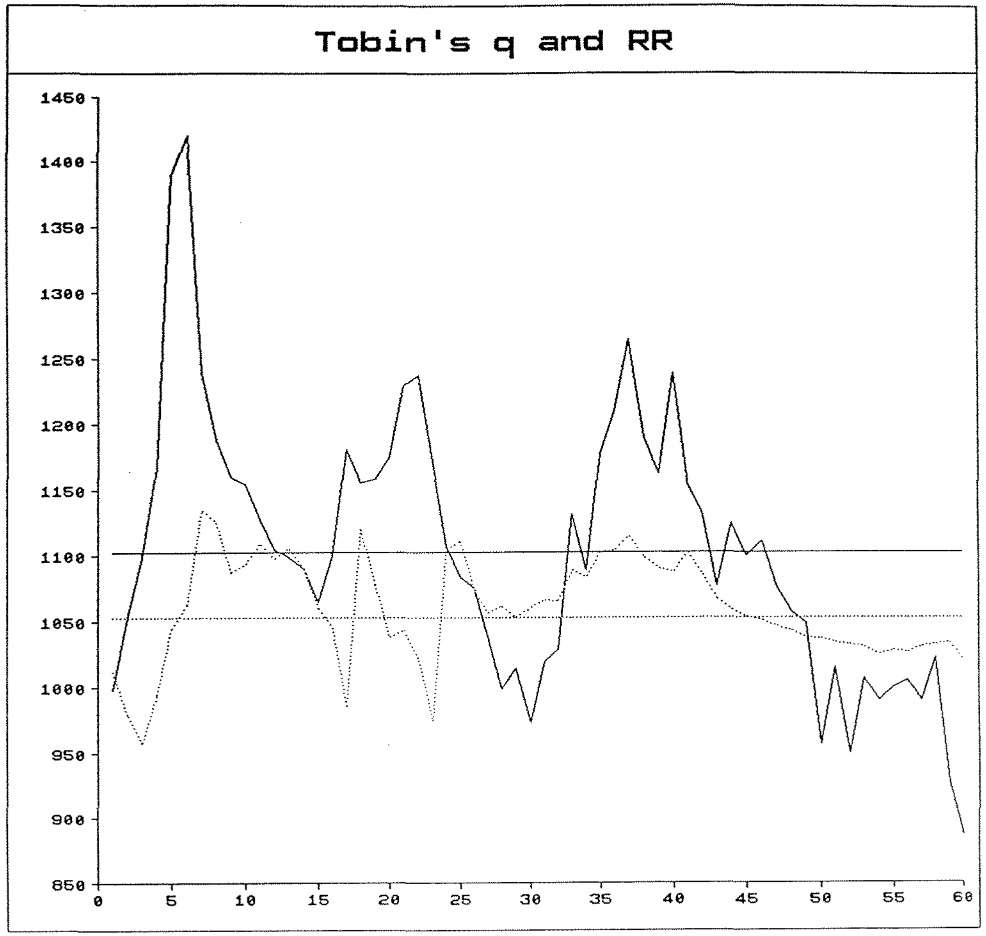

Figure 4. Quarterly observations and time avereges for 15 years:

——— - Tobin's q;

.... - RR.

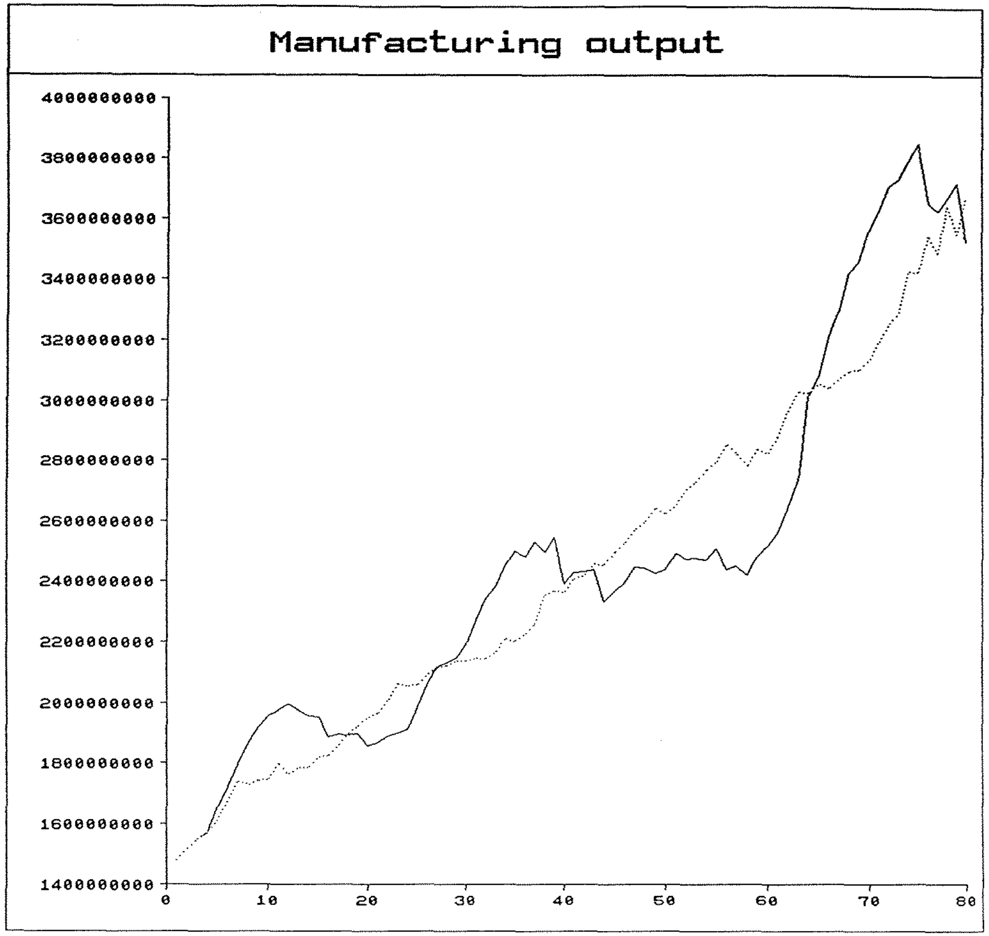

Figure 5. Here and in what follows (fig. 6 - 13) for 20 years:

——— - non-sensitive investment behavior;

.... - sensitive investment behavior.

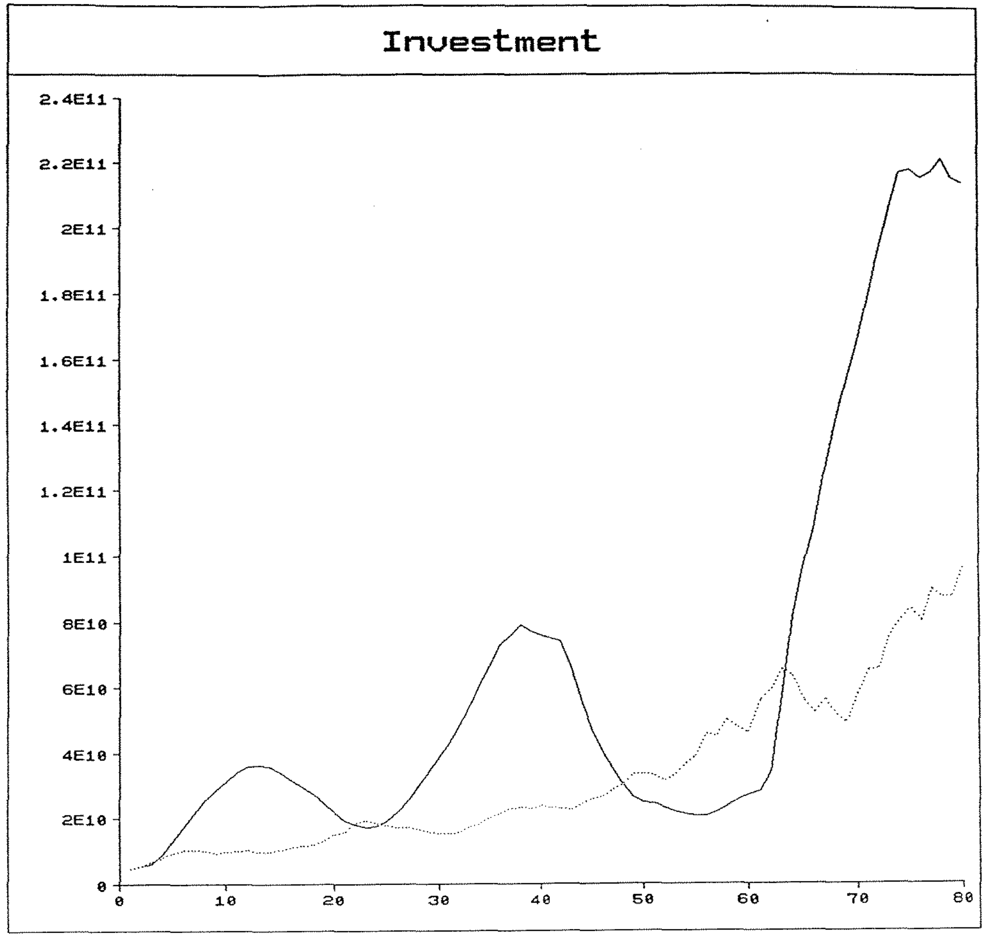

Figure 6.

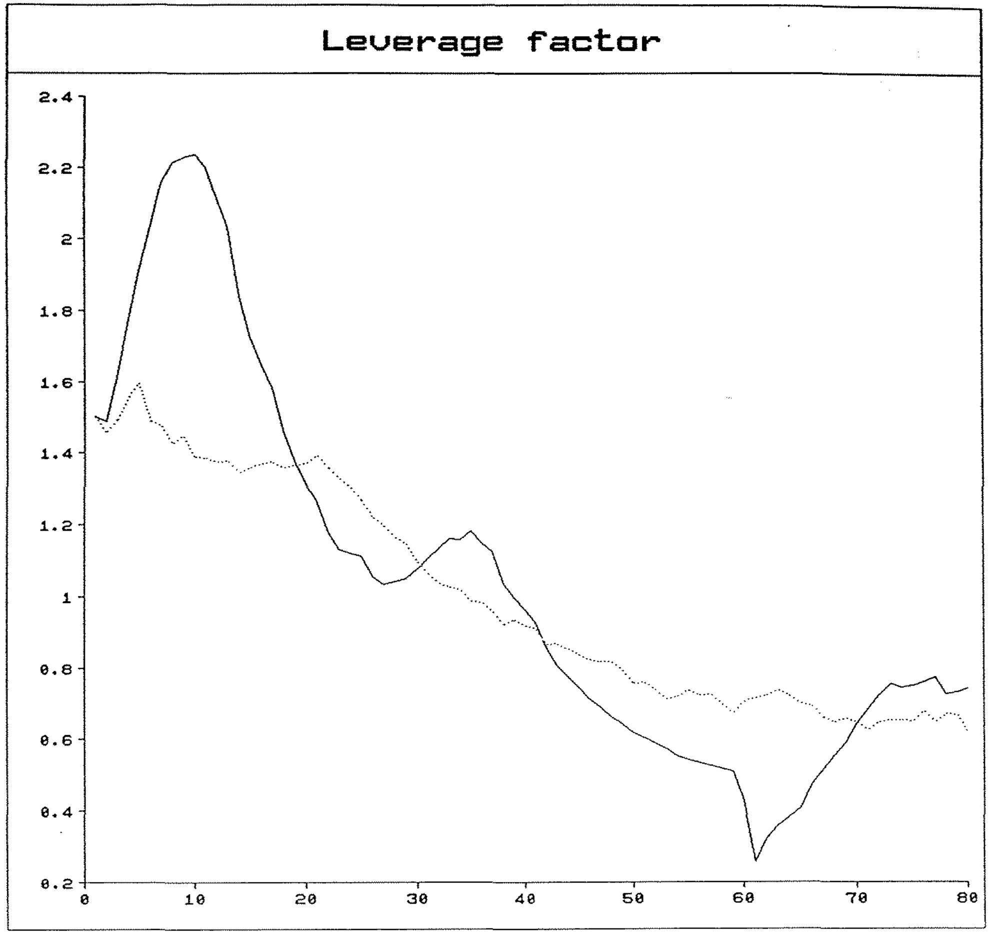

Figure 7.

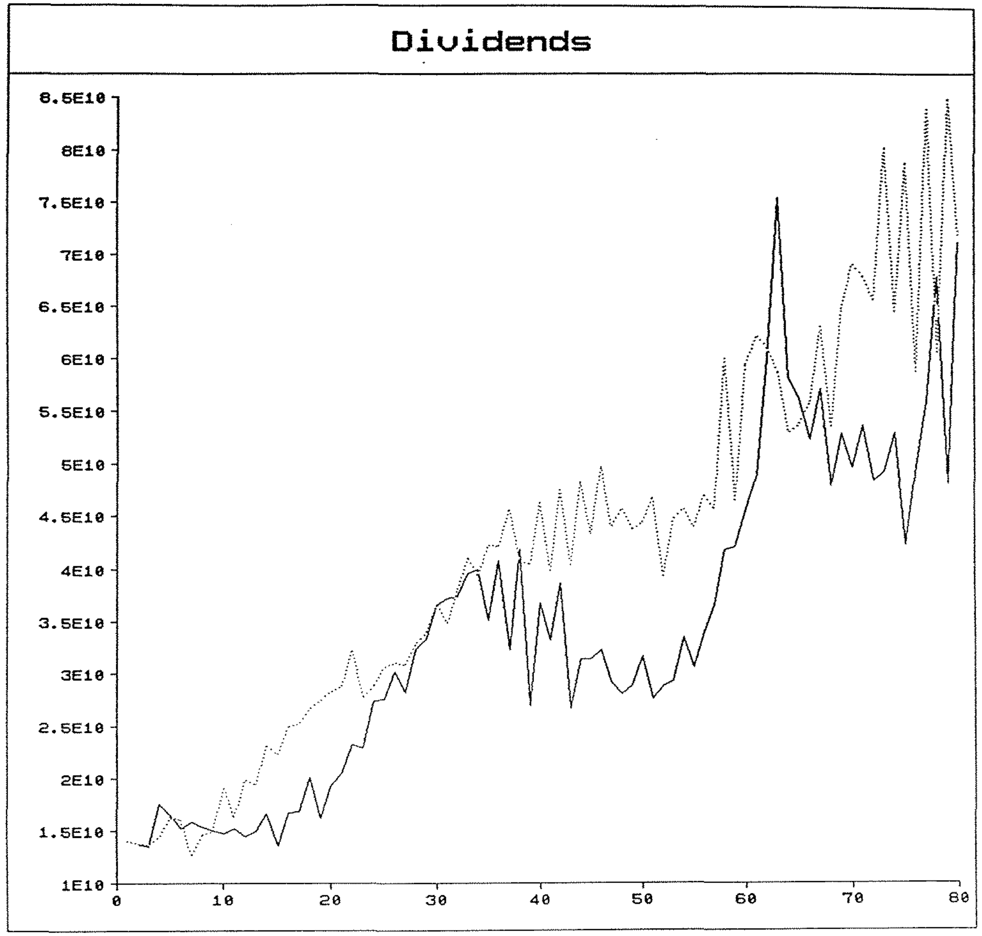

Figure 8.

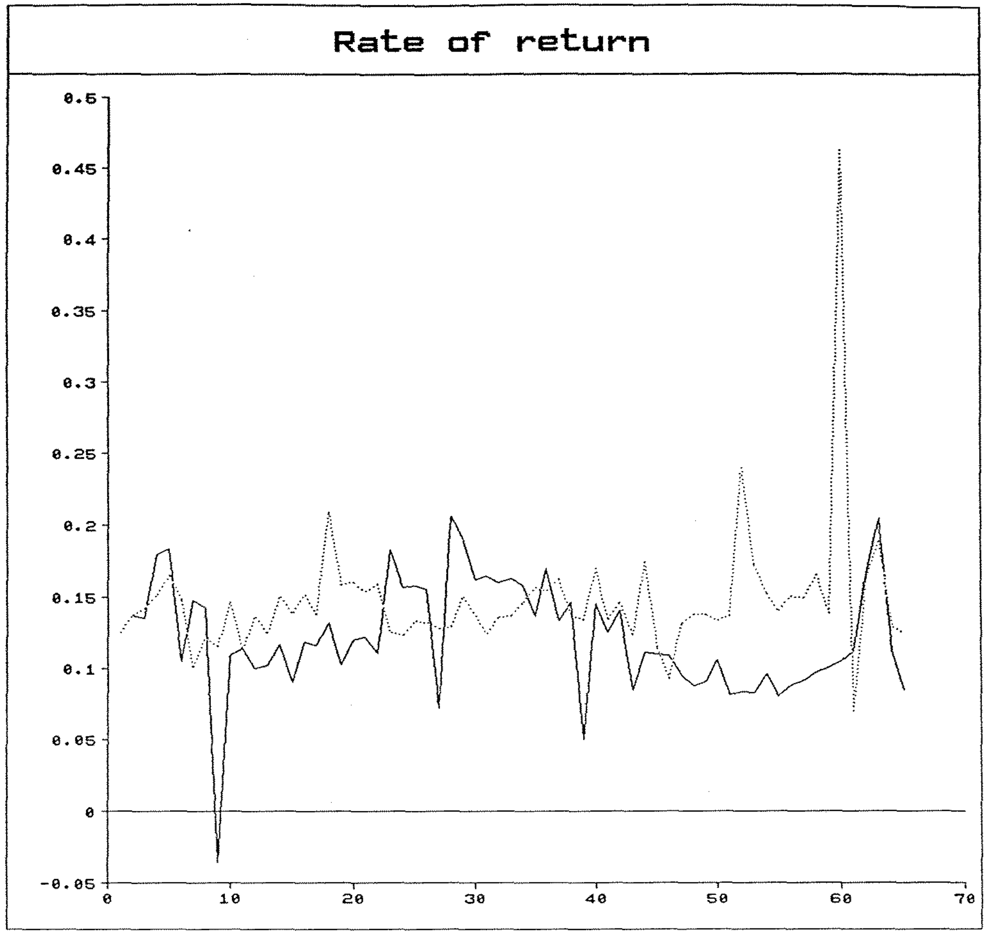

Figure 9.

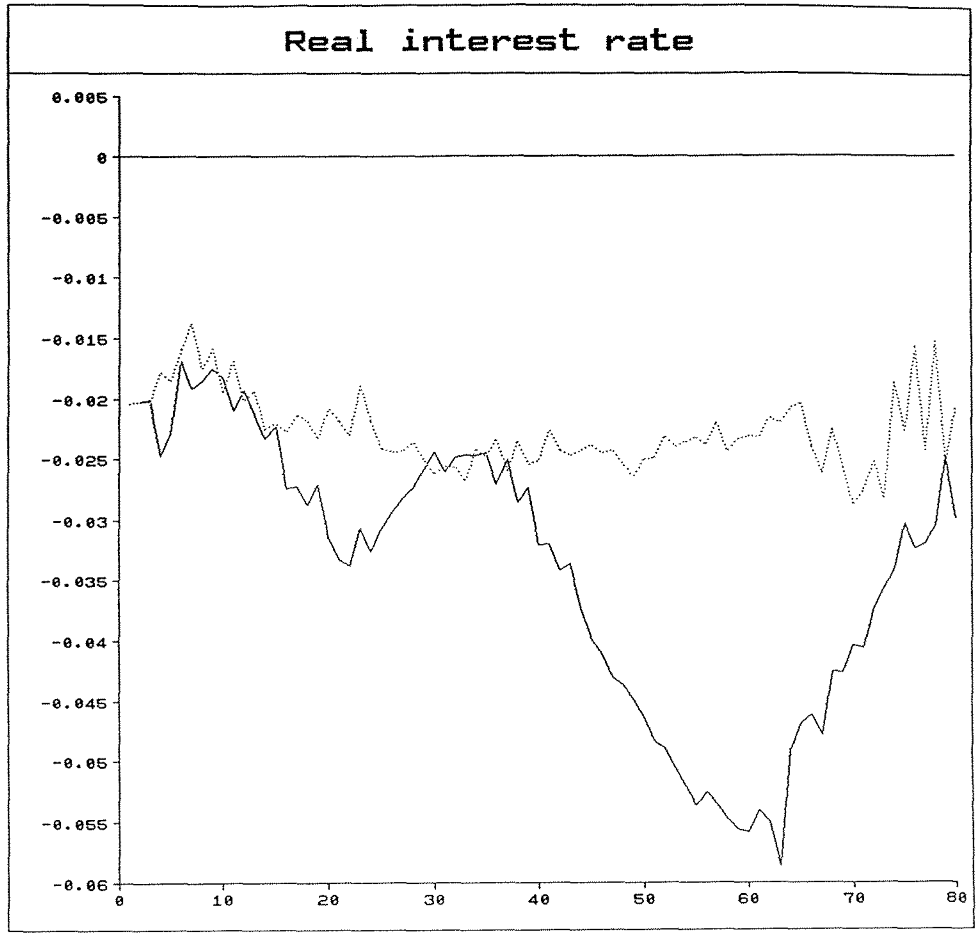

Figure 10.

Figure 11.

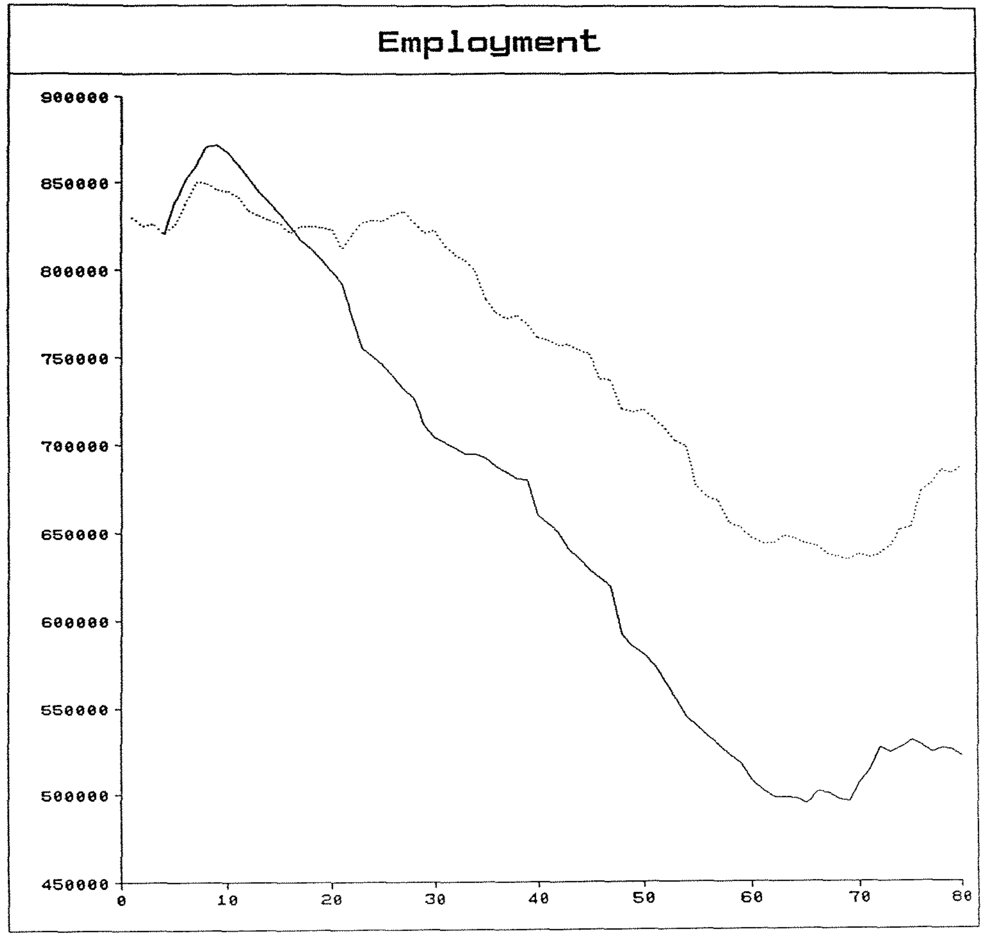

Figure 12.

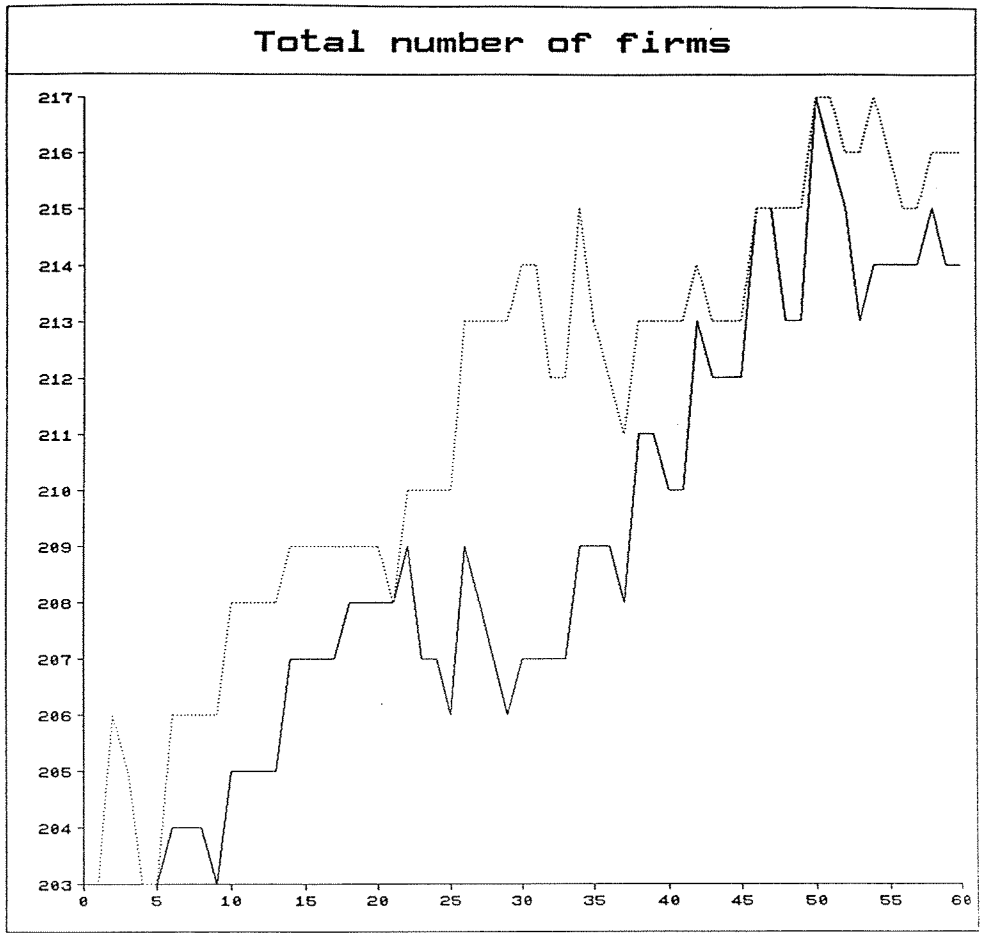

Figure 13.

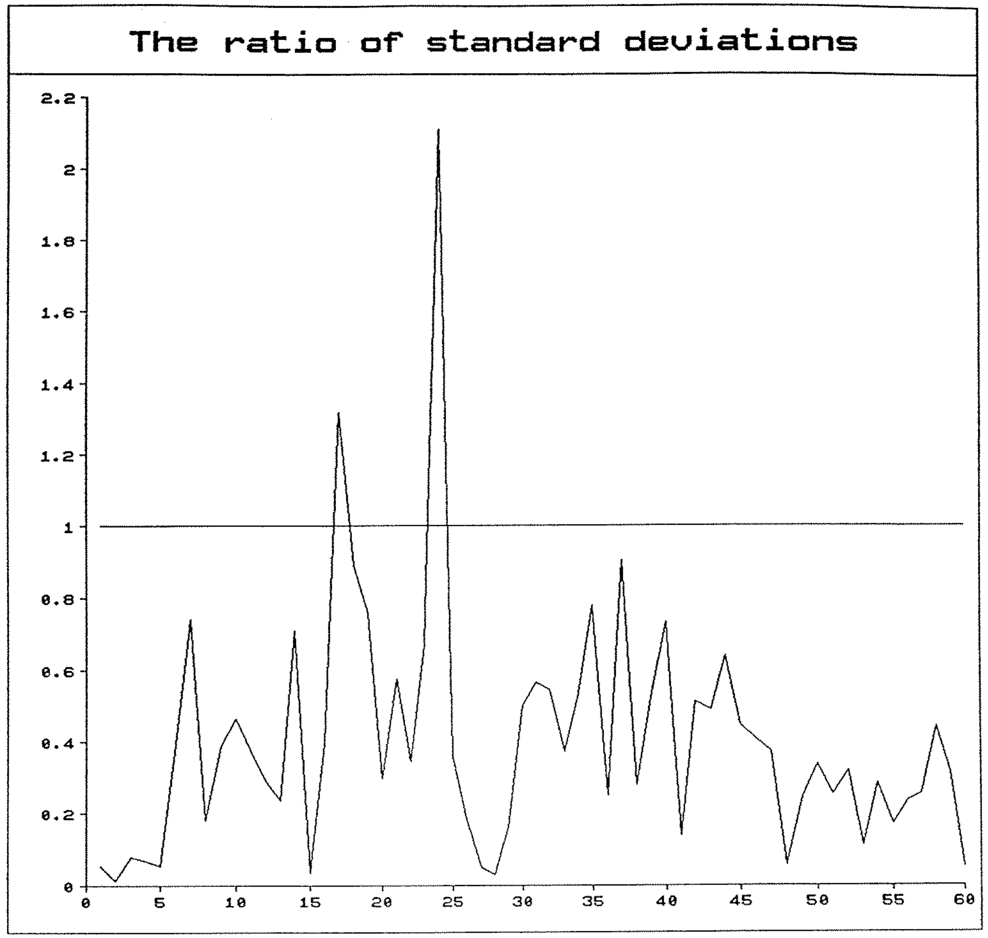

Figure 14.

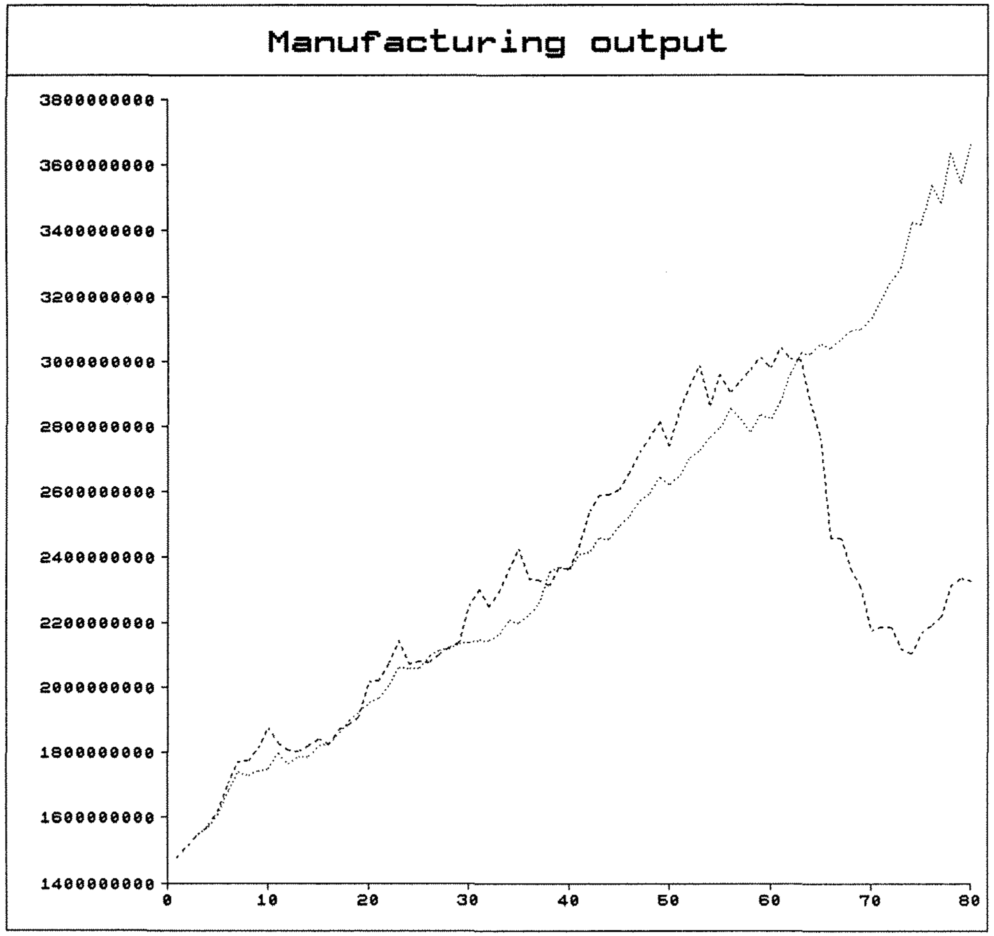

Figure 15. .... - Normal risk aversion;
------- - Low risk aversion.