BANK OF FINLAND
DISCUSSION PAPERS

5/95

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SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONSUNDERLAG

ISBN 951-686-443-0
ISSN 0785-3572

Suomen Pankin monistuskeskus
Helsinki 1995

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Abstract

This paper contains a description of a small quarterly model for the Finnish economy model (formerly, the QMED model). In addition to the basic features of this macroeconomic model, we report results from some stochastic simulations which illustrate the model's properties. Thus, the role of uncertainty in both endogenous and exogenous variables is scrutinized. We also report some simulations in which we try assess the importance of various factors which (presumably) contributed to the economic depression in Finland in 1991–1994.

Tiivistelmä

Keskustelualoitteessa käsitellään Suomen Pankissa rakennetun neljännesvuosimallin (entinen QMED-malli) nykyistä versiota. Tässä yhteydessä esitellään paitsi mallin rakennetta ja mallin käyttöön liittyviä asioita myös stokastisten simulointien tuloksia. Näillä simuloinneilla pyritään selvittämään mallin perusominaisuuksia ennustekäytössä. Tällöin käy ilmi se, miten sekä endogeenisiin että eksogeenisiin muuttujiin liittyvät ennustamattomat satunnaistekijät ilmenevät ennusteiden epävarmuutena. Näiden tarkasteluiden ohella analysoidaan vuosien 1991–1994 laman taustalla olleiden tekijöiden merkitystä.

Contents

1 Introduction

This paper reports some basic results obtained with a small Finnish quarterly model developed at the Bank of Finland, where it is mainly used in short-term forecasting. In addition, some advice is provided on the practical use of the model. We would encourage free and experimental use of the model. Thus, our colleagues may also make changes in the behavioral equations and/or values of exogenous variables and solve the model for the proper time period. The model can be used either in a mainframe environment (EKTA program) or in a PC environment (MICRO-EKTA and SIMPC programs). Needless to say, we are happy to provide more detailed information in this connection.

In this paper we concentrate on examining the simulation properties of the model. First, we scrutinize the properties of the model by means of stochastic simulation using the procedure suggested by Brown and Mariano (1981) and actual residuals data. For the sake of comparison, several simulations using Monte Carlo -generated data are also performed. The simulations concern both the overall sensitivity of the model and the sensitivity of the model in terms of exogenous variables. The purpose of these simulations is to assess the level of forecasting uncertainty: uncertainty stemming from both endogenous and exogenous variables. This analysis boils down to computing certain confidence intervals for a recent model forecast. The simulations also make it possible to examine the linearity of the model. This issue is crucial, for instance, in evaluating the values of various dynamic multipliers of the model.

The second type of analysis that we carry out is an examination of the exceptionally severe Finnish depression of 1991–1994. In fact, in terms of GDP, it has been deeper than the 1929–1932 depression. We analyze the importance of certain exogenous macroeconomic shocks as well as some key policy choices made before and during the depression years. The main purpose of the analysis is to develop a contrafactual interpretation of Finnish economic history: what could have happened if certain things had been different (for a similar exercise, see Brinner (1985)).

2 Simulation results

2.1 Some computational properties of the model

The model is basically similar to earlier versions of the model (which have been used only with a mainframe computer; see Lahti and Virén (1989) and Lahti (1989) for details). The main difference is that the current QMED model is somewhat smaller, having 14 stochastic equations, 11 identities and 50 variables (excluding the residuals). The second difference with respect to the earlier versions of the model is that the estimation period is now 1976.1–1993.4. The exclusion of the early 1970s is motivated by the fact that the institutional framework (particularly in terms of the capital market) is now very different from what it was in that period (not to mention the 1950s and 1960s). Thirdly, but not less importantly, the structure of the model has been changed. Now, rational expectations affect both consumption demand and wage formation via expected inflation and the rate of change of income. In addition, the (endogenous) capacity variable has been changed so that it now corresponds to the actual capacity utilization rate obtained from the Bank of Finland investment inquiry. And the model now includes an unemployment rate equation. Otherwise the model structure is fairly standard. Output, although affected by endogenous capacity is determined by aggregate demand, wages – or more precisely wage drift – is determined by a Phillips curve and prices are determined according to a mark-up model.

We do not go into the details of the model, but a brief summary of the main behavioral equations is presented in Appendix 1. The estimates are OLS estimates. The model is also estimated by Hatanaka's (1978) two-step estimation procedure, in which the instruments are derived from the model solution. This is done although the relatively small number of observations makes the estimation procedure somewhat questionable. In order to save space, the Hatanaka two-step estimates are not reported here. They, in fact, differ very little from the OLS estimates. In addition, Appendices 1 and 2 contain some diagnostic statistics for these equations (see also Figure 27, which contains a cross-plot of the residuals). As can be seen, these test statistics do not indicate serious shortcomings, although some alarming signs can be detected.

As mentioned above, the rational expectations version of the model is solved using the Fair-Taylor (1983) algorithm. Because the model is relatively small and the maximum number of leads is only two, the computational problems are generally minimal – this is also true when working with a PC (cf. Sulamaa and Virén (1989) for further details). However, this does not mean that the model simulations are similar to those obtained with standard backward-looking expectations models. The simulated values for the sample period depend on post-sample period values. Thus, if a forecast is computed for, say, the period 1994–2000 the values of the exogenous variables both for this period and for certain subsequent periods are needed (depending on the forecast horizon and on the number of periods over which the solution path is extended in type III iterations (cf. Fair and Taylor (1983)). Thus, when rational expectations models are used in forecasting one cannot simply leave the post-forecasting period values of the exogenous variables unspecified or extrapolate them mechanically. In particular, if the forecasting (dynamic simulation) period is short and these future values are merely assumed to be constant, the simulation results are markedly different from the case where the future values are based on all available information.

The model is solved by using either the MICRO-EKTA or SIMPC program. In the former case, one must define the time-series versions for the exogenous and endogenous variables (in this case, for instance, M,V U2,U2,U2,UX, where U2 denotes the current data version for both endogenous and exogenous variables and UX the data version for simulation results), the period for dynamic simulation (in this case, T,K 1994Q3 2000Q4) and the solution command (in this case, M,FQR QMED, where QMED denotes the name of the model, F denotes the use of the rational expectations algorithm, Q indicates that the lagged values are used as starting values in iterations and R indicates that residuals are set to zero in the simulation). When the SIMPC program is used, only a few commands are required. One has to define the model (M QMED), read the data (R QMED.DAT), define the simulation period

(SMPL 94.3 2000.4) and solve (simulate) the model with the SIM command. The use of the model is very easy with both computer programs and no special computer facilities are required (one can even do the job with a PC286). With a PC486, the solution takes only a few seconds.

2.2 Results of the stochastic simulations

Procedure

The stochastic simulations were done as follows. First, we ran a standard (deterministic) dynamic simulation for the forecasting period 1994Q3–2000Q4. The solution, called the **baseline**, is used as a point of reference in the subsequent simulations. Secondly, we obtained 250 shuffled residuals for the period 1994Q3–2000Q4 (the current forecasting period) from the original (OLS) residuals by means of random drawing. Thirdly, we obtained 250 pseudo values for each exogenous variable using the AR(8) model (augmented with a linear time trend) residuals of the exogenous variables (estimated for the period 1976Q1–1993Q4) as a set of values from which 26 values were drawn randomly. Thus, the pseudo values for the exogenous variables were obtained as $X_{it} + \varepsilon_{ijt}$, $i = 1,2,..,25$, $j = 1,2,...,250$, where ε_{ijt} is the shuffled value of the residual.

In the case of exogenous variables, there is no self-evident way of carrying out the stochastic simulations. Our method is similar to the analysis of Fair (1989). AR(4) or AR(8) residuals are used simply to get some idea of the uncertainty attached to the exogenous variables. If the time path of the variable is very smooth (volatile), it is obviously much easier (more difficult) to make correct assumptions about the future values of the variable. However, one should keep in mind that this is a very crude way of estimating the uncertainty. It turns out that the time paths of the AR model forecasts for 1994Q3–2000Q4 do not always make sense. Thus, if the exogenous variables are replaced by univariate AR models and the whole model is solved, the new baseline differs substantially from the original baseline. Hence, we prefer to use the approach in which the exogenous variables are treated in an "old-fashoned" way and the stochastic shocks are added to these variables to get the new pseudo variables.

Presentation of results

The results are presented as follows: The stochastic simulation results with the OLS residuals from the estimated behavioural equations are presented in Tables 1 and 2. In Table 1, the results correspond to the case in which all residuals (in all stochastic equations) are taken into account. The table shows how this appears in the model forecast for these endogenous variables. Table 2, in turn, contains an equation-by-equation analysis in the case where only the residual of the corresponding equation is allowed to get a randomly drawn (nonzero) value. In this case, the effects on the Gross Domestic Product (GDP) and consumption prices (PC) are scrutinized. The results for the first experiment (cf. Table 1) are also illustrated in Figures 1–18. The figures include the baseline, the average of the respective 250 simulations and the confidence intervals (at the 95 per cent level) computed as the average ± 2*STD where STD denotes the standard deviation of the 250 simulations. The first figure shows the actual GDP time paths for these 250 simulations.

The stochastic simulation results for the exogenous variables are reported in the same way: Table 3 contains the (annual) average errors and standard deviations with respect to the GDP forecast for each shocked exogenous variable, while Figure 19 shows the time paths for GDP when all exogenous variables are shocked. Figure 20, in turn, shows the GDP baseline, the average of 250 stochastic simulations (when all exogenous variables are replaced by the corresponding shocked pseudo values) and, finally, the confidence intervals computed in the context of these simulations.

Interpretation

In commenting on the results we start with the case in which all endogenous variables are shocked at the same time (Table 1 and Figures 1–18). The first thing which ought to be mentioned here concerns the spread of the simulated time paths. It is no surprise that there is a lot of volatility, but the time paths cannot be characterized as explosive. The variance increases over time, which is natural, but even after 26 quarters the forecast values of GDP concentrate very much around the baseline solution.

Quarterly values are clearly more volatile than annual values. In most cases the latter values are of greater interest (by contrast, no one is interested in the value of GDP in, say, 1999Q3). Scrutinizing the annual values reveals that the average simulation error of GDP is 1 per cent for the last year of the forecasting period. The corresponding standard deviation is 3 per cent. Thus, the 95 per cent confidence interval is 12 per cent. In the case of GDP prices (implicit GDP deflator), the average error is nil and the standard deviation 3.8 per cent, implying a confidence interval of 15 per cent.

The fact that the average error of GDP is not zero may be the result of nonnormal error terms or nonlinearities. The first explanation seems more likely, that is the distribution of estimated residuals is not in all cases normal (see Appendix 2 for certain descriptive statistics concerning the residuals and Figure 27 for a cross-plot and frequency distribution of the residuals). Thus, the residuals are clearly (negatively) skewed, and they are marked by excess kurtosis. It is no surprise that using these residuals in stochastic simulation introduces some error in the levels of the endogenous variables.

Regarding the nonlinearity issue, we also carried out an experiment in which we performed the stochastic simulation with genuinely normally distributed random numbers (with variance equal to the residual variance of the OLS residuals). The results of this exercise are reported in Figures 21 and 22. The first figure presents the same results as Figure 2, i.e. the baseline solution: the average of 250 stochastic simulations and the corresponding 95 per cent confidence interval. Figure 22 shows the (cumulative) differences between the average simulation paths and the baseline solution. The upper curve gives the results for the actual OLS residuals and the lower curve the results for the random normal variates. Clearly, the average simulation error in the case of the random normal variates is negligible (except for the two last forecast years), suggesting that the model is indeed linear. This is an important piece of information for interpreting of different policy simulations (and dynamic multipliers). In the linear case, the size of the effects depends linearly on the size of the change in the respective exogenous variable(s) and hence the effects of different policy actions do not depend on the specific value of the policy variable (but the change of the variable).

We have discussed mainly the behaviour of GDP. Some comments on other variables are also called for. If we first consider the nature of the forecast uncertainty, we notice that the variable with the largest average simulation error and the largest variance is business investment. Thus, the level of investment for year 2000 can be forecast only very imprecisely. One cannot exclude the possibility that investment expenditure in 2000 is at the same level as at the beginning of 1994, nor can one exclude the possibility that the level is twice as high as in 1994. Clearly, business investment is the weak link of the model. The reason is obvious: the investment equation involves a high degree of simultaneity. Investment both depends on and directly affects GDP.

In addition to investment, wages and income are variables that are difficult to forecast. Thus, with this model, the confidence interval is very wide. This is also intuitively obvious, as it is very difficult to say anything about future incomes policy, i.e. whether future wage settlements will be moderate or excessively high. In the past (i.e., in the estimation period 1976–1993), both regimes can be detected.

A somewhat different picture emerges when we scrutinize the sources of GDP (and consumption price) uncertainty using the equation-by-equation analysis as a frame of reference. Again, business investment produces a lot of variability in the GDP. Not surprisingly, also private consumption and exports and imports are important sources of GDP variability. The variables do not, however, affect GDP in the same way. As can be seen from the first row of Table 2, the variability is relatively small when all endogenous variables are shocked at the same time – much smaller than the sum of the individual variabilities (thus, assuming that they are independent).

In terms of consumption prices, the most important effects come from wages (negotiated wages and wage drift), from the own error term and from unemployment and capacity utilization rates. This is not unexpected. In the same way, the minor role of the other real variables comes as no real surprise. The level of demand itself does not simply translate to price changes.

Finally, we turn to the results of the analysis of exogenous variables. The results in Table 3 suggest that if uncertainty with respect to the future values of exogenous variables is somehow proportional to the variance of AR(8) residuals of the respective variable, the resulting GDP effects are quite small. This is true both in terms of bias and variability of the simulated forecasts. None of the variables is strikingly bad in this respect. Not surprisingly, export prices, volume of eastern trade, inventory investment and the FIN–FRG interest rate differential are the variables which make the largest contribution to GDP forecasts.

2.3 Analysis of alternative policies

Alternatives

In the early 1990s Finland was hit by an exceptionally severe depression. The Gross Domestic Product decreased in three consecutive years, 1991, 1992 and 1993, altogether by 15 per cent. Unemployment, which had been below 100 000 in 1990 increased in late 1993 to over 500 000, which pushed the unemployment rate up to about 20 per cent (see Bordes, Currie and Söderström (1993) for a more detailed description of the Finnish crisis and an assessment – in fact, three assessments – of its origins).

It is surely of some interest to examine the factors which caused these developments. Thus, we may scrutinize the relative importance of the most often mentioned factors:

- total collapse of eastern trade
- slowdown of western export demand growth
- deterioration of the terms of trade
- contractive fiscal policy measures
- exchange rate crises and the resulting interest rate increases

Following Brinner (1988) and Brunner and Kamin (1994) we carry out some contrafactual simulations for the recession period 1991Q1–1994Q2 using the QMED model. In these simulations, we simply smooth the respective exogenous variables. Thus, for instance, we assume that eastern trade would have remained at its pre-1989 level during the whole period. In the second simulation we assume that export demand growth would have continued at the same rate as in the 1980s. In the third simulation we remove the terms-of-trade deterioration after 1989 and in the fourth simulation we keep public consumption at the 1989 level. Finally, we assume that the interest rate (i.e. the Bank of Finland base rate) remains at the 1989 level following the German Bundesbank discount rate and that the interest rate differential vis-à-vis Germany is zero, as was the case in mid-1994.

One might imagine that in a very lucky scenario Finland would not have experienced a fall in exports and that the current account would have stayed at a reasonable level, which in turn would have made contractive fiscal policy measures unnecessary and would have avoided exchange rate crises and interest rate increases. Needless to say, this scenario is based on a great number of "ifs".

Actual vs dynamic simulation

Before we scrutinize the importance of different exogenous variables we scrutinize the performance of the QMED model in explaining both the recent boom and the recession that followed. Of course, a good simulation record does not guarantee that the model is correct (cf. Pagan (1989) for a more affirmative argument). Even so, it is obvious that if the model is completely unable to mimic the observed cyclical behaviour of GDP, it is difficult to use it as tool for explaining the reasons behind the cycles.

Therefore, we carry out some dynamic simulations for the time period 1986–1994. In fact, we experiment with all possible starting periods in 1986–1991 to see how the past simulation record affects the model's performance in the recession period, 1991–1994. The simulation errors (i.e. percentage differences between actual and simulated GDP) are reported in Table 4 for the alternative starting points. Figure 23, in turn, gives the same information for every second starting period, i.e. first quarters of 1987, 1989, and 1991. The figure also shows the actual time path of GDP. In Figure 24 this analysis is repeated, but this time the simulation is carried out in the reverse direction (i.e. backwards). Thus, we start from the third quarter of 1994 and solve the model back to the first quarter of 1987. Clearly, the GDP changes have been very large: the period 1985–1990 in Finland was characterized by economic growth that was certainly unprecedented in the whole OECD area. The same can be said of the subsequent depression. It is not easy to specify a model which could exactly track this enormous reversal.

Given this background, one may argue that the model's performance is quite satisfactory. True, the model somewhat underestimates the peak of the boom in 1987–1989 and the severity of the depression in 1992–1993 (in the conventional forward simulation). However, the main features of the cyclical movements are rather well taken into account in the dynamic simulation paths and, therefore, the use of the model in explaining the reasons behind the depression may not completely futile (see e.g. Fisher and Wallis (1990) for an analysis of the tracking performance of U.K. models').

Although the difference between forward and backward simulations cannot be analytically explained, one may speculate that the difference is caused by the initial conditions and the persistence. Of course, the observed time irreversibility may also suggest that there are certain nonlinearities in behaviour and/or institutional evolution. To study these matters, is obviously beyond the scope of this study.

Policy effects

We now turn to the analysis of the effects of different exogenous variables on the severity of the 1991–1993 depression. The time paths of these exogenous variables are presented in Figure 25. The figure shows both the actual time paths of the respective series and the smoothed time paths. The latter paths are typically obtained by simple mechanical extrapolation. For instance, it has been assumed that the level of eastern trade could have continued at the 1990 level over the whole period. Only in the case of interest rate is a more sophisticated approach used. In the smoothing alternative it has been assumed that the (Finnish) base rate tracks the German discount rate and that the (market) interest rate differential between Finland and Germany goes to zero.

Obviously, one should also reconsider the behaviour of exchange rates during the depression period. Had the current account developed according to the most optimistic scenario, there would have been much less pressure to devalue the Finnnish markka (as it happened in 1991 and 1992). Here we disregard completely the exchange rate policy analysis because different exchange rate alternatives depend very much on the outcomes of all other variables and because analysis in this connection would necessarily be highly speculative.

The analysis now proceeds in a very straightforward manner: the smoothed values instead of actual values are used for each exogenous variable. Eastern trade is the first variable, followed (in order) by western export demand growth, fiscal policy, interest rates and the terms of trade. The results from this analysis are reported in Figure 26 and Table 5.

One can clearly see that the most important factor in explaining the depth of depression is the collapse of eastern trade. Next is the squeeze in public consumption and then the (real) interest rate crisis. The slowdown in western export demand is also of some importance, but the terms of trade effects seems to be of minor importance. One should not hasten to declare the terms of trade completely negligible. As can bee seen from the table, the terms of trade effect is very important with respect to the current account. In the QMED model, most of the terms of trade effect feeds into prices, not volumes. However, one cannot say that this is definitely the case. It is obvious that the nature of the terms-of-trade effect is very sensitive in terms of export firms' demand and profitability conditions. Thus, it could well have happened that most of the terms of trade would have fed into the volumes of exports and imports, with stronger effects on GDP. Of course, the current account effect is not unimportant. An improvement in the current account means more space for domestic demand expansion (less need for contractionary fiscal and monetary policy).

Even if our analysis is just a single crude experiment, it may indicate that economic developments of recent years are not a complete puzzle. Thus, for instance, the reasons behind the depression can be quantified rather well. About two-thirds of depth of the depression can be explained by shocks to the key exogenous variables. A hundred per cent explanation is obviously beyond our model. There is no channel through which long-term income expectations could have an impact. Also the effects of wealth, indebtedness and uncertainty are not well accounted for in the model. Needless to say, these effects would deserve more attention in future respecifications of the model.

3 Concluding remarks

The QMED model seems to be relatively reliable in macroeconomic forecasting. There seem to be no systematic forecasts biases. Of course, there is a lot of uncertainty with forecasts, a fact which is seldom realized in working with model forecasts. In the case of the QMED model, this uncertainty seems to be related very much to the business investment equation, which obviously requires more careful analysis in the future. As far as the exogenous variables are concerned, our analysis did not detect a single most important source of uncertainty. It is, however, very difficult to analyze uncertainty associated with to exogenous variables. The distinction between endogenous and exogenous variables is, after all, rather arbitrary and it should perhaps be reconsidered at least in a forecasting situation.

In this paper, the model was used as an analytical device to examine the reasons behind the recent cyclical movements in the Finnish economy. In particular, the recent recession was analyzed. In short, the results seem to indicate that the whole recession can be rather well explained with the model, particularly with export market developments. Had the most important exogenous variables behaved in a different (smoother) way, the recession would have been much milder. Of course, there are may caveats to this kind of analysis. Models like the QMED model are not very good in terms of various wealth, indebtedness and expectations effects, which are nowadays of crucial importance for macroeconomic behavior and which surely affected the economy during the depression.

Macroeconomic models have recently met criticism from various directions. To a great extent, the criticism is well-founded. The models are indeed quite old-fashioned, only weakly data-consistent and rather cumbersome in practical forecasting work. Needless to say, much work is needed to improve the reputation of these models. Surely, one of the most important tasks is show that the models are indeed useful and reliable in this kind of work.

Table 1. **Results from stochastic simulations with OLS residuals from estimated equations**

		1994	1995	1996	1997	1998	1999	2000
Bond yield	avg	−0.01	−0.01	0.05	0.03	0.01	−0.01	−0.02
	std	0.23	0.41	0.40	0.40	0.39	0.39	0.41
Capacity U.R.	avg	0.06	0.15	0.11	−0.05	−0.09	0.03	0.02
	std	0.64	1.91	2.31	2.44	2.64	2.98	3.09
Consumption prices	avg	0.01	0.23	0.54	0.87	0.97	1.06	1.01
	std	0.28	1.31	2.00	2.41	2.84	3.06	3.21
Current account	avg	1.80	3.48	2.35	2.06	0.71	−0.20	−1.28
	std	20.03	27.59	32.37	28.16	32.85	29.62	25.95
Disposable income	avg	0.07	0.52	0.95	1.38	1.79	1.99	2.19
	std	0.59	2.23	3.59	4.69	5.82	6.71	7.45
Exports	avg	−0.07	0.08	0.52	0.48	0.17	0.44	0.53
	std	1.41	2.56	2.58	2.67	2.63	2.39	2.56
GDP	avg	0.12	0.27	0.35	0.48	0.64	0.77	1.00
	std	0.57	1.30	1.73	2.17	2.42	2.59	3.00
GDP deflator	avg	0.00	0.06	0.16	0.31	0.26	0.16	−0.03
	std	0.29	1.34	2.10	2.66	3.16	3.45	3.76
Imports	avg	−0.30	−0.26	0.39	0.37	0.18	0.68	0.92
	std	1.76	3.08	3.58	3.80	4.00	4.30	4.16
Investment	avg	0.32	1.15	2.16	3.18	4.29	5.35	7.29
	std	2.90	9.72	13.90	16.40	19.34	22.48	23.58
Negotiated wages	avg	0.03	0.28	0.53	0.85	0.91	0.94	0.86
	std	0.66	2.46	3.65	4.62	5.30	5.65	5.94
Private consumption	avg	0.07	0.06	0.08	0.11	0.28	0.42	0.49
	std	0.60	1.66	2.03	2.54	3.01	3.34	3.68
Residental investment	avg	0.10	0.72	0.39	0.57	0.66	0.57	0.82
	std	1.66	2.67	2.65	2.76	2.97	2.62	2.53
Saving rate	avg	−0.01	0.18	0.25	0.29	0.36	0.30	0.42
	std	0.48	1.53	1.96	2.15	2.17	2.33	2.44
Unemployment rate	avg	−0.01	−0.04	−0.09	−0.12	0.02	0.08	0.05
	std	0.23	0.89	1.43	1.87	2.40	2.73	3.00
Value of GDP	avg	0.13	0.34	0.51	0.80	0.91	0.96	1.01
	std	0.71	1.83	2.75	3.61	4.30	4.85	5.58
Wage rate	avg	0.03	0.25	0.49	0.77	0.82	0.80	0.72
	std	0.64	2.44	3.77	5.05	6.14	6.84	7.52

Average error refers to the difference between the base and the 250 simulations computed over 26 quarters. The displayed figures are annual sums. Standard deviation is the corresponding statistic for the sums of quarterly standard deviations with respect to the base. In the case of PG, PI and B470, the GDP effects were completely negligible, hence the numbers are not reported. Figures 2–18 show the quarterly values.

Table 2. **Equation-by-equation results for GDP and consumption prices from stochastic simulations with OLS residuals from estimated equations**

Effects on GDP

		1994	1995	1996	1997	1998	1999	2000
All equations	avg	0.12	0.27	0.35	0.48	0.64	0.77	1.00
	std	0.57	1.30	1.73	2.17	2.42	2.59	3.00
Bond yield	avg	−0.00	0.00	0.01	0.01	0.01	0.01	0.01
	std	0.00	0.02	0.04	0.05	0.06	0.06	0.06
Business investment	avg	0.01	−0.45	−0.41	−0.40	−0.34	−0.25	−0.09
	std	0.19	0.61	0.95	1.19	1.53	1.85	1.99
Capacity utilization rate	avg	−0.00	0.00	0.00	0.02	0.02	−0.00	0.00
	std	0.03	0.12	0.13	0.16	0.18	0.21	0.24
Consumption prices	avg	−0.00	−0.07	−0.16	−0.25	−0.30	−0.35	−0.36
	std	0.13	0.41	0.53	0.59	0.66	0.66	0.66
Disposable income	avg	0.00	0.03	0.06	0.09	0.16	0.23	0.30
	std	0.04	0.22	0.44	0.66	0.85	1.03	1.18
Exports	avg	−0.02	0.04	0.15	0.14	0.07	0.17	0.19
	std	0.38	0.67	0.69	0.73	0.74	0.69	0.74
Imports	avg	0.24	0.22	0.13	0.19	0.24	0.16	0.18
	std	0.45	0.74	0.89	0.89	0.87	0.80	0.82
Investment prices	avg	−0.00	−0.01	−0.01	−0.02	−0.03	−0.03	−0.04
	std	0.01	0.03	0.04	0.05	0.06	0.06	0.07
Negotiated wages	avg	−0.00	−0.01	−0.01	−0.02	0.01	0.02	0.04
	std	0.04	0.22	0.27	0.27	0.32	0.43	0.60
Private consumption	avg	0.03	0.04	0.04	0.04	0.09	0.08	−0.02
	std	0.28	0.74	0.88	0.95	0.96	0.90	0.96
Residental investment	avg	0.00	0.03	0.02	0.04	0.04	0.03	0.05
	std	0.07	0.12	0.14	0.15	0.17	0.15	0.15
Unemployment rate	avg	−0.00	−0.01	−0.00	0.01	−0.03	−0.04	−0.03
	std	0.07	0.21	0.24	0.25	0.28	0.24	0.24
Wage rate	avg	0.00	0.01	0.02	0.02	0.01	0.01	−0.01
	std	0.01	0.09	0.15	0.16	0.16	0.22	0.32

See footnote to Table 1. In the case of all equations (i.e. stochastic terms introduced to all equations), the result is the same as the GDP row in Table 1.

Table 2 continued

Effects on consumption prices

		1994	1995	1996	1997	1998	1999	2000
All equations	avg	0.01	0.23	0.54	0.87	0.97	1.06	1.01
	std	0.28	1.31	2.00	2.41	2.84	3.06	3.21
Bond yield	avg	–0.00	0.00	0.00	0.00	0.01	0.01	0.01
	std	0.00	0.00	0.01	0.02	0.02	0.03	0.03
Business investment	avg	0.00	–0.06	–0.13	–0.17	–0.16	–0.11	–0.01
	std	0.01	0.10	0.23	0.37	0.50	0.62	0.71
Capacity utilization rate	avg	–0.00	0.00	0.00	0.01	0.02	0.01	0.01
	std	0.00	0.01	0.09	0.27	0.52	0.79	1.05
Consumption prices	avg	0.01	0.16	0.40	0.63	0.74	0.84	0.85
	std	0.27	0.99	1.31	1.43	1.59	1.60	1.59
Disposable income	avg	0.00	0.00	0.01	0.02	0.04	0.06	0.09
	std	0.00	0.02	0.07	0.14	0.23	0.33	0.42
Exports	avg	–0.00	–0.01	0.02	0.05	0.05	0.06	0.08
	std	0.02	0.13	0.20	0.23	0.25	0.26	0.26
Imports	avg	0.02	0.08	0.09	0.09	0.12	0.12	0.11
	std	0.03	0.15	0.23	0.28	0.30	0.29	0.29
Investment prices	avg	–0.00	–0.00	–0.00	–0.01	–0.01	–0.02	–0.02
	std	0.00	0.01	0.02	0.03	0.04	0.04	0.05
Negotiated wages	avg	0.00	0.05	0.12	0.18	0.14	0.15	0.10
	std	0.15	1.04	1.66	2.05	2.27	2.27	2.23
Private consumption	avg	0.00	0.01	0.02	0.02	0.03	0.04	0.04
	std	0.02	0.13	0.26	0.36	0.43	0.47	0.48
Residental investment	avg	0.00	0.01	0.01	0.01	0.02	0.02	0.02
	std	0.00	0.02	0.03	0.04	0.05	0.05	0.05
Unemployment rate	avg	–0.00	–0.00	–0.01	–0.01	–0.02	–0.04	–0.07
	std	0.01	0.09	0.22	0.35	0.47	0.58	0.65
Wage rate	avg	–0.00	–0.04	–0.10	–0.16	–0.22	–0.31	–0.39
	std	0.05	0.44	0.96	1.44	1.84	2.18	2.47

Table 3. **Results for GDP from stochastic simulations for the exogenous variables**

		1994	1995	1996	1997	1998	1999	2000
All variables	avg	−0.11	0.45	0.53	0.58	0.70	0.76	0.76
	std	0.41	0.60	0.64	0.56	0.58	0.56	0.59
Base rate	avg	−0.00	0.00	0.00	−0.00	−0.00	−0.00	−0.00
	std	0.00	0.02	0.03	0.03	0.04	0.04	0.04
Basket interest rate	avg	−0.00	0.00	0.00	0.00	0.00	0.00	0.00
	std	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Building permits	avg	0.00	0.01	0.00	0.00	−0.01	−0.01	−0.01
	std	0.03	0.11	0.12	0.10	0.10	0.09	0.09
Eastern trade	avg	−0.01	−0.05	−0.06	−0.05	−0.04	−0.04	−0.06
	std	0.18	0.32	0.29	0.27	0.25	0.26	0.24
Export demand	avg	0.01	0.00	−0.00	0.00	0.00	0.00	−0.00
	std	0.04	0.09	0.10	0.10	0.09	0.09	0.09
Export prices	avg	−0.01	0.00	−0.00	0.01	−0.01	−0.00	0.02
	std	0.07	0.16	0.17	0.16	0.17	0.16	0.17
Foreign prices	avg	0.00	−0.01	−0.00	0.01	0.01	0.01	0.00
	std	0.06	0.12	0.15	0.14	0.13	0.13	0.14
Government domestic debt	avg	−0.00	0.00	0.00	0.00	0.00	0.00	0.00
	std	0.00	0.00	0.00	0.00	0.00	0.00	0.00
House prices	avg	0.01	0.00	−0.01	0.01	0.01	0.00	0.00
	std	0.04	0.06	0.06	0.06	0.05	0.06	0.05
Import prices	avg	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	std	0.05	0.08	0.10	0.10	0.09	0.09	0.10
Income tax rate	avg	−0.00	0.00	0.00	0.00	0.00	0.00	0.00
	std	0.00	0.01	0.01	0.01	0.02	0.01	0.01
Interest rate differential	avg	0.00	0.01	0.02	0.02	0.02	0.02	0.02
	std	0.02	0.07	0.11	0.15	0.18	0.20	0.22
Inventory investment	avg	0.03	0.01	0.04	−0.03	0.02	0.02	−0.00
	std	0.33	0.45	0.50	0.42	0.41	0.41	0.40
Oil prices	avg	−0.00	0.00	0.00	0.00	0.00	0.00	0.00
	std	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Public consumption	avg	−0.00	0.00	0.00	0.01	0.00	0.01	0.00
	std	0.05	0.07	0.06	0.07	0.06	0.06	0.06
Public investment	avg	−0.00	−0.00	0.00	0.00	0.00	0.01	−0.00
	std	0.05	0.07	0.06	0.07	0.06	0.06	0.06
Soc. security tax rate	avg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	std	0.01	0.02	0.02	0.03	0.03	0.03	0.03
Stock prices	avg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	std	0.00	0.00	0.00	0.02	0.02	0.02	0.01
Working age population	avg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	std	0.00	0.00	0.01	0.01	0.01	0.01	0.01

See footnote to Table 1. Dummies are excluded here. All results are derived with respect to GDP.

Table 4. **Simulation errors with respect to GDP**

	1991	1990	1989	1988	1987	1986
1985						
1986						-1.26
1987					-1.45	-2.10
1988				0.08	-1.89	-2.49
1989			-1.39	-1.64	-3.23	-3.85
1990		0.74	-2.26	-2.63	-3.83	-4.53
1991	-0.54	0.16	-2.05	-2.48	-3.20	-4.03
1992	1.98	2.51	0.84	0.35	0.06	-0.92
1993	3.64	3.98	2.69	2.14	2.22	1.13
1994	3.67	3.90	2.82	2.20	2.60	1.42

Values are percentage differences between actual and simulated values when dynamic simulations were started from the first quarter of 1986, 1987, ..., 1991. Annual values are based on quarterly values.

Table 5. **Effects of exogenous variables**

on GDP

	1991	1992	1993	1994
Eastern trade	2.6	3.6	2.9	1.3
Western export demand	0.1	0.4	1.1	1.8
Fiscal policy	0.1	0.7	2.1	3.0
Interest rate	0.6	1.5	1.8	1.9
Terms of trade	0.4	0.5	0.3	0.4
Total	3.7	6.7	8.2	8.4
Actual GDP gap	-7.0	-10.5	-12.3	-8.9

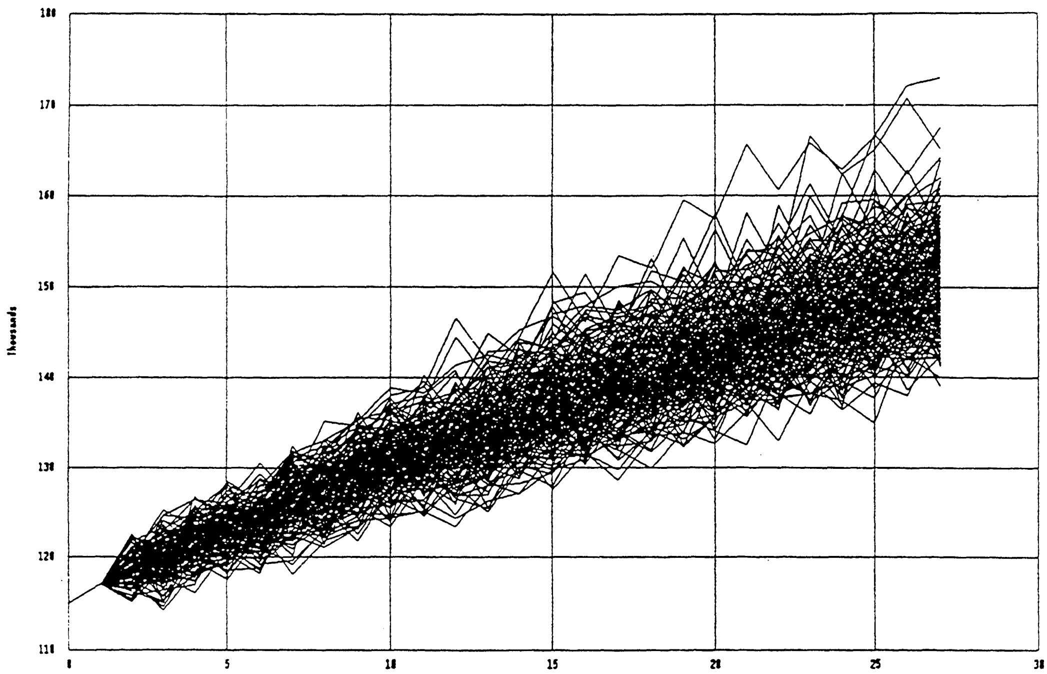
The GDP gap denotes the percentage difference between actual GDP and the 1990 value of GDP. Effects are measured in terms of percentage differences between the baseline and the alternative (dynamic) simulation.

on the current account

	1991	1992	1993	1994
Eastern trade	-18481	-9810	5504	15983
Western export demand	-18159	-8405	9678	23296
Fiscal policy	-18181	-8841	8110	20469
Interest rate	-19024	-11925	3109	14481
Terms of trade	-12818	-2331	18416	30279
Actual current account	-26980	-22411	-4436	11288

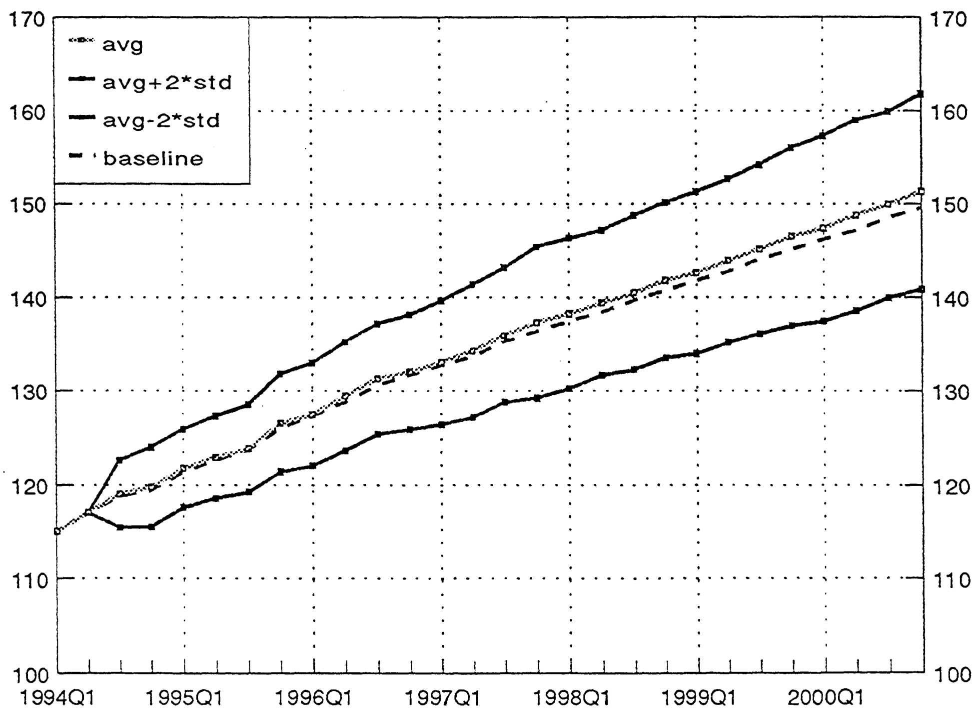
Values are expressed in mill. FIM. The effects of different exogenous variables are added one-by-one to the baseline.

Figure 1. **250 simulations for the Gross Domestic Product**



Observation 3(26) corresponds to 1994Q3 (2000Q4). The figure is based on 250 simulations. Displayed figures are billions of GDP at constant 1990 Finnish markka prices. Subsequent volumes are expressed in an analogous way.

Figure 2. **Forecast for the Gross Domestic Product**



"baseline" is the deterministic dynamic simulation path, "avg" is the average of 250 stochastic simulations and "avg ±2*std" is the 95 per cent confidence interval.

Figure 3. **Forecast for imports**

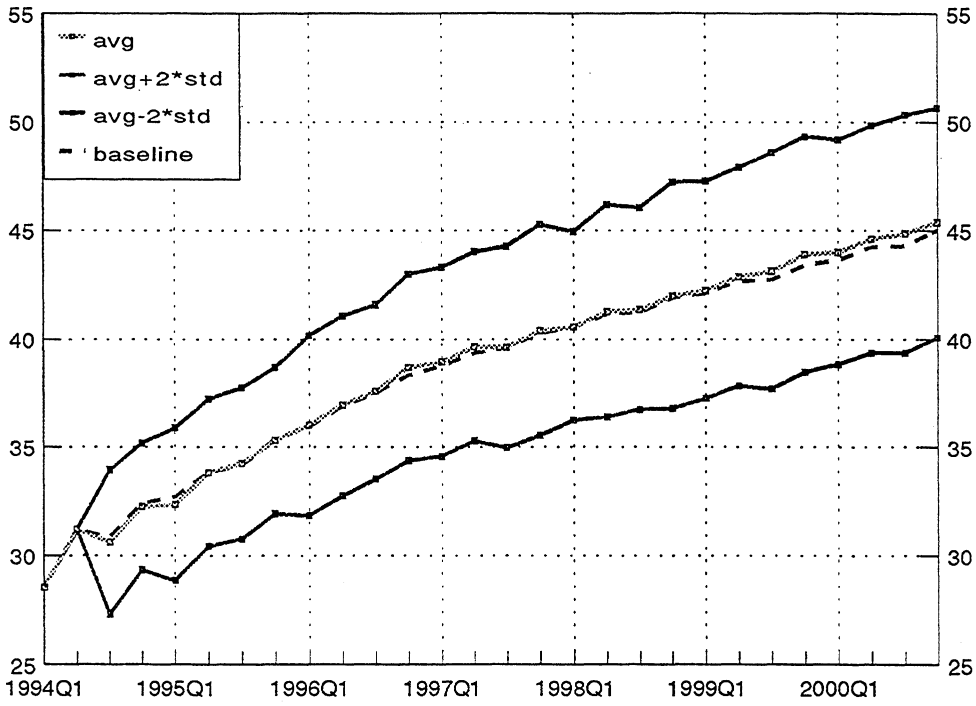


Figure 4. **Forecast for exports**

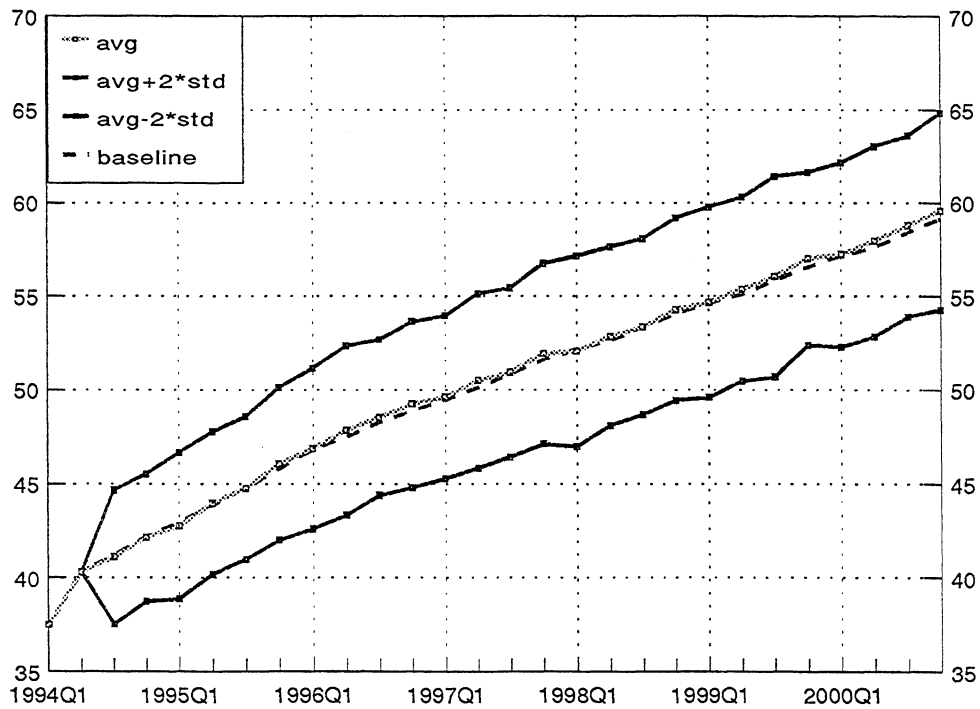


Figure 5. **Forecast for private consumption**

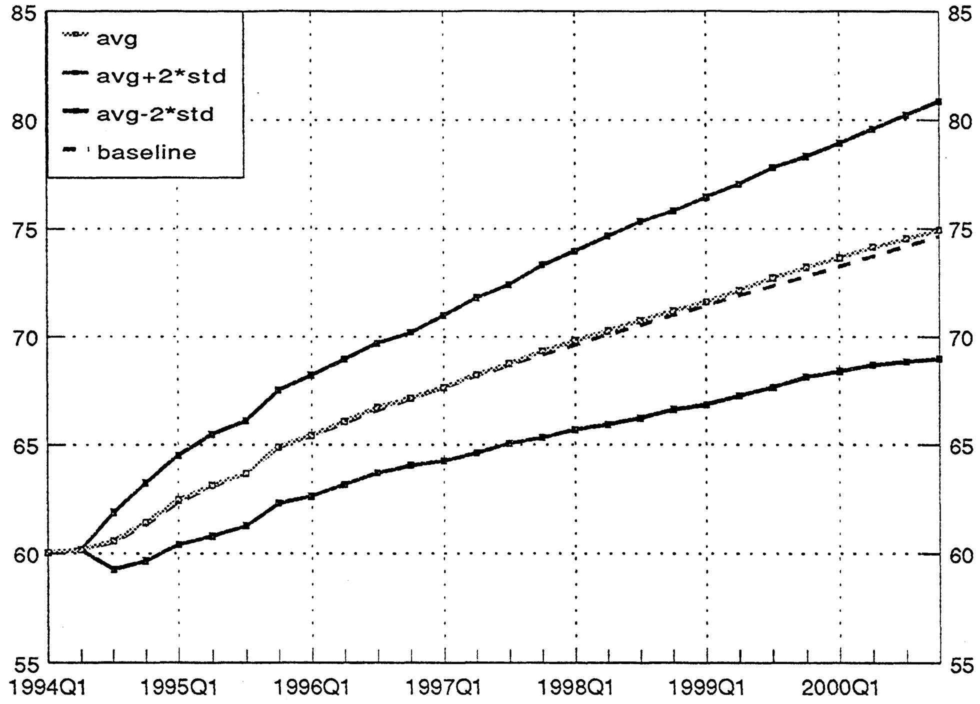


Figure 6. **Forecast for business investment**

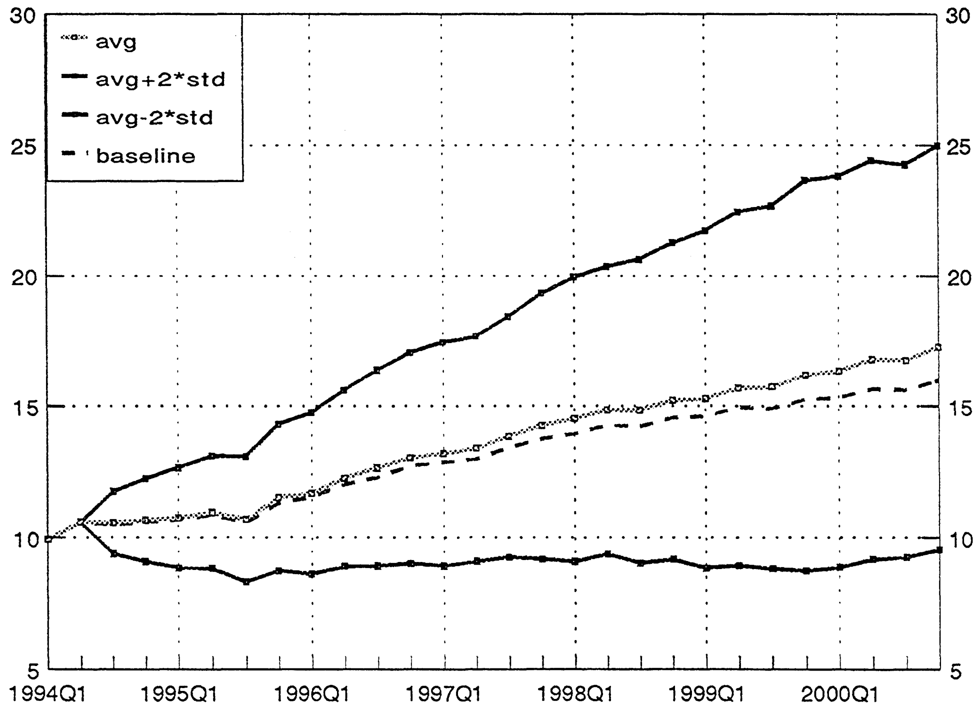


Figure 7. **Forecast for the value of GDP**

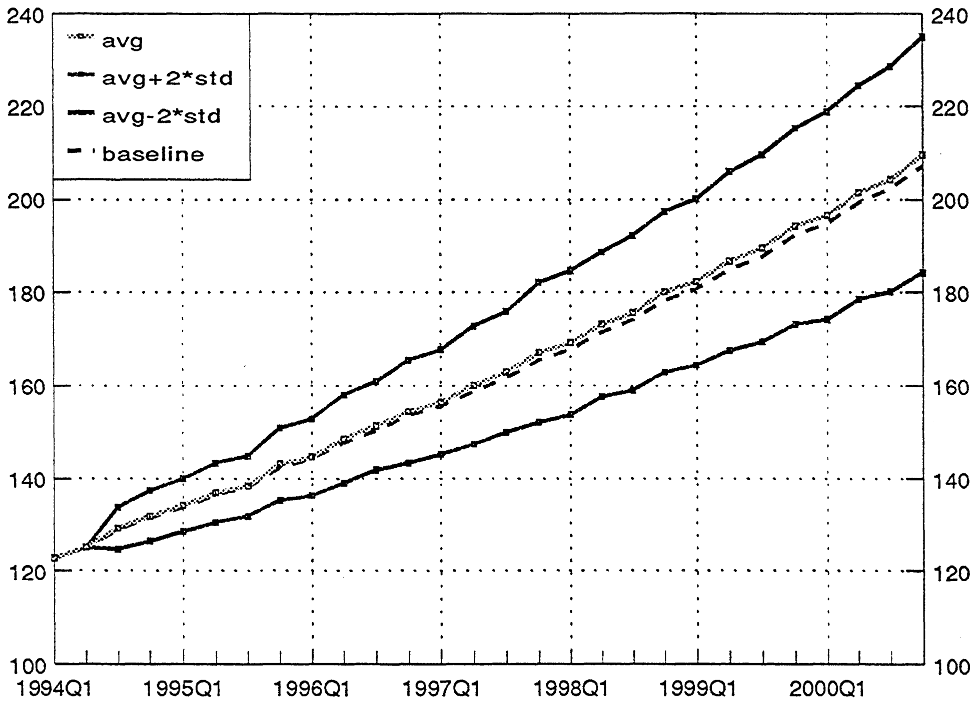


Figure 8. **Forecast for the GDP deflator**

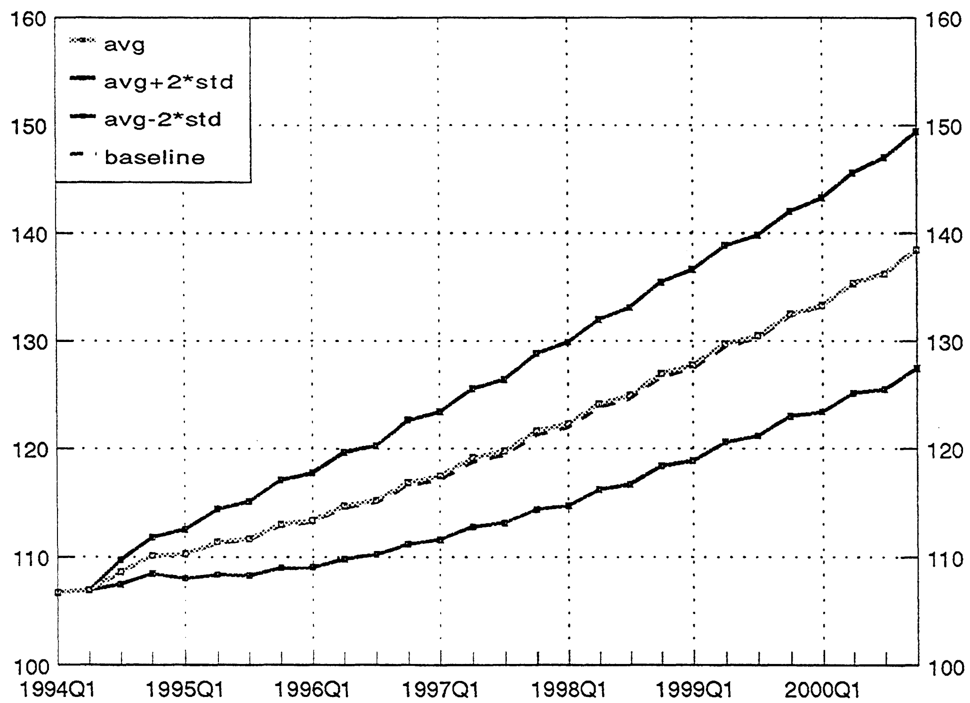


Figure 9. **Forecast for consumption prices**

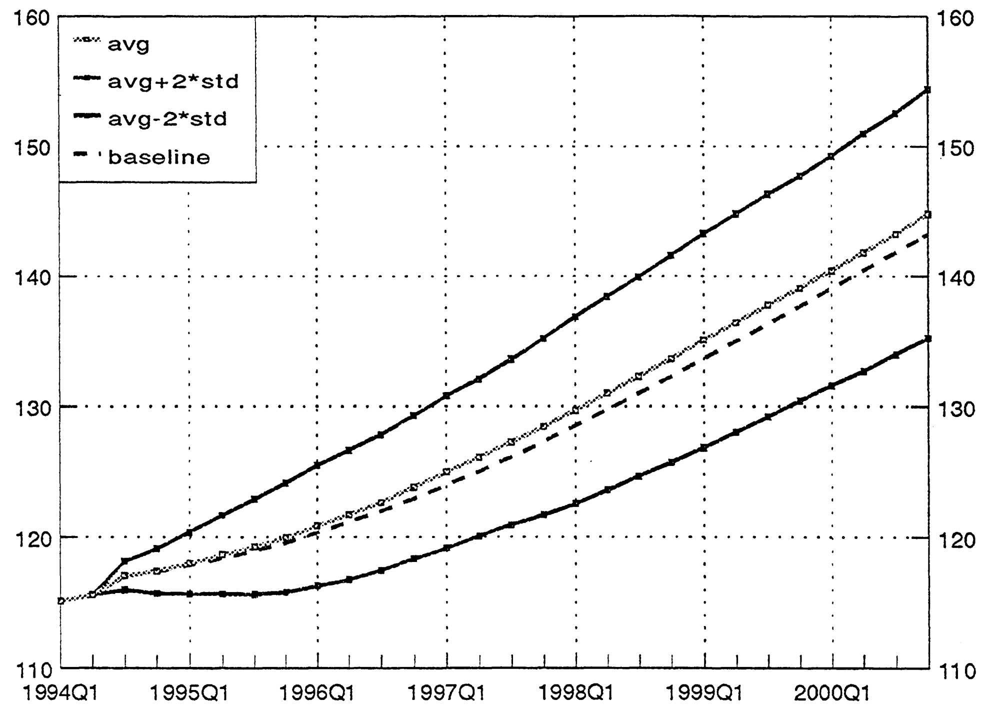


Figure 10. **Forecast for the wage rate**

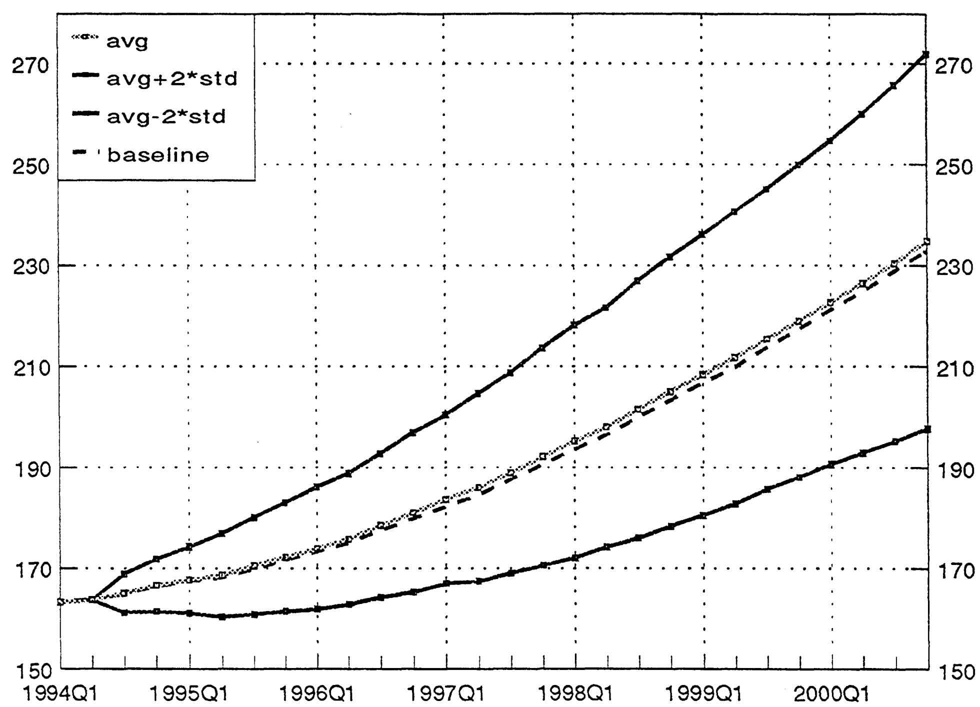


Figure 11. **Forecast for negotiated wages**

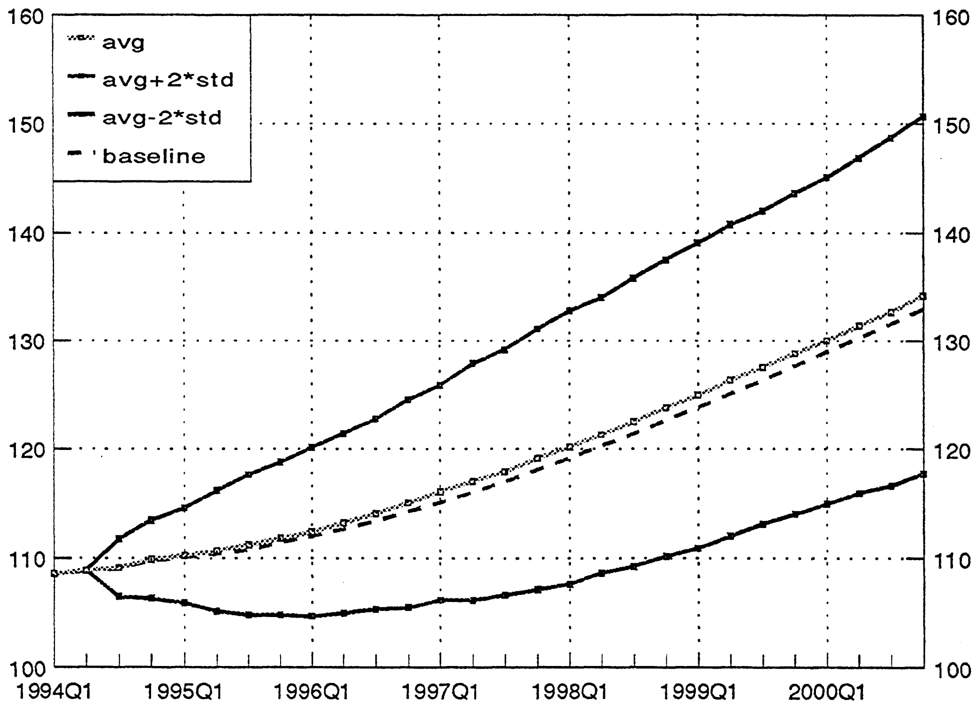


Figure 12. **Forecast for the saving rate**

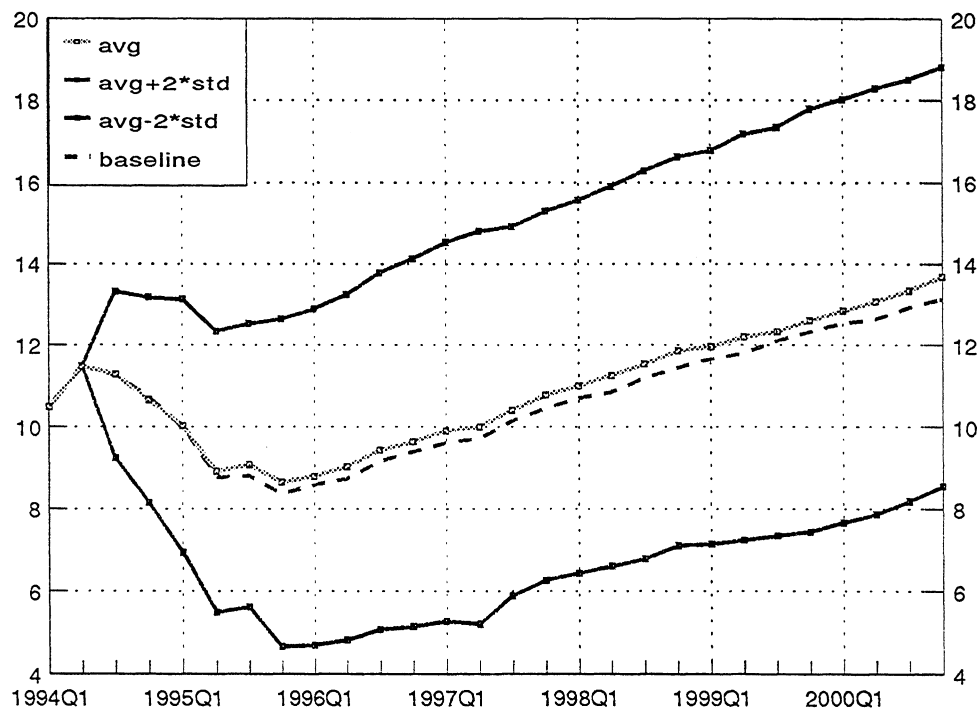


Figure 13. **Forecast for residental investment**

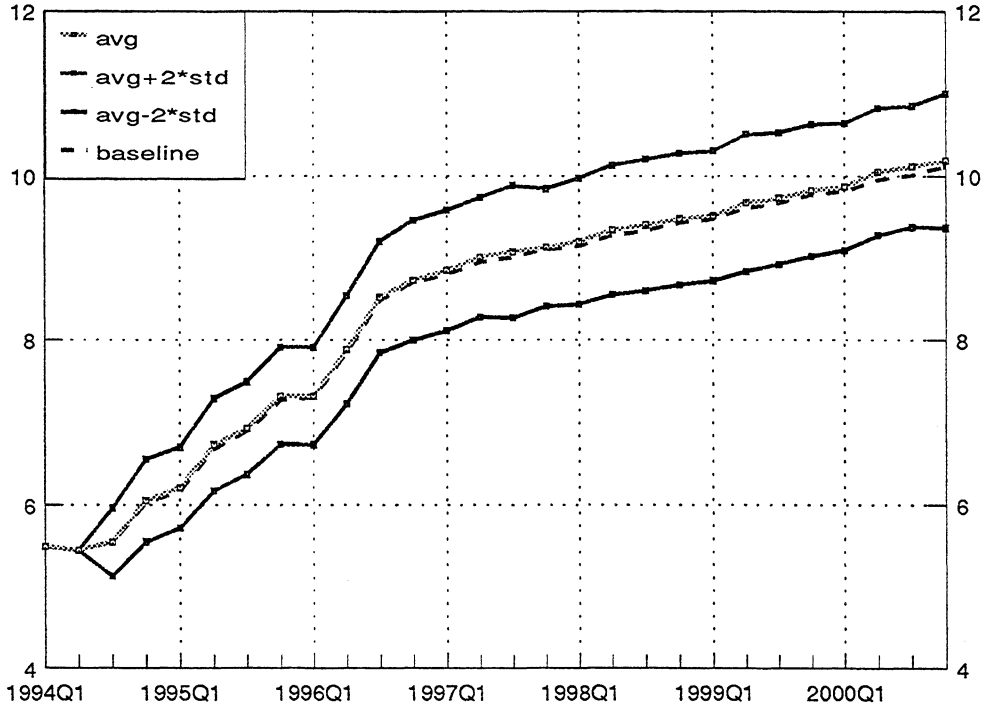


Figure 14. **Forecast for the government bond yield**

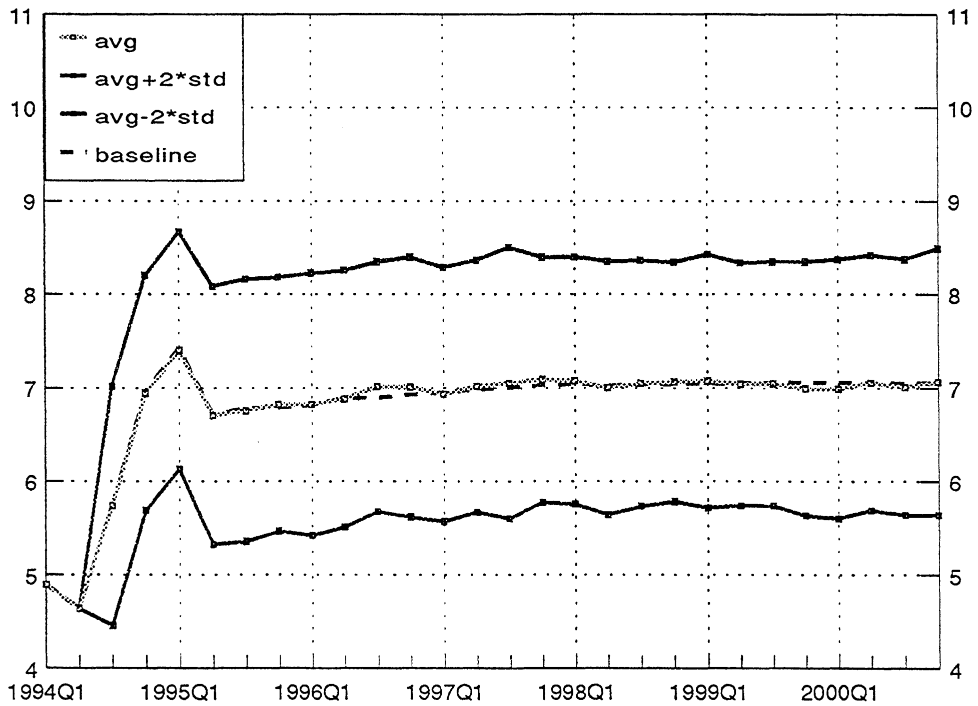


Figure 15. **Forecast for the current account**

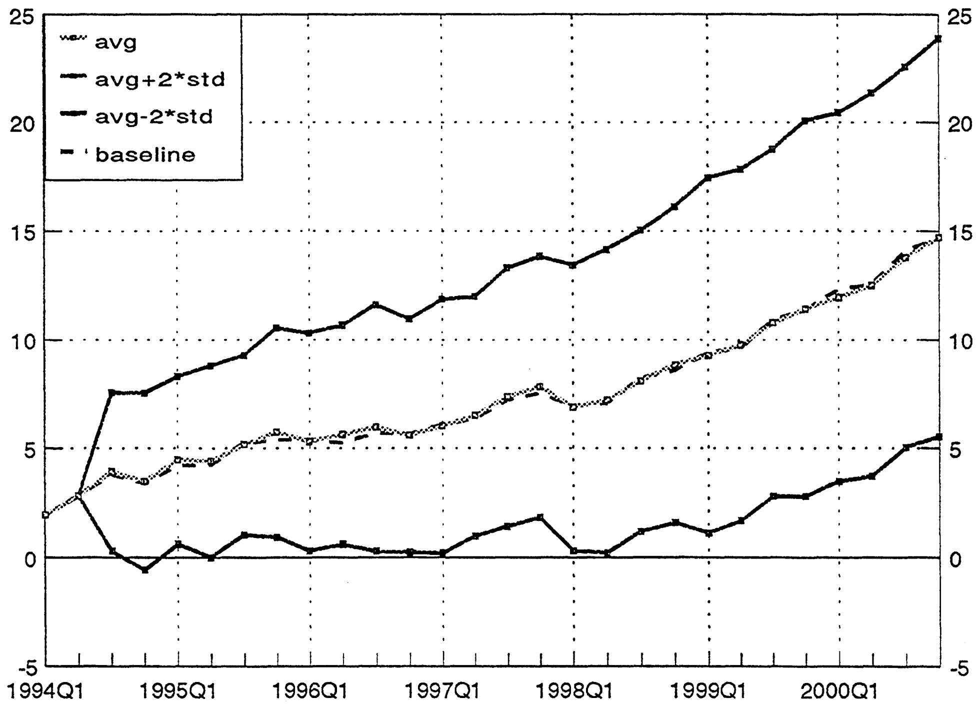


Figure 16. **Forecast for the unemployment rate**

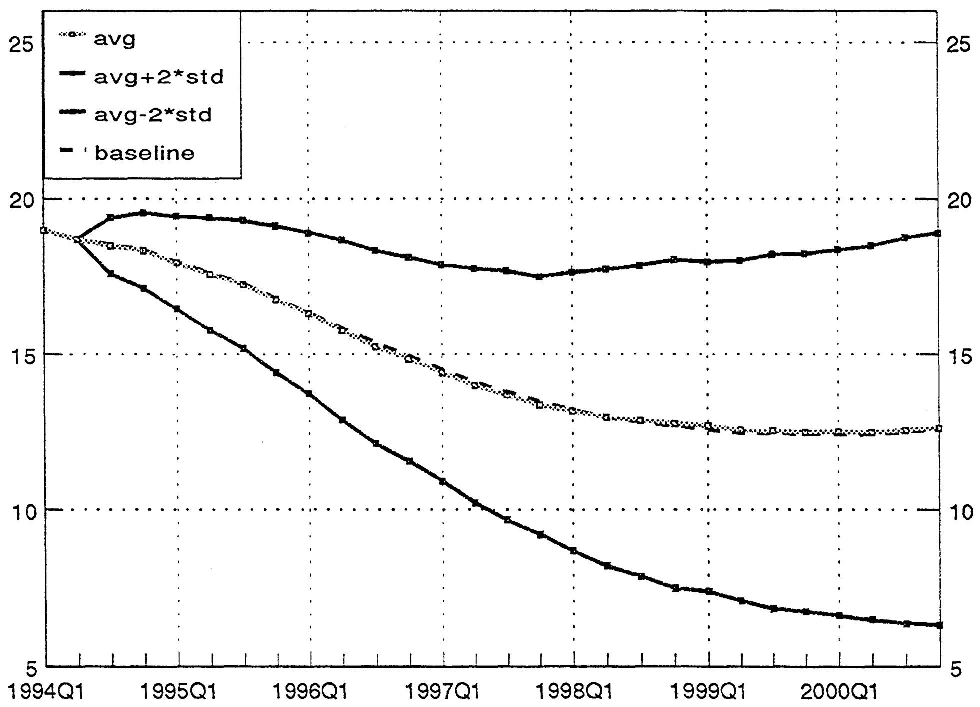


Figure 17. **Forecast for the capacity utilization rate**

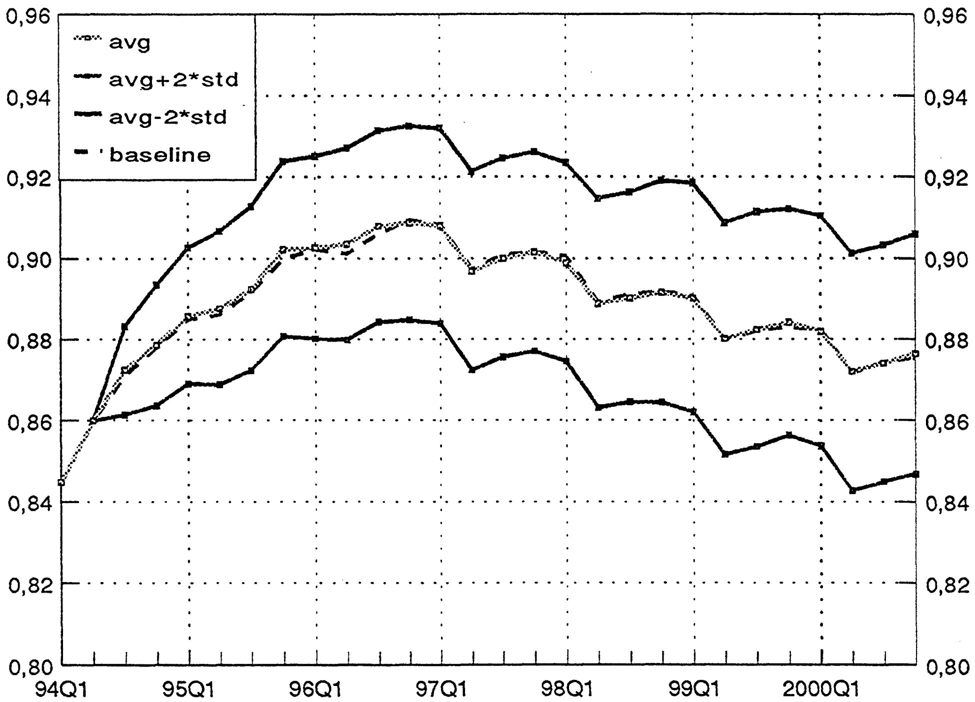


Figure 18. **Forecast for households' disposable income**

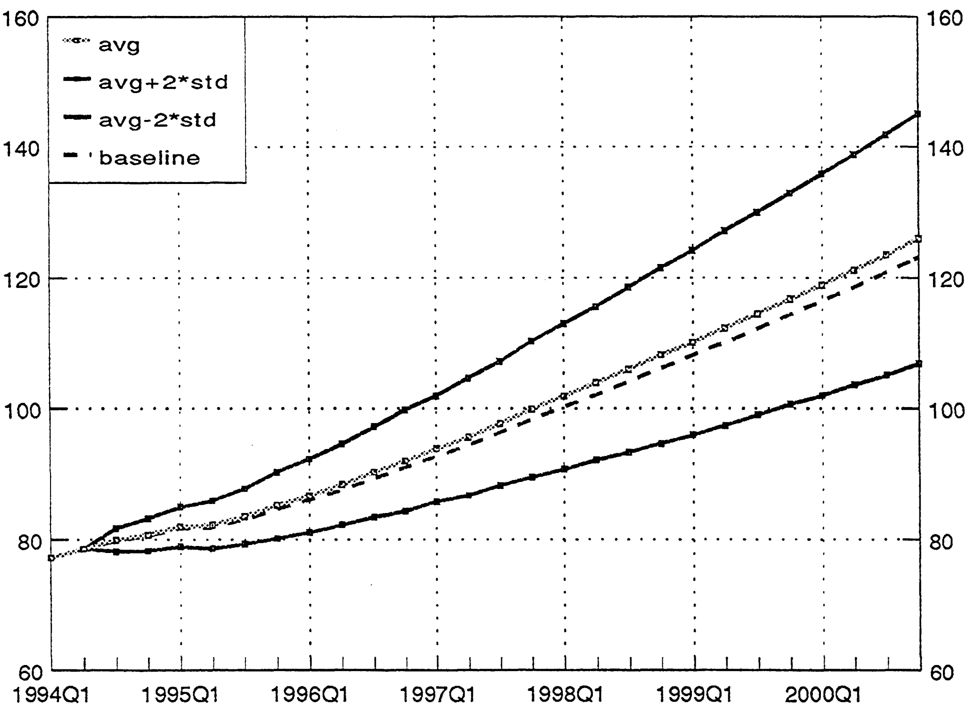


Figure 19. **250 simulations with shocked exogenous variables for the GDP**

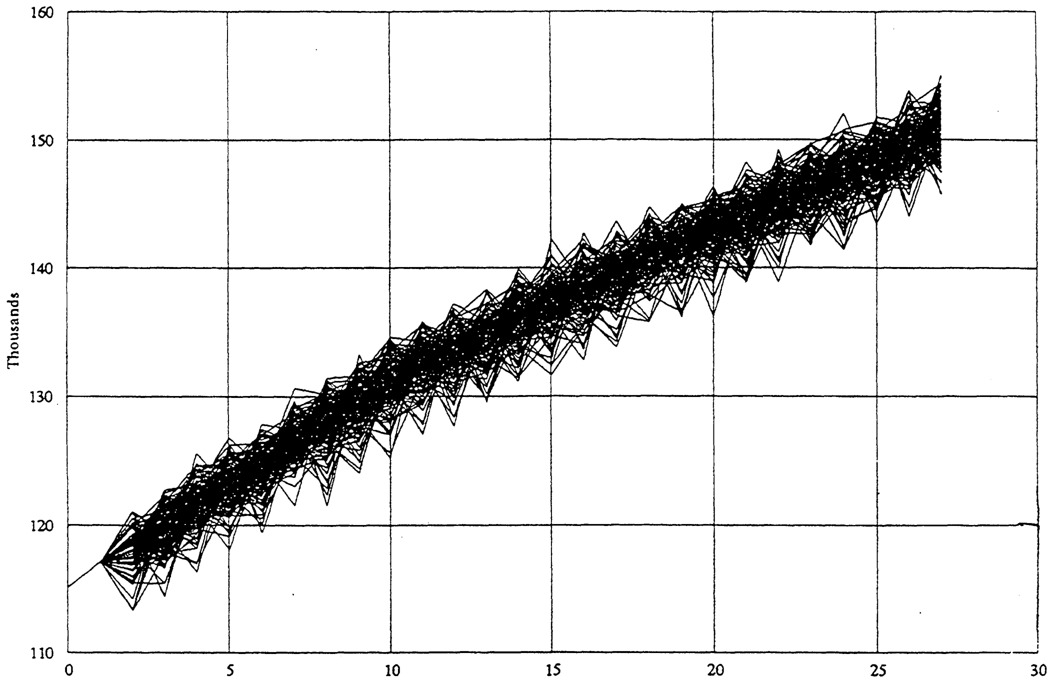


Figure 20. **Forecast for the GDP with exogenous variable uncertainty**

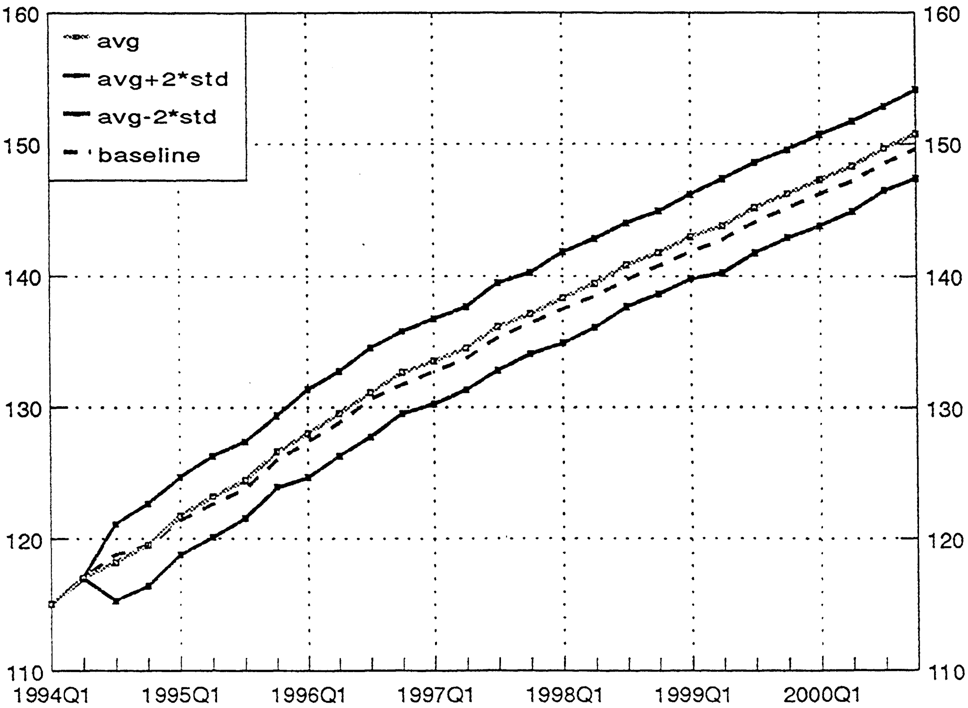
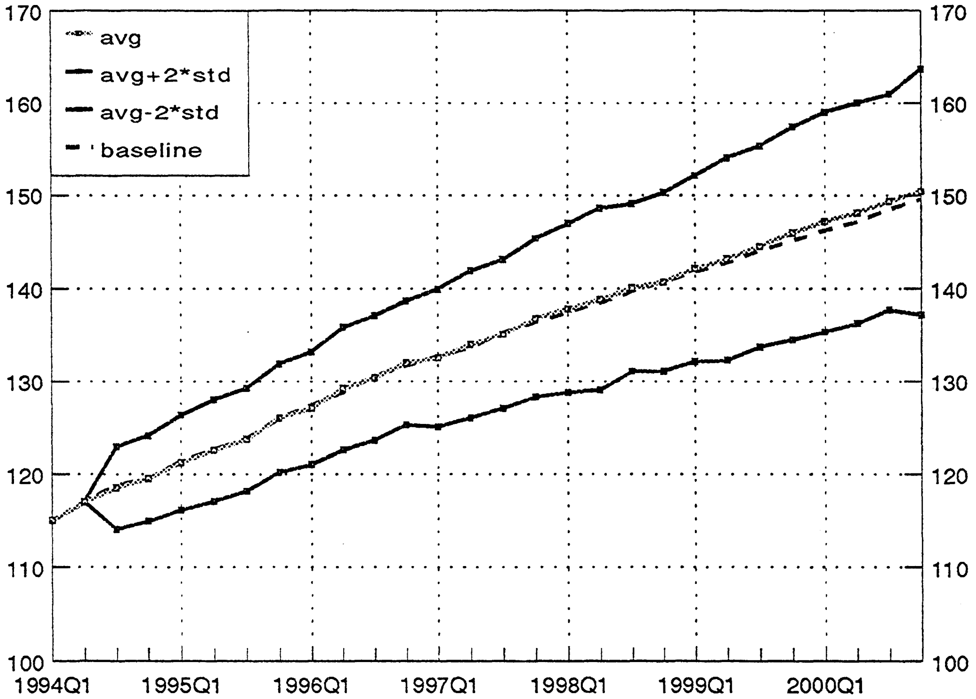
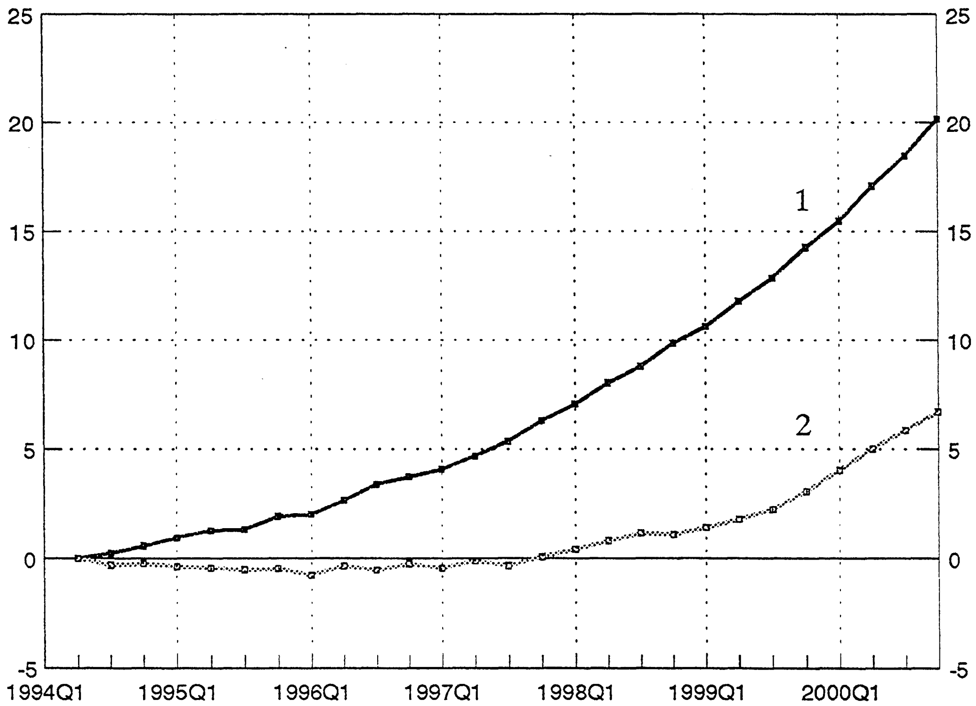


Figure 21. **Stochastic simulation results for GDP with random normal variates**



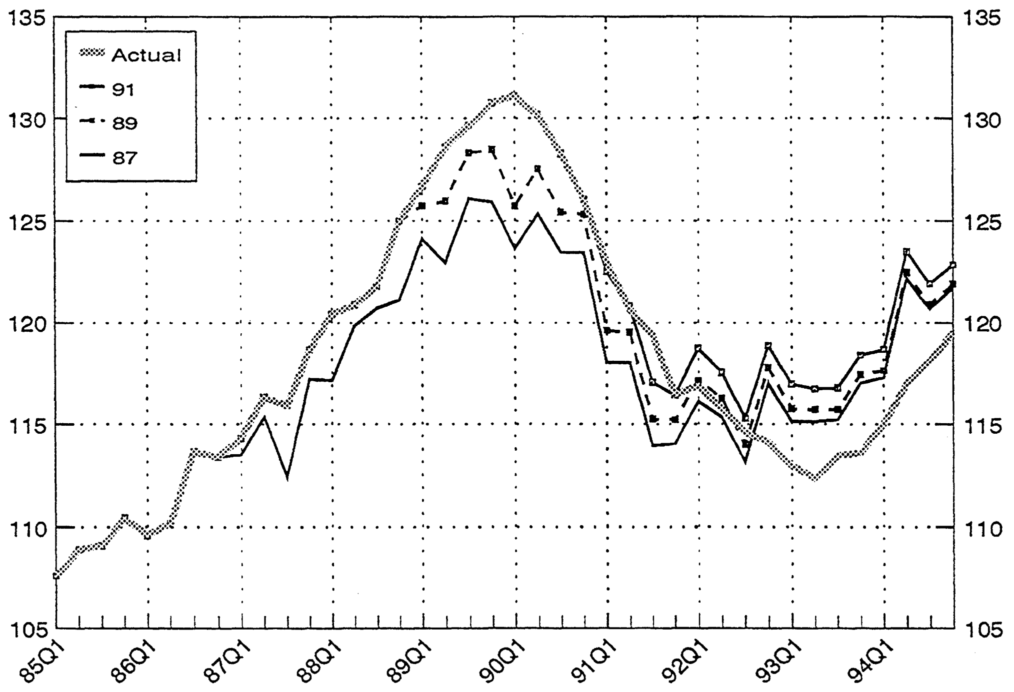
Note that this figure is comparable to figure 2.

Figure 22. **Comparison of cumulative simulation errors**



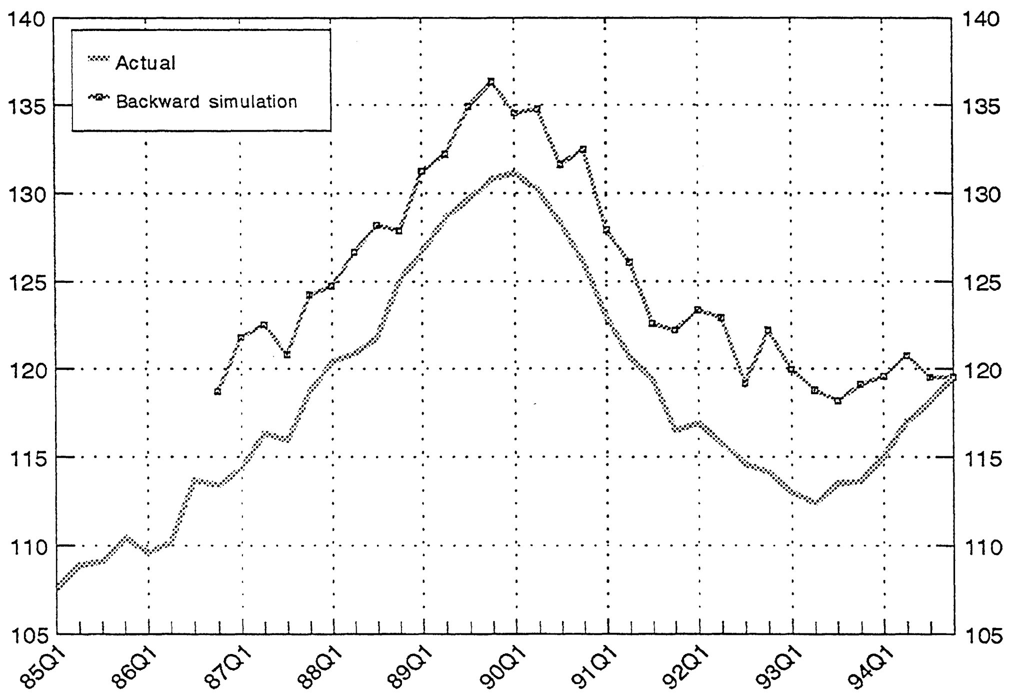
Actual (shuffled) residuals (1), generated random normal variates (2).

Figure 23 **Simulation results for 1987-1994**



"87" denotes a dynamic simulation which starts from 1987Q1. "89" and "91" are made in an analogous way. Values are billions of GDP at constant 1990 prices.

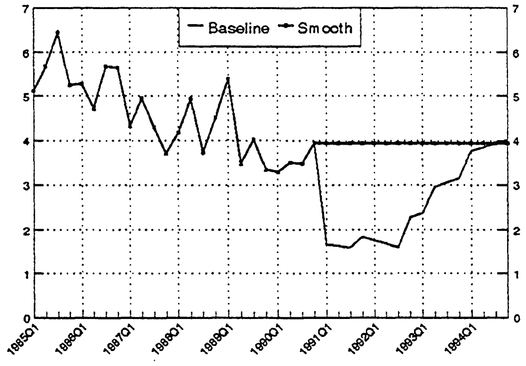
Figure 24 **Backward simulation for 1987-1994**



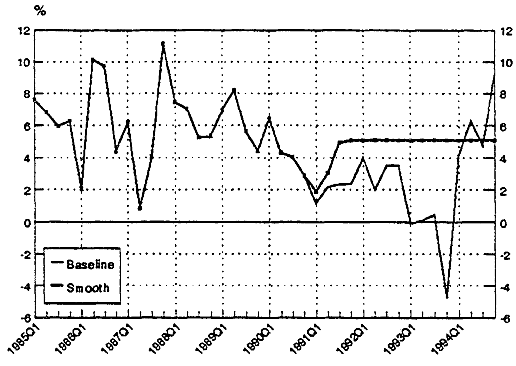
In this simulation, the stock of capital is held exogenous. Values are billions of GDP at constant 1990 prices.

Figure 25. **Actual and smoothed values of exogenous variables**

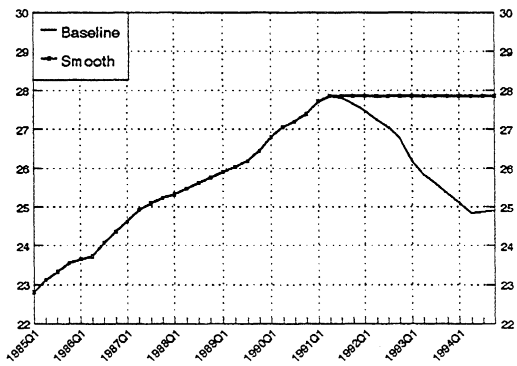
Eastern trade
Bill. FIM



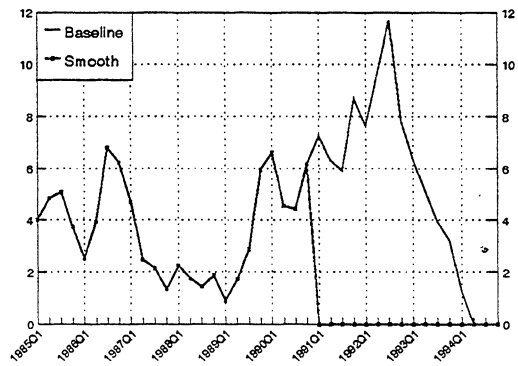
Export demand growth



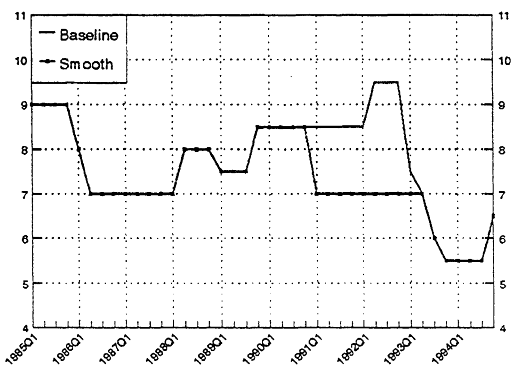
Public consumption
Bill. FIM



Interest rate differential
%



The base rate
%



The terms of trade
Index, 1990=100

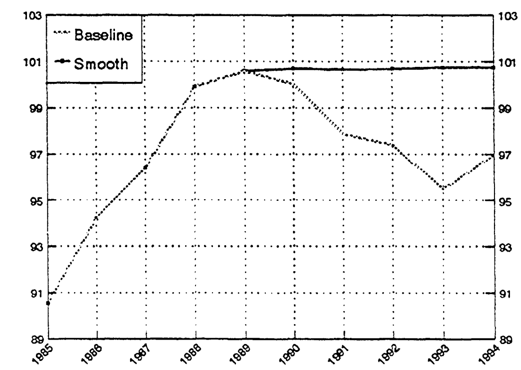
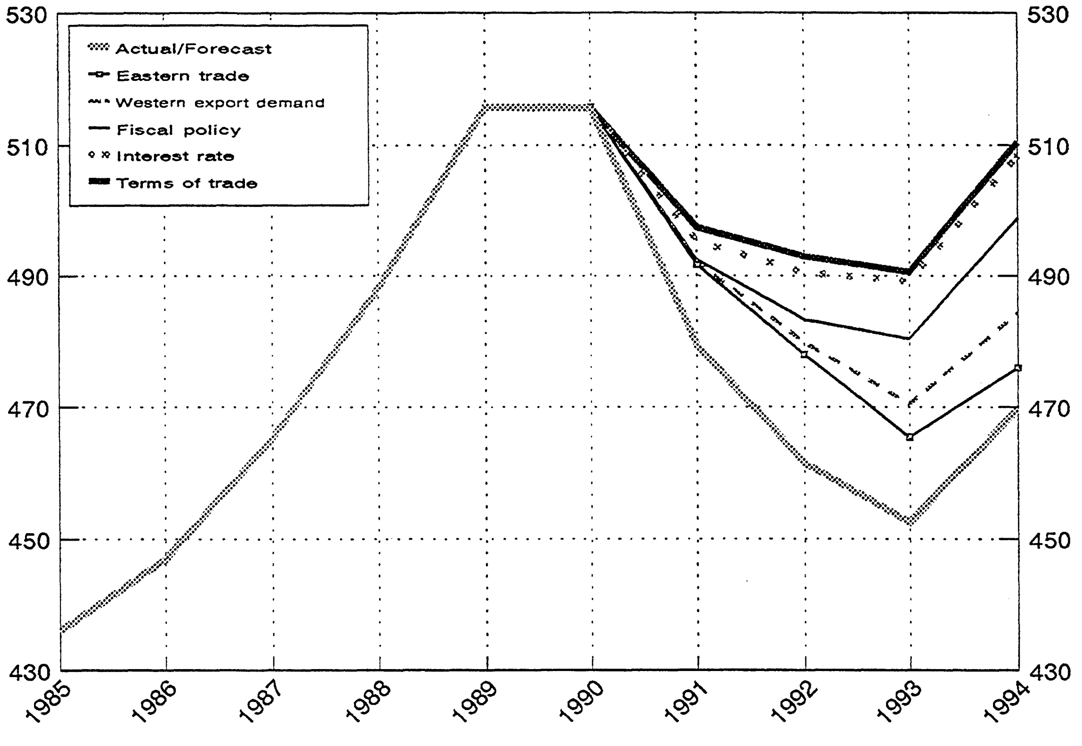
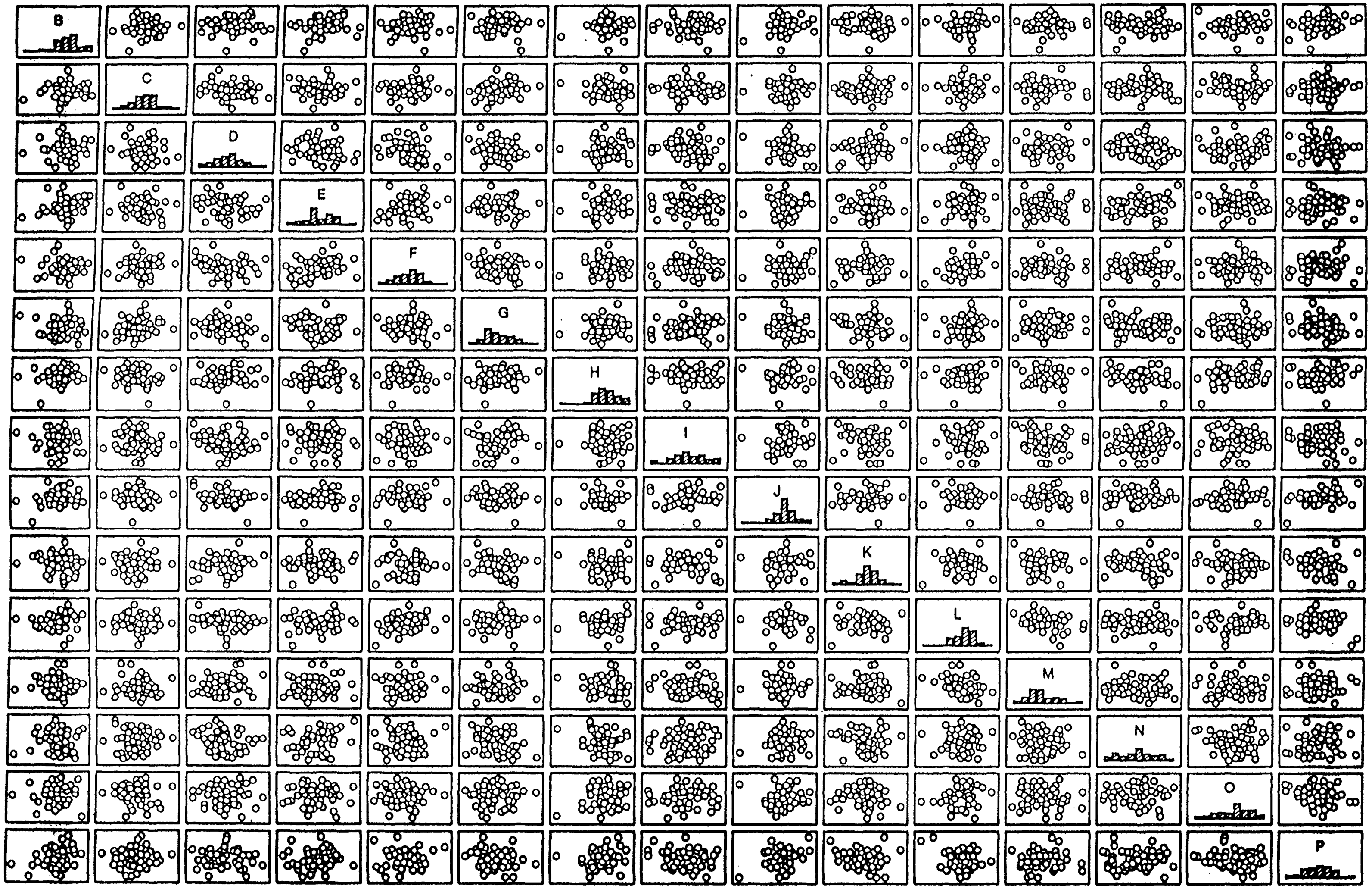


Figure 26. **Effects of smoothing the time paths of exogenous variables on GDP**



Values are billions of GDP at constant 1990 prices. Actual values cover the period 1985Q1–1994Q2. 1994Q3–1994Q4 are forecasted values. The effects of different exogenous variables are added after each other to the baseline. Also the simulation error is added to the baseline so that resulting value equals to the actual GDP. Note that the figure is drawn with annual values.

Figure 27. **Cross-plot of the QMED model residuals**



The residuals are in the same order as in the subsequent tables of diagnostic statistics. The frequency distribution of residuals is presented on the diagonal.

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Appendix 1 The contents of the model

List of equations and endogenous variables

1	XTQ.UX	*	Exports
2	MTQ.UX	*	Imports
3	HS.US	*	Capacity utilization
4	GDPQ.US		Volume of Gross Domestic Product
5	GDPV.UX		Value of Gross Domestic product
6	YD.US		Domestic demand
7	PW.UX	*	Wage rate
8	PWS.UX	*	Negotiated wage rate
9	PI.US	*	Investment prices
10	PC.UX	*	Consumption prices
11	PG.US	*	Public consumption prices
12	PIG.US		Public investment prices
13	PYD.UX		Domestic demand prices
14	YH.UX	*	Household income
15	IQC1.US	*	Residential investment
16	I1Q.US	*	Business investment
17	IQ.US		Total fixed investment
18	CQ.UX	*	Private consumption
19	RB.UX		Current account
20	ROFIN.US		Government bond yield
21	L040.UX	*	Unemployment rate
22	PQ.US		GDP deflator
23	KDN.US		Foreign debt
24	T002U.UX		Transfers and other expenditure
25	B470.UX	*	Other expenditure

A more detailed description is presented below; * indicates that the variable is determined by a behavioural equation, otherwise it is determined by an (accounting) identity.

Equations and OLS estimation results

Exports at 1990 prices

XTQ = EXP(A1*LOG(XTQ!2!) + A2*LOG(MFOR!1!) +
A3*LOG(PX!1!/PPFC!1!) + A4*LOG(XQE) + A5 + XTQ&)

Parameter	Estimate	SD.Deviation
A1	0.48257	0.06508
A2	0.39100	0.06323
A3	−0.80197	0.13517
A4	0.13072	0.02437
A5	2.27871	0.31849

R2 = 0.9559	R2C = 0.9533
DW = 1.8529	RHO = 0.0697
SE = 0.0416	MAPE = 0.3160

The notation X!n! indicates that variable X is lagged by n quarters. Negative lags are leads. EXP(.) denotes the value of e raised to the power indicated in parentheses. Use the logarithm to get the inverse.

Imports at 1990 prices

MTQ = EXP(A1*LOG(MTQ!2!) + A2*LOG(CQ) + A3*LOG(IQ) +
A4*LOG(XTQ) + A5*LOG(PM/PYD) + A6*LOG(HS!1!) + A7 + MTQ&)

Parameter	Estimate	ST.Deviation
A1	0.26457	0.08896
A2	0.07786	0.20612
A3	0.17403	0.07711
A4	0.40674	0.09735
A5	−0.49413	0.13522
A6	0.41519	0.20690
A7	0.80334	1.08301

R2 = 0.9516	R2C = 0.9472
DW = 1.5875	RHO = 0.1964
SE = 0.0468	MAPE = 0.3440

Rate of capacity utilization (from Bank of Finland investment survey)

HS = (A1*(HS!1!) + A2*(LOG(GDPQ) – LOG(GDPQ!1!)) + A3*(LOG(L010!1!) – LOG(L010!2!)) + A4*LOG(I1Q!1!) + A5*(LOG(PMO!4!/PQ!4!) – LOG(PMO!5!/PQ!5!)) + A6*(HS!2!) + A7 + HS&)

Parameter	Estimate	ST.Deviation
A1	0.93324	0.10226
A2	0.45134	0.10173
A3	–2.12653	1.86440
A4	–0.00967	0.00876
A5	–0.00816	0.01246
A6	–0.01980	0.10625
A7	0.16632	0.07159

R2 = 0.9172
DW = 2.2118
SE = 0.0113

R2C = 0.9096
RHO = –0.1062
MAPE = 0.9684

Gross Domestic Product at 1990 market prices

GDPQ = CQ + GQ + XTQ + IQ + IW – MTQ

Gross Domestic Product at current market prices

GDPV = (CQ*PC + GQ*PG + IQ*PI + IW*PVV + PX*XTQ – MTQ*PM)/100

Domestic demand at 1990 prices

YD = I1Q + IQC1 + CQ + XTQ

Wage rate

PW = PWS*(PW!1!/PWS!1!)*EXP(A1*LOG((PW!4!/PWS!4!)/(PW!5!/PWS!5!)) + A2*LOG(GDPQ/GDPQ!4!) + A3*(LOG(PC/PC!1!) − LOG(PC!1!/PC!2!)) + A4*LOG(PMO/PMO!1!) + PW& − .00026)

Parameter	Estimate	ST.Deviation
A1	0.84661	0.04854
A2	0.03923	0.01265
A3	0.14596	0.07902
A4	0.00545	0.00449

R2 = 0.7822	R2C = 0.7726
DW = 2.1771	RHO = −0.1411
SE = 0.0043	MAPE = 131.2565

Negotiated wages

PWS = PWS!1!*EXP(A1*LOG(PC!1!/PC!2!) + A2*LOG((PW!1!/PWS!1!)/(PW!2!/PWS!2!)) + A3*LOG(YH!1!/GDPV!1!) + A4*LOG(GDPQ/GDPQ!1!) + A5*(L040-LU) + PWS&)

Parameter	Estimate	ST.Deviation
A1	0.49410	0.16409
A2	0.36222	0.16223
A3	−0.00673	0.00683
A4	0.16084	0.10102
	−0.00063	0.00046

R2 = 0.2237	R2C = 0.1774
DW = 2.1779	RHO = −0.0934
SE = 0.0120	MAPE = 138.7661

Investment prices

PI = PI!2!*EXP(A1*LOG((PW*(1+YSWD))/(PW!2!*(1 + YSWD!2!))) + A2*LOG(PI!1!/PI!3!) + A3*LOG(PM/PM!2!) + PI&)

Parameter	Estimate	ST.Deviation
A1	0.47374	0.10284
A2	0.28884	0.10770
A3	0.11993	0.06513

R2 = 0.5356 R2C = 0.5221
DW = 1.6151 RHO = 0.1778
SE = 0.0198 MAPE = 58.9765

Consumption prices (i.e. implicit price deflator for private final consumption)

PC = PC!1!*EXP(A1*LOG((PW*(1+YSWD))/(PW!1!*(1 + YSWD!1!))) + A2*LOG((PW!1!*(1+YSWD!1!))/(PW!2!*(1 + YSWD!2!))) + A3*LOG((PW!2!*(1 + YSWD!2!))/(PW!3!*(1+YSWD!3!))) + A4*LOG(PM/PM!1!) + A5*LOG(PM!1!/PM!2!) + A6*LOG(PC!1!/PX!1!) + PC& + AVL)

Parameter	Estimate	ST.Deviation
A1	0.15655	0.05815
A2	0.16671	0.06331
A3	0.20690	0.05645
A4	0.05927	0.03369
A5	0.10987	0.03436
A6	−0.02356	0.00920

R2 = 0.6235 R2C = 0.5950
DW = 1.7253 RHO = 0.1372
SE = 0.0052 MAPE = 34.5504

Public consumption prices (i.e. implicit deflator for public consumption prices)

PG = PG!1!*EXP(A1*LOG((PW*(1 + YSWD))/(PW!1!*(1 + YSWD!1!))) + A2*LOG(PM/PM!1!) + A3*LOG(PG!1!/PG!2!) + PG&)

Parameter	Estimate	ST.Deviation
A1	0.80791	0.05320
A2	0.04479	0.03179
A3	0.06734	0.05298

R2 = 0.7800 R2C = 0.7736
DW = 2.0729 RHO = −0.0845
SE = 0.0058 MAPE = 73.9402

Implicit price deflator for public investment

PIG = PIG!1!*EXP(LOG(PI/PI!1!))

Implicit deflator for domestic demand

PYD = 100*((((IQ*PI − I2FQ*PIG)/100) + (CQ*PC/100) + (XTQ*PX/100))/(I1Q + IQC1 + CQ + XTQ))

Disposable income of households and nonprofit institutions (gross income)

YH = PC*(YH!1!/PC!1!)*EXP(A1*LOG((PW*(1 + YSWD)/PC)/(PW!1!*(1 + YSWD!1!)/PC!1!)) + A2*(TAX − TAX!1!) + A3*LOG(GDPQ/GDPQ!1!) + A5*LOG(GDPQ!1!/GDPQ!9!) + YH&)

Parameter	Estimate	ST.Deviation
A1	0.48749	0.08519
A2	1.17976	0.18589
A3	0.31871	0.06436
A4	−0.00258	0.00158
A5	0.04326	0.01501

R2 = 0.6418 R2C = 0.6204
DW = 2.2195 RHO = −0.1610
SE = 0.0072 MAPE = 2833.8589

Residential investment at constant 1990 prices

IQC1 = EXP(A1*LOG(IQC1!1!) + A2*LOG(I5101!1!) + A3*LOG(I5101!3!) + A4*(ROFIN!4! – 400*LOG(PA!3!/PA!4!)) + A5*LOG(YH!4!/PA!4!) + A6*D761 + A7 + IQC1&)

Parameter	Estimate	ST.Deviation
A1	0.40859	0.09137
A2	0.24864	0.04956
A3	0.14807	0.05987
A4	–0.00153	0.00056
A5	0.05709	0.06483
A6	–0.11005	0.02967
A7	4.29793	0.97127

R2 = 0.9241
DW = 2.1152
SE = 0.0409

R2C = 0.9171
RHO = –0.0606
MAPE = 0.3415

Business fixed investment at constant 1990 prices

I1Q = I1Q!1!*EXP(A1*LOG(GDPQ/GDPQ!1!) + A2*DD803 + A3*(ROFIN – 400*LOG(PI/PI!1!)) + A4*KORKO + A5*LOG(UNI!12!/UNI!13!) + I1Q&)

Parameter	Estimate	ST.Deviation
A1	1.56716	0.41085
A2	0.05901	0.02242
A3	–0.00132	0.00073
A4	–0.00203	0.00091
A5	0.10378	0.05639

R2 = 0.4889
DW = 2.7054
SE = 0.0454

R2C = 0.4584
RHO = –0.3542
MAPE = 458.8468

Total fixed investment at constant 1990 prices

IQ = I2FQ + I1Q + IQC1

Private final consumption expenditure at constant 1990 prices

CQ = EXP(A1*LOG(CQ!1!) + A2*LOG(YH! – 1!/PC! – 1!) + A3*(ROFIN!3! – 400*LOG(PC!2!/PC!3!)) + A4*LOG(PC/PC!1!) + A5*(L040-L040!1!) + A6*LOG(PA/PA!1!) + A7 + CQ&)

Parameter	Estimate	ST.Deviation
A1	0.89263	0.04000
A2	0.09473	0.04472
A3	–0.00037	0.00044
A4	–0.62343	0.19477
A5	–0.00617	0.00210
A6	0.10484	0.03429
A7	0.57599	0.17222

R2 = 0.9967 R2C = 0.9964
DW = 2.2000 RHO = –0.1252
SE = 0.0088 MAPE = 0.0608

The current account balance

RB = (XTQ*PX/100) – (MTQ*PM/100) + JK + T002U

Government bond yield (4–5 years to maturity)

ROFIN = (A1*LOG(PC! – 1!/PC!3!) + A2*S6000 + A3*LOG((R6041!1!/PC!1!)/(R6041!2!/PC!2!)) + A4 + ROFIN&)

Parameter	Estimate	ST.Deviation
A1	16.87725	3.26798
A2	1.01403	0.09811
A3	3.58107	1.63278
A4	–0.17297	0.73956

R2 = 0.8139 R2C = 0.8057
DW = 0.6147 RHO = 0.6858
SE = 0.6317 MAPE = 5.5121

Rate of unemployment

L040 = .95*L040!1! + A1*LU + A2*HS!1! + A3*LOG(GDPQ/GDPQ!1!) + A4 + L040&

Parameter	Estimate	ST.Deviation
A1	0.20652	0.02972
A2	−11.03909	1.31325
A3	−12.90695	3.56338
A4	8.52952	1.05096

R2 = 0.6735 R2C = 0.6591
DW = 1.4428 RHO = 0.2728
SE = 0.3970 MAPE = 1005.0313

Implicit price deflator for Gross Domestic Product

PQ = 100*(GDPV/GDPQ)

Foreign debt (net)

KDN = KDN!1! + .944*RB

Income transfers and other (interest) payments to abroad (net)

T002U = −.0015*GDPV + B470

Other payments to abroad (net)

B470 = PM*(A1*(EP3V10*KDN/PM) + A2 + B470&)

Parameter	Estimate	ST.Deviation
A1	0.00371	0.00014
A2	1.26205	1.09763

R2 = 0.9096 R2C = 0.9083
DW = 1.6572 RHO = 0.1615
SE = 4.7855 MAPE = 16.2165

Exogenous variables

Variable

1	MFOR	Foreign import demand
2	PX	Export prices
3	PPFC	Foreign producer prices
4	XQE	Exports to non-market economies
5	PM	Import prices
6	L010	Working-age population
7	PMO	Import prices of oil products
8	GQ	Public consumption
9	IW	Inventory investment plus statistical error
10	PVV	Implicit price deflator for residential investment
11	LU	Natural rate unemployment
12	YSWD	Employees' social security expenses
13	AVL	Dummy for introduction of value-added taxation
14	I2FQ	Public investment
15	TAX	Average income tax rate (net of transfers)
16	I5101	Building permits
17	PA	House prices
18	D761	Dummy for 1976Q1
19	DD803	Dummy for 1988Q3
20	KORKO	Interest rate differential between Finland and Germany
21	UNI	Stock prices
22	JK	Statistical error in current account
23	S6000	Bank of Finland base rate
24	R6041	Domestic debt of central government
25	EP3V10	Long-term interest rate for FRG, UK and USA

Correlation matrix

	B470	CQA	HS	I1Q	IQC1	L040	MTQ	PC	PG	PI	PW	PWS	ROFIN	XTQ	YH
B470	1.0000														
CQA	0.0804	1.0000													
HS	0.0003	−0.1519	1.0000												
I1Q	0.1685	−0.2088	−0.1857	1.0000											
IQC1	0.0218	−0.0125	−0.1596	0.2608	1.0000										
L040	0.0134	0.1323	−0.1710	−0.1155	−0.1874	1.0000									
MTQ	0.1094	−0.0279	0.1403	0.1442	−0.0149	0.1356	1.0000								
PC	−0.1237	−0.1244	−0.2099	−0.0545	0.0033	0.1893	−0.0221	1.0000							
PG	0.2161	0.0060	−0.2391	0.1302	0.1405	−0.2082	−0.0359	0.0180	1.0000						
PI	−0.1377	0.0518	0.2190	−0.0181	−0.0178	−0.2748	−0.0493	−0.1361	0.0775	1.0000					
PW	0.0697	−0.0300	−0.0845	0.1826	0.3184	0.0376	0.1807	0.0989	−0.1107	−0.0256	1.0000				
PWS	−0.0658	0.0885	0.1322	−0.0149	−0.0752	−0.0355	−0.0732	−0.1542	−0.0103	0.0258	−0.3647	1.0000			
ROFIN	−0.0324	0.0373	−0.2340	0.1706	0.0133	−0.1821	−0.3443	0.1507	0.0132	−0.1228	−0.0141	−0.0737	1.0000		
XTQ	0.0943	−0.1554	−0.0320	−0.0209	−0.0499	0.0424	0.1718	0.0275	0.0467	−0.1229	0.2072	−0.0839	−0.1051	1.0000	
YH	0.2492	−0.0004	−0.0414	0.1180	0.0707	−0.1697	0.0975	−0.1469	0.3387	−0.2460	−0.1726	−0.0593	0.0696	−0.1711	1.0000

A coefficient of 0.24 is significant at the 5 per cent level. Only 7 coefficients out of 105 exceed this level.

Appendix 2 Diagnostic statistics

Descriptive data for residuals

	Mean	Std Dev	Minimum	Maximum	Variance	Skewness	Kurtosis-3	Normality
B470	.0000	4.7517	−18.4743	9.9940	22.57833	−0.8465	2.5334	.9590
CQA	.0000	0.0085	−0.0239	0.0254	0.000071	0.0125	0.7203	.9930
HS	−.0000	0.0108	−0.0231	0.0293	0.000116	0.2181	0.1970	.9784
I1Q	.0010	0.0440	−0.1027	0.1143	0.001940	0.0617	0.0016	.9824
IQC1	−.0000	0.0391	−0.0963	0.1197	0.001532	0.0149	0.6684	.9870
L040	−.0000	0.3885	−0.8691	1.1891	0.15097	0.3768	0.1161	.9812
MTQ	.0000	0.0448	−0.1772	0.0876	0.002006	−0.6280	2.2323	.9608
PC	.0005	0.0050	−0.0113	0.0103	0.000025	−0.2366	−0.1636	.9716
PG	−.0004	0.0056	−0.0239	0.0136	0.000032	−0.5600	3.7291	.9489
PI	−.0019	0.0194	−0.0551	0.0532	0.000377	−0.3836	0.9103	.9710
PW	−.0002	0.0042	−0.0157	0.0104	0.000017	−0.8466	2.1910	.9608
PWS	.0001	0.0117	−0.0230	0.0340	0.000136	0.7419	0.4931	.9530
ROFIN	−.0000	0.6182	−1.1832	1.3314	0.38219	−0.0643	−0.7785	.9638
XTQ	−.0000	0.0404	−0.1048	0.0770	0.001630	−0.3901	−0.2530	.9711
YH	.0009	0.0070	−0.0155	0.0190	0.000048	−0.1002	−0.0208	.9792

For the variable names, see Appendix 1. The Shapiro-Wilk test is used here to test normality.

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