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THE FINNISH RATIONAL EXPECTATIONS QMED MODEL: ESTIMATION, DYNAMIC PROPERTIES AND POLICY RESULTS***

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ABSTRACT

This paper reports some policy experiments carried out with the QMED model of the Bank of Finland. These experiments illustrate the dynamic and long-run properties of this model. Thus, it is investigated how different temporary and permanent, random and nonrandom, shocks affect the cyclical path and long-run growth rate of total output. The main issue is, however, the role of expectations. Thus, we compare a static expectations version with two rational expectations versions of the model. These two versions differ in terms of the time horizon of expectations. When various policy simulations are carried out with these different versions - both in terms of anticipated and unanticipated shocks - it turns out that the whole short-run dynamics is crucially affected by the way in which expectations are modelled. In particular, we find the advance effects in the case of the rational expectations versions can be of considerable magnitude.

CONTENTS

1 INTRODUCTION

This paper reports some policy experiments carried out with the Quarterly Model of the Economics Department of the Bank of Finland (QMED). In designing these experiments we have paid particular attention to the dynamic and long-run properties of the model, and, even more, to the role of expectations. Thus, in essence we have two model specifications to be compared: a model version in which expectations - to be more precise, inflation, wage and income expectations - are modelled using a simple static scheme and a model version in which these expectations are modelled using the Rational Expectations Hypothesis. Obviously, the rational expecations version is of special interest because it allows us to examine the difference between anticipated and unanticipated policy changes and the importance of the time horizon of expectations. In addition, it is of some interest to investigate how various computational aspects affect the simulation results.

The paper is organized as follows: In section 2 we present a short summary of the current version of our model and discuss some problems connected with estimating and simulating the model. Section 3 deals with the dynamic properties of the model, i.e. long-run effects of temporary (once-for-all) shocks and cyclical responses of various random (unautocorrelated) and autocorrelated shocks. Section 4, in turn, contains the simulation results with alternative expectation specifications, and, finally, there is a brief concluding section.

2 A SHORT DESCRIPTION OF THE QMED MODEL

QMED is a small, aggregative quarterly model of the Finnish economy. The current version consists of 79 endogenous and exogenous variables, the number of stochastic equations being 21. However, 6

Table 1

OLS Estimates of the Main Behavioral Equations of the QMED-Model

(1) $$\Delta x = -.346*\Delta x(-4) - .669*\Delta pxf(-2) - .369*(x-f)(-1) + .363*(x-f)(-2) + .800*\Delta f + .638*\Delta f(-2) + .360*cap(-2)$$

$R2 = .553$ D-W = 2.181 SE = .052

(2) $$\Delta m = 1.184*\Delta z + .704*\Delta pzm - .484*(m-z)(-1) + .263*(m-z)(-2) + .204*(m-z)(-3) - .250*cap(-1)$$

$R2 = .569$ D-W = 2.342 SE = .055

(3) $$c = .595*c(-1) + .410*yhr(+1) - .002*(r-(400*\Delta pc(+1))) - .685*\Delta pc(+1) + .023*d1 + 1.800$$

$R2 = .992$ D-W = 2.474 SE = .012

(4) $$ih = .594*ih(-1) + .166*yhr(+1) - 1.992*hk(-1) + 14.062*n - .001*(r-(400*\Delta pc(+1))) - 0.450*pcih(-4) - 87.509$$

$R2 = .733$ D-W = 2.264 SE = .045

(5) $$\Delta if = \Delta ye - .412*(if-y)(-1) - .064*d13*(if-y)(-1) - .001*\Delta(r-(400*\Delta pi))(-1) - .250*\Delta wr(+1) + .114*d14 + .111*d15 + .113*d16 - .926$$

$R2 = .552$ D-W = 2.239 SE = .046

(6) $$\Delta l = .198*\Delta l(-4) + 1.344*\Delta yi - .053*\Delta wr(+1) - .224*(l-n)(-1) - .049*cap(-1) - .005*d2 + .024*d3 + .008*d4 - .329$$

$R2 = .646$ D-W = 1.524 SE = .004

(7) $$\Delta w = .109*\Delta 4(pc(+1)) + .894*\Delta wc - .011*cap(-1)$$

$R2 = .886$ D-W = 1.915 SE = .005

(8) $$\Delta pc = .305*\Delta wn + .127*\Delta w(-1) + .232*\Delta wn(-2) + .078*\Delta pm + .058*\Delta pm(-1) + .053*pm(-2)$$

$R2 = .695$ D-W = 1.975 SE = .007

(9) $$\Delta pi = .591*\Delta wn + .043*\Delta pmo + .043*\Delta pm(-2) + .182*\Delta pi(-1) + .012*d5 + .013*d6$$

$R2 = .437$ D-W = 2.173 SE = .015

(10) $$\Delta pg = .595*\Delta wn + .218*\Delta wn(-3) + .099*\Delta pm + .008*d7 - .053*d8 + .028*d9$$

$R2 = .725$ D-W = 1.963 SE = .010

(11) $\Delta px = .156*\Delta 2(\Delta px(-2)) + .300*\Delta wn + .503*\Delta pf + .192*\Delta er(-4) + .060*d10 + .057*d11$

R2 = .705 D-W = 2.047 SE = .019

(12) $r = .732*r(-1) + 9.444\Delta pc + .240*rd + 3.332*\Delta dr$

R2 = .892 D-W = 1.750 SE = .546

(13) $q = .440*q(-1) + .552*z + .084*ig - .108*d12 - 1.547$

R2 = .988 D-W = 1.369 SE = .020

(14) $cap = .006*t - 2.066 + .7*k(-1) + .3*n - q + mr$

(15) $\Delta wc = gp(-3) + .611*\Delta pc(-3) + .404*\Delta(w-wc)(-3) + .052*d17 - .006$

R2 = .242 D-W = 2.285 SE = .020

All variables, except r, are expressed in logs, and all expenditures are defined in real terms. The number of lags in quarters is shown in parentheses after each lagged variable (i.e. (-1) refers to period t-1 and (+1) to period t+1). Δ denotes the first backwards differencing operator and Δ4 denotes the fourth backwards differencing operator. R2 = coefficient of determination, D-W = Durbin - Watson statistic and SE = standard error of estimate.

List of variables
(Exogenous variables are underlined.)

c	private consumption
ca	current account
cap	capacity utilization rate in manufacturing
d1-d17	dummy varibles
er	exchange rate
f	foreign import demand
g	public consumption
gp	rate of change in labour productivity (five-year moving average)
hk	stock of residential capital
ig	public consumption and investment
if	manufacturing investment
ih	housing investment
k	stock of capital, manufacturing sector
l	wage-earners' employment
m	imports (excluding oil)
mr	scale parameter for capacity utilization
n	working-age population
pc	private consumption prices
pcih	pc - pih
pf	foreign producer prices, manufacturing
pg	public consumption prices
pi	investment prices
pih	housing investment prices
pm	import prices
pmo	import prices of oil
pq	GDP deflator
pr	prices of raw materials
prz	pr - pz
px	export prices of goods (excluding bilateral)
pxf	px -pf
pz	domestic demand prices
pzm	pz -pm
q	manufacturing production
r	interest rate (government bond yield)
rd	discount rate
s	employers' social security contributions
t	linear trend
w	wage rate
wc	contract wage rate
wn	w*(1+s)
wr	w*(1+s) - pq
x	exports of goods (excluding bilateral exports)
xe	bilateral exports
y	gross domestic product at constant 1985 market prices (GDP)
ye	instrumental variable for output (determined by f and g)
yh	households' disposable income
yhr	yh - pc
yi	instrumental variable for output (determined by xe, f, (px-pq) and ig)
z	domestic demand

of these equations are some sort of auxiliary equations for income accounting, the structure of private consumption expenditure, and employment and the labor fource. The remaining 15 main equations are reported in Table 1. In order to save space only the coefficient estimates and the basic equation statistics are reported. (The corresponding diagnostic statistics, which rather well pass muster, are, however, reported in Appendix 1.) The estimates are OLS estimates; Hatanaka's iterative IV estimates (see the discussion on page 12) are presented in Appendix 2. The model uses seasonally adjusted data which are almost entirely derived from the Finnish National Accounts. A novel feature of the current version of the model is the treatment of expectations. It is assumed that expectations with respect to the rate of inflation, the rate of change of real wages, and the real income are formed rationally given the current period information. Inflation expectations, in turn, determine the expected real interest rate, and all these variables together affect, in the first place, private consumption, investment in residental construction, manufacturing investment and employment.[1]

Obviously, this kind of specification creates problems both in terms of estimation and simulation. As far as the estimation problems are concerned, we try to solve them by making use of the Iterative Instrumental Variable technique proposed by Hatanaka (1978). Thus, we first estimate the whole model using OLS, the period of estimation being 1971.1 - 1986.4. Then we form the Gauss-Seidel solution for the whole model and use the solution as the instrument for both the expected inflation rate and the current period endogenous variables. The solution of the model is carried out using the Extended Path Method developed by Fair and Taylor (1983). In order to improve the small-sample properties of the estimators the whole procedure is iterated several times.

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[1]Household's disposable income is endogenous in the model in the sense that it is determined by the income tax rate, employment (a distinction is made between wage-earners and self-employed persons), the wage rate and other income (which is modelled using an auxiliary equation in terms of the wage rate, the price level, the self-employed person's employment and the time trend).

As a rule, no serious computational problems were encountered in estimation and simulation. This is obviously due to the small size of the model, and also to the fact that only one period-ahead predictions are used in the basic version of the model.[2]

We are not able here to discuss all features of (the rational expectations version) of QMED. Suffice it to say that it is basically a Keynesian macromodel in which effective demand plays a crucial role. There are, however, some features which abstract from this standard Keynesian framework: first, prices, wages and interest rates are not (completely) rigid; second, the capacity variable is endogenous, allowing for supply side effects; third, the demand for labor and capital depend on relative prices and some demand shift variables - not on actual output; and, finally, expectations with respect to some key variables are modelled using the rational expectations framework.

We cannot really describe in any detail here how the model works. Thus, we limit out reporting to the presentation of the Mean Absolute Percent Errors (MAPE) for some key variables (see Table 2).

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[2]Various path extension parameter k values and various tolerance levels were used in solving the model. Thus, k was taken to be between 2 and 10, and the tolerance levels were varied between .01 and .000001 for the three iteration types which were used in solving the model for the estimation period (see Fair and Taylor (1983) and Fisher et al (1985) for details of the procedure). Different values for k did not make any noticeable difference. Rather, the tolerance level turned out to be of little importance. For instance, as regards GDP, we could detect an average quarterly difference of magnitude of .01 % between two successive simulations, which differed by .1 in terms of the tolerance level (with k this difference was of the magnitude of .0005 %). The average total number of passes through the model for the overall solution was about 13 000. However, when the time horizon of expectations was extended to two periods (see the discussion on page 20) about 30 000 passes were required. The corresponding average amount of CPU time with a Burroughs A12 computer was about 6 minutes (in the case of the static expectations version of the model only about 20 seconds were required). Most of the computational work was carried out using the IAS-SYSTEM software (see Sonnberger (1985) for details). In the present study the tolerance level was set at .005 for all three types of iteration; k, in turn, was set at 3. The model was estimated with three iterations of Hatanaka's IV estimation procedure. On another occasion we experimented by continuing the iterations until ten but further iterations did not produce any noticeable difference in results.

These statistics are derived from a dynamic simulation which makes use of data for the estimation period 1971.1 - 1986.4. In addition, we report some standard policy simulations using changes in interest rates, contract wages, public consumption and investment as well as taxes, and, finally, oil prices as "policy variables".[3]

Clearly, the MAPE values indicate that the model generates the actual data rather well. This is true particularly if one takes into account the relatively (in a cross-country sense) high volatility of Finnish exports and price movements during the sample period. Moreover, there do not appear to be any noticeable problems in terms of the long-run properties of the model.

Table 2 MAPE-values for the estimation period 1971.1 - 1986.4, %

	OLS	H2S
Gross Domestic Product (v)	1.41	1.47
Private Consumption (v)	2.27	2.22
Private Investment (v)	2.30	2.33
Exports (v)	3.59	3.66
Imports (v)	3.28	3.40
Implicit GDP Deflator (p)	1.89	1.21
Consumption Prices (p)	1.88	1.19
Export Prices (p)	4.55	3.63
Wage Rate (p)	1.77	1.71
Employment (h)	.94	.90

v refers to volumes, p to implicit price deflators and h to working hours. OLS indicates the MAPE-values obtained using the OLS version of the model (with exogenous contract wages). H2S indicates the MAPE-values obtained with Hatanaka's iterative IV version of the model.

[3]In order to understand the logic of these simulations it should perhaps be pointed out that Finland is a highly unionized country (the overall unionization rate being about 80 %) and thus collective wage agreements covering the whole economy are (or at least seem to be) of crucial importance. As far as determination of interest rates is concerned, they are (or have been until very recently) effectively controlled by the Bank of Finland via the discount rate.

We now turn to the simulation results presented in Table 3. The effects of the following sustained policy changes on gross domestic product (y), consumption prices (pc), the interest rate (r) and current account balance (rb) are tabulated: an increase in (a) the discount rate, (b) the contract wage rate, (c) public consumption, (d) public consumption and taxes, (e) public investment and taxes, and (f) oil prices. All these changes take place at the beginning of the first quarter of 1972, the model being solved, however, from the first quarter of 1971. Thus, the changes are already known in advance. We do not discuss here the time paths of these policy effects. Rather, we hope it suffices to point out that these time paths are - at least in our opinion - fairly standard (cf. e.g. Taylor (1985)). An increase in interest rates has a persistent - albeit declining - effect on GDP and a persistent - albeit very small - effect on prices. In the oil price simulation the GDP effect is similar but the price effect is - as one might expect - much stronger. An increase in contract wages has only a temporary positive effect on GDP, which becomes negative after only two years (this is due to the deterioration in competitiveness; notice that the exchange rate index is kept unchanged in this simulation). Finally, expansive fiscal policy has a positive effect on output.

There is a multiplier effect of the magnitude of 1.5, the long-run effect being about .5. (Obviously, these values depend very much on the way the deficit is financed: for instance in alternative c it is assumed that foreign borrowing is used).[4] The public investment simulation indicates that if one is able to change the structure of demand so that consumption is decreased and (productive) investment is increased, this has a significant positive effect on output. This is due to a positive capacity effect, which, in turn, affects wages, prices and net exports. Thus, the model suggests that public sector could achieve some favourable growth effects with a well-designed structural policy.

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[4]The contract wage, public demand and tax rate simulations are based on the assumption that the central bank pegs the discount rate. Moreover, the exchange rate index is treated as exogenous. Thus, the resulting real interest rate and real exchange rate effects do to some extent affect the long-run adjustment paths, which, however, are not the main interest here.

Table 3 Policy Simulation Results[1)]

	72.1	73.1	74.1	75.1	76.1
a. Interest rate simulation[2)]					
y	-.02	-.10	-.11	-.09	-.05
pc	.00	-.00	-.02	-.05	-.09
ca	1	8	22	37	52
r	.24	.71	.84	.88	.89
b. Contract wage simulation[3)]					
y	.09	-.01	-.01	-.03	-.06
pc	.30	.79	.84	.85	.85
ca	-2	-12	-21	-33	-42
r	.02	.02	.01	.00	.00
c. Public consumption simulation[4)]					
y	1.71	1.02	.80	.72	.60
pc	.00	.08	.33	.61	.91
ca	-31	-51	-100	-144	-178
r	.00	.00	.01	.02	.02
d. Balanced budget simulation[5)]					
y	1.12	.31	.26	.39	.47
pc	-.00	.00	-.01	-.04	-.08
ca	-4	34	90	147	202
r	-.00	.00	.00	-.00	-.00
e. Public investment simulation[6)]					
y	.46	.46	.77	1.15	1.65
pc	-.00	-.03	-.10	-.21	-.36
ca	27	84	214	369	524
r	-.00	-.00	-.00	-.01	-.01
f. Oil price simulation[7)]					
y	-.01	-.04	-.07	-.08	-.08
pc	.08	.22	.48	.75	.90
ca	-36	-39	-130	-125	-137
r	.01	.01	.01	.01	.01

1) Effects are given as cumulative percentage differences between base and bariant for GDP, y, and consumer prices, pc, and as absolute differences for the interest rate, r, (%) and the current account, ca (millions of FIM). All changes are permanent. Except for simulation b, the contract wage rate is endogenous in the model.
2) A one percentage point increase in the central bank's discount rate.
3) A one per cent increase in the contract wage rate.
4) An increase in public consumption by an amount equal to one per cent of GDP.
5) An increase in public consumption by one per cent of GDP and financed by an equal increase in income tax revenue.
6) An increase in public enterprises' investment by one per cent of GDP and financed by an equal increase in income tax revenue.
7) A ten per cent increase in oil prices.

3 EXAMINING THE DYNAMIC PROPERTIES OF THE MODEL

Before focusing on the role of expectations we shortly analyze the dynamic properties of the QMED model. This is done in two different ways. First, temporary policy shocks are introduced to the model. Six exogenous variables are increased temporarily for the first quarter of 1972 and after this shock model simulation is continued until 1997.2. The purpose of this simulation is to find out whether the model returns to the original (control) solution path. Secondly, purely random shocks and, alternatively, autocorrelated shocks are fed to endogenous and exogenous variables and alternative time paths of GDP are generated by dynamic simulation. The eventual cyclical behavior of GDP is then analyzed in the frequency domain.[5]

Turn first to the exercise with temporary policy shocks. The exogenous (policy) variables which are analyzed here are: public consumption (g), contract wages (wc), discount rate (rd), income tax rate (tax), foreign import demand (m) and import prices of oil (pmo). A 10 per cent shock is introduced to each of these variables and the time path of GDP is derived by means of dynamic simulation. Then the cumulative percentage differences between the base and the variant solutions are computed; these differences are presented in Figure 1. The sample period is 1971.1 - 1997.2. The data for the exogenous variable covering the period 1987.1 - 1999.4 are based on the extrapolated values of these variables.[6]

Clearly, the temporary shock dies out rather quickly and the long-run cumulative effect is zero. The discount rate represents some sort of exception. The effect of the one-quarter shock lasts several quarters and dies out rather slowly (notice, however, that the magnitude of the whole effect is very small). Towards the end of the sample period the time path of GDP clearly deviates from the

[5]See Howrey and Klein (1972), Naylor et al (1969) and Bianchi et al (1978) for ealier examples of this kind analysis. See also Howrey (1980) for a review of basic methodology.

[6]To be more precise, it is assumed that the growth rates of the exogenous variables are the same as in period 1980.1 - 1985.4.

corresponding control solution path. (A similar effect can be discerned with other policy shocks as well). The obvious reason for this is that the model is here solved without any terminal constraints which can be of crucial importance given the rational expectations form of the model.[7] Anyway, these simulations suggest that the stability properties of the model are not far from satisfactory.

After this we try to analyze the cyclical properties of the model. This is done by introducing, in the first place, purely random shocks to both the endogenous and the exogenous variables of the model and by solving the model and then by scrutinizing the cyclical pattern of the resulting time paths of GDP. This exercise is carried out in the following way. First we generate data for the exogenous variables for a sample period of 150 quarters. In the case of the control solution these variables obtain constant values for all quarters, the values being equal to the actual values for the last quarter of 1985. Then, in the first experiment we introduce random shocks to ten of these exogenous variables. These ten variables are: public consumption (g), foreign import demand (f), discount rate (rd), foreign producer prices (pf), working age population (n), bilateral exports (xe), import prices exluding oil (pme), import prices of oil (pmo), income tax rate (tax) and contract wage rate (wc).[8]

The random shocks are generated by using normal distribution so that the standard deviations correspond to those obtained from the computed deviations between the actual values and the time trend. Thus, random shocks occur in all of these ten variables in each one

[7]It also turned out that the time path of the dynamic solution for the last observations in the data sample was rather sensitive in terms of computational accurary (cf. fn. 2). In general, this sensitiveness could be decreased by increasing accuracy from, say, the conventional .01 to .0001. As far as the role of terminal conditions is concerned see e.g. Fisher (1987) and Minford et al (1979).

[8]In the case of the discount rate (rd) and the tax parameter (tax) the standard deviation is computed around the mean.

of the 150 periods. The model is solved using these shocked exogenous variables and the spectral densities are computed for the corresponding log difference of GDP. The exercise is repeated ten times and the resulting average value of the spectral densities of $\Delta\log(GDP)$ is presented in Figure 2a.[9]

In the same way, stochastic shocks are introduced to endogenous variables (cf. equations (1) - (13) in Table 1). Thus, a nonzero error term (with the standard deviation corresponding to the standard error of the estimate) is introduced to all equations and the model is solved by means of dynamic simulation for the same sample period of 150 observations but now using constant values of exogenous variables. Again, spectral densities of $\Delta\log(GDP)$ are computed and the exercise is repeated ten times. The average value of these densities is also presented in Figure 2a.

Now, what can be said of the cyclical properties of the QMED model? As far as shocks in exogenous variables are concerned it is immediately obvious that the resulting cyclical behavior is characterized by short-term movements with duration less than one year so it is really more a question of some sort of seasonal cycle. There is a weak cyclical component representing a 2-year cycle but this is really overshadowed by the short-term cyclical behavior. Finally, there are no signs of long swings (lasting more than, say, ten years). Given the earlier results with temporary policy shocks presented in Figure 1 these long-run properties are not really very surprising.

It is surprising, however, that shocks in endogenous variables create a completely different cyclical behavior of GDP. As can be seen from Figure 2, these shocks do not produce any clear cyclical pattern. There are some signs of short cycles and of a long cycle lasting over ten years. But after all, we find that completely random shocks in endogenous variables of the model do no generate clearly distinquishable business cycles, nor other well-behaving

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[9]The Tukey-Hanning window is used the lag length being 40.

cycles. Shocks in exogenous variables might do better in this respect even though it remains clear that the shocks which are fed in must not be completely random but some degree of autocorrelation must be assumed.

This is why we carried out another simulation experiment in which we introduced autocorrelated shocks in both endogenous and exogenous variables. The idea that shocks are indeed autocorrelated instead of being purely random can be justified by various arguments which have been put forward in the real business cycle literature. Among others, one can refer to the Kydland and Prescott (1982) approach which emphasizes the importance of relatively long gestation periods in investment and production, and in addition various (persistent) technology shocks. Moreover, one can refer i.a. to the possibility of indivisiblities in labor supply, sectoral shifts, oil shocks and preference shocks (although preference shocks are not very popular in this literature). Shocks to government purchases or tax rates are typically not introduced to real business cycle models, but this is mainly due to the simple structure of these models. Anyway, the important thing is that all these shocks can hardly be considered as purely random but rather more or less persistent. (See e.g. Eichenbaum and Singleton (1986) for an overview of these models.)

In order to have persistent shocks we applied the following moving average transformation to the random shocks u_{it} which were used in the previous exercise:

(1) $$ur_{it} = u_{it} + .45u_{it-1} + .30u_{it-2} + .15u_{it-3} + .08u_{it-4},$$

where i = 1, 2, ..., 10 for exogenous variable shocks and i = 11, 12, ..., 23 for endogenous variable shocks. Given these processes, the generated shocks ur_{it} are, of course, autocorrelated and, moreover, in a way which is not much different from an AR(1) case. On the other hand, the AR(1) structure seems to be a rather good approximation for the time series properties of the key variables of the model (see Appendix 3 which contains the estimated autocorrelation functions of first log differences of these series).

The dynamic simulation experiment with these autocorrelated shocks was carried out in the same way as the above presented experiment with the purely random shocks. The resulting spectral density functions are presented in Figure 2b. Clearly, the GDP series display some cyclical behavior. When exogenous variables are shocked the GDP cycles are still rather short, although a clear cyclical peak at the frequency of 2.2 years can also be discerned. In the case of shocks to endogenous variables the corresponding cycle length is about 3 years. Obviously, these cycle lengths are too short compared with conventional business cycles, although with Finnish data for the 1970s and 1980s business cycles are not easily found. Only a rather weak 4-year-cycle can be discerned but that does not represent an important point of reference. This is not, however, important. It is obvious that the cycle length of the generated series can be increased by increasing the persistence of shocks. In this occasion the important thing is to know that reasonably persistent shocks do generate medium-term cycles while purely random shocks only generate short-term cycles (or no cycles at all).

4 EXAMINING THE ROLE OF EXPECTATIONS

Next, we deal with the question of how expectations operate in this model. To do so, we consider four alternative versions of the model or ways of performing the policy simulation. The policy simulation on which we concentrate here is the contract wage simulation, in which the contract wage rate is increased by one per cent at the beginning of the first quarter of 1972. The alternatives are:

1) We use the REH version of the model (see Table 1) and assume that the change in contract wages is already known at the beginning of the first quarter of 1971.

2) We change the model by extending the time horizon for expectations to two periods and assume again that the change in contract wages in known in advance.

3) We repeat simulation 1 but assume now that the policy change is not known in advance.

4) We change the model by using static expectations for the rate of change in consumption prices and household's disposable income, respectively.

The results of these simulations are reported in Figure 3. When the results are scrutinized, it turns out that there is at least one important difference in the results. Namely, simulations 1 and 2, on the one hand, and simulations 3 and 4, on the other hand, differ considerably in terms of the advance effect. Thus, if we use a rational expectations specification(s) and allow economic agents to know the policy change in advance this change already has significant (real) effects before the policy change actually takes place.

In this model, the advance effects are mainly due to the income effect: household's real disposable income will increase and households react to this increase in advance by increasing consumption and investment in residential construction. In addition to this "income effect" the model reacts to inflationary expectations. A change in inflationary expectations operates through the direct inflation effect (which affects consumption negatively) and the real interest rate effect (which tends to increase consumption) (see equations 3 and 4 in Table 1).[10]

It is not only in terms of the advance effects that these three simulations are different. The whole short-run dynamics is very different. In the case of simulations 1 and especially 2 the advance effect dominates the whole short-run dynamics. This effect is of considerable magnitude. If the time horizon of expectations is two

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[10] When evaluating these results one should keep in mind that prices and wages are not completely flexible in the short run. Hence, the results may be more consistent with Neary and Stiglitz (1983) -type models than with stereotype market-clearing cum rational expectations models.

periods, a one per cent increase in contract wages increases GDP by .06 per cent during the previous year. If the time horizon is only one period - as in the basic version of our model - the effect on an annual basis is a little bit less than one half of this. By contrast, in the case of simulation 3 (the "surprise case") the positive short-run effect is strikingly small: the positive consumption (real wage) effect is nearly offset by the simultaneous negative net exports effect. Finally, in the case of simulation 4 (with static inflation and income expectations) the simulated time paths are very close to those of the "surprise" simulation 3 (the positive output effect being, however, slightly larger). Thus, in a sense one can say that old-fashioned static expectations macromodels assume that all policy changes are, in fact, unanticipated.

Even though the simulations differ considerably in terms of short-run effects, the medium-run and long-run effects are very similar. In the medium run the effect is either nil or slightly negative while in the long run the effect is clearly negative.[11]

One could of course discuss the proper ways of specifying the transmission mechanisms of price and income expectations, for instance in the context of the present model. It is clear that the present specification is deficient in many respects. But we do not think that this is of crucial importance. What is important here is the fact that rational expectations do matter. That is, the short-run effects of various "policy" changes are extremely sensitive with respect to the way expectations are allowed to have an influence in the model.

5 CONCLUDING REMARKS

Our model is by no means complete. This is particularly true as regards the way expectations are modelled. Even so, some interesting new results can be obtained by making use of rational expectations

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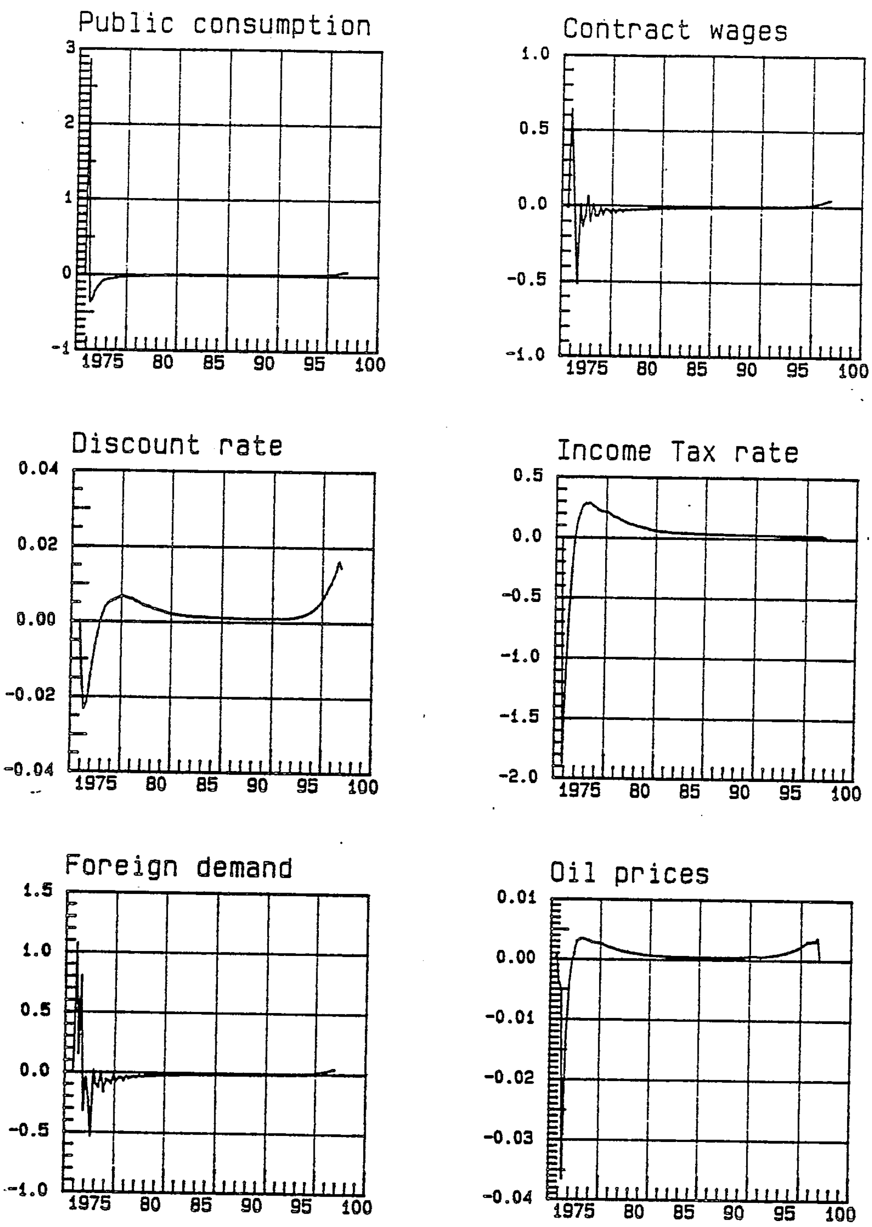
[11]The results seem to be analogous to those obtained by Fair (1979).

(and by allowing for flexible wages and prices as well as supply side effects). Without attempting to summarize our results in full, we would like to stress two points. First, the estimation and simulation of (small-scale) models which make use of some form of rational expectations does not represent a computational nightmare - as was generally assumed in the 1970's (cf. e.g. Poole (1976)). Second, we can no longer carry out policy simulations without specifying whether the change is anticipated or unanticipated. This would seem to suggest that treating policy variables as exogenous should be considered with great caution. Clearly, it is not only the question of whether some variables are endogenous or exogenous which becomes delicate with the rational expectations macromodels. Such things as "the existence of policy regimes" and "the credibility of economic policy" also start to be real problems. If the advance effects are really of crucial importance then it is, of course, of crucial importance how different signals from policy-makers are interpreted. That, in turn, has something to do with past record of policy actions.[12]

[12]Unfortunately, we cannot continue this discussion further here. The interested reader is referred to Barro and Gordon (1983) and Friedman (1979).

Figure 1

EFFECTS OF TEMPORARY POLICY ACTIONS ON GDP (1)

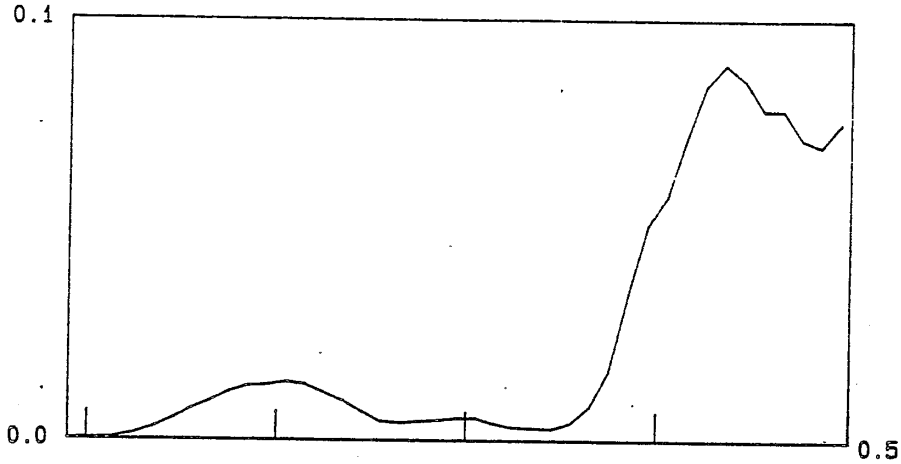


1) All effects are given as cumulative percentage differences between base and variant for GDP given a 10 percent increase in exogenous variables

Figure 2 a

AVERAGES OF SPECTRAL DENSITIES FOR GDP

Random shocks in exogenous variables



Random shocks in endogenous variables

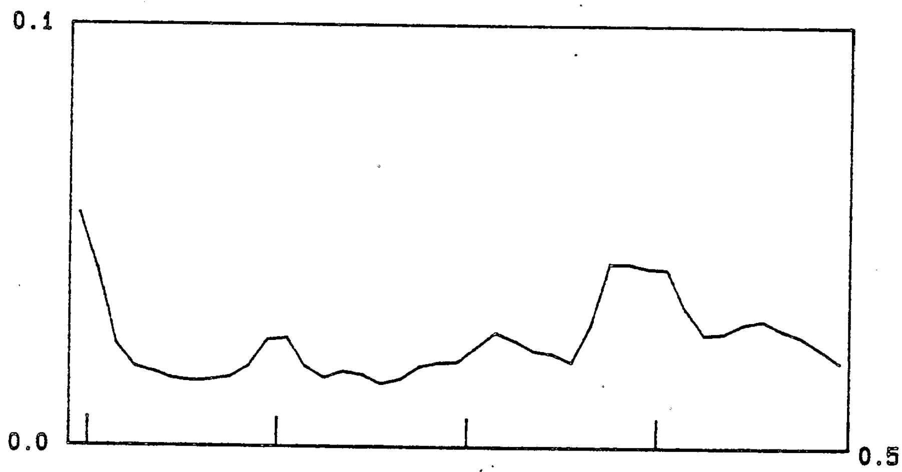
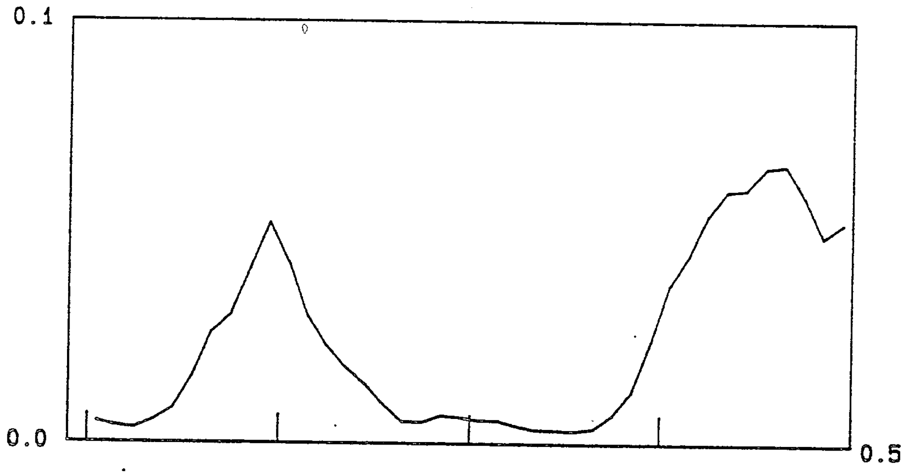


Figure 2 b

AVERAGES OF SPECTRAL DENSITIES FOR GDP

Autocorrelated shocks in exogenous variables



Autocorrelated shocks in endogenous variables

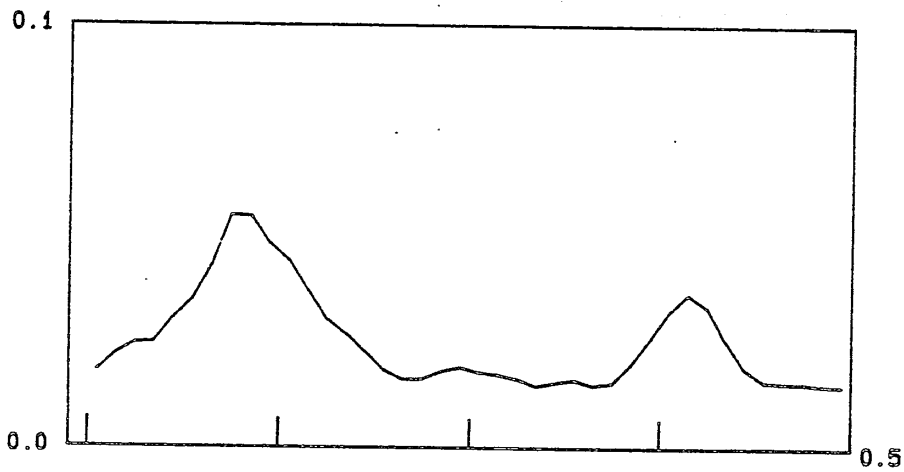
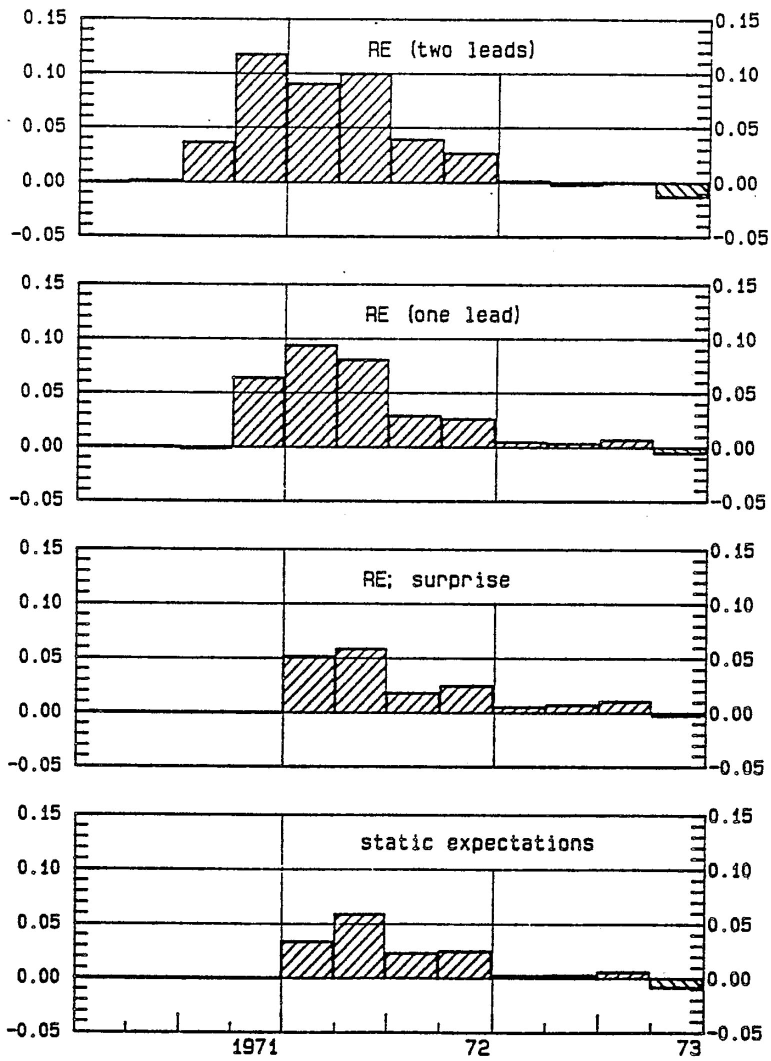


Figure 3 (a)

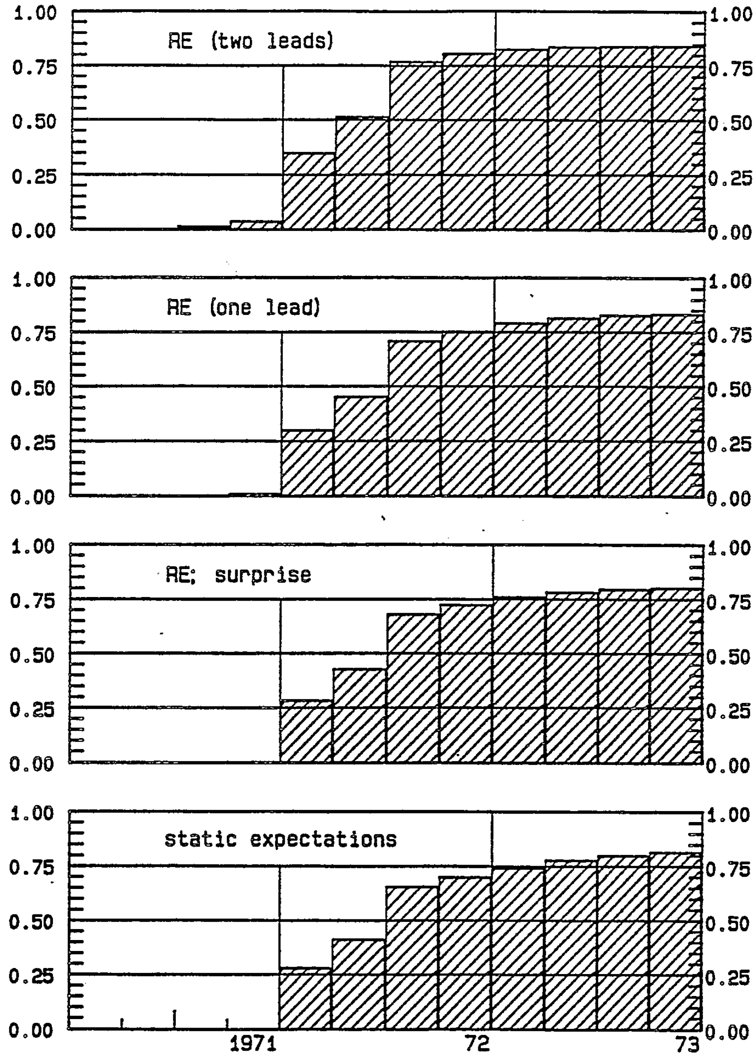
EFFECT OF AN INCREASE IN CONTRACT WAGES ON GDP UNDER DIFFERENT FORMS OF EXPECTATIONS FORMATION *)



*) Percentage difference between base and variant

Figure 3 (b)

EFFECT OF AN INCREASE IN CONTRACT WAGES ON CONSUMER PRICES UNDER DIFFERENT FORMS OF EXPECTATIONS FORMATION *)



***) Percentage difference between base and variant**

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Appendix 1.

Diagnostic test statistics

Equation No.	r_1	r_2	r_3	r_4	CHOW	J-B	ARCH(4)
1	-.764	-.277	1.258	-1.088	.749	.416	11.904
2	-1.374	-.317	-1.568	.380	2.717	.112	6.016
3	-2.081	.126	.860	-.670	-	4.433	.768
4	-1.115	.255	.291	-1.560	2.844	.188	1.152
5	-1.046	.461	1.494	-2.679	-	.756	8.064
6	1.506	.700	.438	.061	-	4.154	2.432
7	-.113	1.662	-1.294	1.780	2.783	1.163	5.440
8	.066	-.264	-1.047	2.762	.501	6.980	1.920
9	-1.150	-1.633	-.859	3.635	-	2.099	26.048
10	-.094	-3.851	-1.231	3.206	-	.917	11.520
11	-.190	-.383	-1.316	-.171	-	1.072	1.984
12	.906	-.696	1.447	1.232	3.521	10.805	7.936
13	2.516	.840	1.327	-.157	-	23.808	1.152
Critical values	1.645	1.645	1.645	1.645	2.370	5.991	9.488

Equation numbers are the same as in Table 1. The r_i's refer to Godfrey's autocorrelation test statistics for lags 1, 2, 3 and 4, CHOW to the Chow stability test statistic for the period 1977.2 (due to dummy variables this statistic could not be computed for all equations), J-B to the Jarque-Bera test statistic for normality, and ARCH(4) to Engle's autoregressive conditional heteroscedasticity test statistic for four lags. For other details, see Krämer and Sonnberger (1986).[1]

[1]In this context we can mention that the OLS residuals are typically not contemporaneously correlated. Thus, only 4 out of 78 coefficients of correlation exceed the 5 per cent critical value. In the case of squared residuals, however, the corresponding number is 12. Moreover, if principal components are computed for these (13) squared residuals, the first two account for about 80 of total variation. Quite clearly the variability of price and volume series is affected by some common source(s) of variation.

Appendix 2.

Hatanaka's Iterative IV Estimates of the Main Behavioral Equations of the QMED-Model

(1) $\Delta x = - .346*\Delta x(-4) - .669*\Delta pxf(-2) - .369*(x-f)(-1) + .362*(x-f)(-2) + .800*\Delta f + .638*\Delta f(-2) + .360*cap(-2)$

R2 = .553 D-W = 2.180 SE = .052

(2) $\Delta m = 1.032*\Delta z + .698*\Delta pzm - .494*(m-z)(-1) + .280*(m-z)(-2) + .197*(m-z)(-3) - .246*cap(-1)$

R2 = .568 D-W = 2.326 SE = .055

(3) $c = .662*c(-1) + .333*yhr(+1) - .001*(r-(400*\Delta pc(+1))) - .782*\Delta pc(+1) + .025*d1 + 1.567$

R2 = .992 D-W = 2.636 SE = .012

(4) $ih = .537*ih(-1) + .407*yhr(+1) - 2.190*hk(-1) + 14.733*n - .003*(r-(400*\Delta pc(+1))) - 0.494*pcih(-4) - 91.497$

R2 = .720 D-W = 2.221 SE = .046

(5) $\Delta if = \Delta ye - .370*(if-y)(-1) - .057*d13*(if-y)(-1) - .001*\Delta(r-(400*\Delta pi))(-1) - .250*\Delta wr(+1) + .168*d14 + .111*d15 + .118*d16 - .896$

R2 = .552 D-W = 2.239 SE = .046

(6) $\Delta l = .210*\Delta l(-4) + 1.213*\Delta yi - .101*\Delta wr(+1) - .234*(l-n)(-1) - .052*cap(-1) - .006*d2 + .024*d3 + .008*d4 - .344$

R2 = .639 D-W = 1.615 SE = .004

(7) $\Delta w = .110*\Delta 4(pc(+1)) + .891*\Delta wc - .011*cap(-1)$

R2 = .886 D-W = 1.908 SE = .005

(8) $\Delta pc = .307*\Delta wn + .127*\Delta wn(-1) + .231*\Delta wn(-2) + .078*\Delta pm + .058*\Delta pm(-1) + .053*pm(-2)$

R2 = .695 D-W = 1.976 SE = .007

(9) $\Delta pi = .592*\Delta wn + .043*\Delta pmo + .043*\Delta pm(-2) + .180*\Delta pi(-1) + .012*d5 + .013*d6$

$R2 = .437$ D-W = 2.172 SE = .015

(10) $\Delta pg = .612*\Delta wn + .205*\Delta wn(-3) + .097*\Delta pm + .007*d7 - .053*d8 + .028*d9$

$R2 = .725$ D-W = 1.980 SE = .010

(11) $\Delta px = .159*\Delta 2(\Delta px)(-2) + .325*\Delta wn + .482*\Delta pf + .192*\Delta er(-4) + .060*d10 + .057*d11$

$R2 = .705$ D-W = 2.048 SE = .019

(12) $r = .747*r(-1) + 13.582\Delta pc + .215*rd + 3.354*\Delta dr$

$R2 = .890$ D-W = 1.803 SE = .548

(13) $q = .425*q(-1) + .575*z + .081*ig - .108*d12 - 1.627$

$R2 = .988$ D-W = 1.354 SE = .020

(14) $cap = .006*t - 2.066 + .7*k(-1) + .3*n - q + mr$

All definitions are the same as in Table 1. The contract wage rate was assumed to be exogenous in this version of the model.

Appendix 3.

Estimated Autocorrelation Function Values

lag	1	2	3	4	5	6	7	8	9	10	11	12	BP	ARMA
g	.01	.07	.19	.01	-.09	.34	.16	-.14	.15	.08	.02	.22	18.35	RW
f	-.01	.00	.20	-.20	-.32	-.04	-.01	-.32	.14	.17	-.12	.10	22.82	RW
rd	.89	.72	.53	.35	.16	-.04	-.16	-.27	-.34	-.37	-.32	-.24	144.66	AR(1)
pf	.21	.21	.28	.12	.10	-.00	.03	.10	.11	.06	.23	.09	17.47	RW
n	.32	.34	.33	.54	.23	.34	.23	.43	.19	.21	.10	.09	71.60	AR(4)
xe	-.22	.03	-.11	-.10	.04	-.06	.04	-.06	.20	-.06	-.12	-.01	8.96	RW
pme	-.02	-.33	.03	.36	-.00	-.22	-.11	.16	.09	.01	-.07	.08	22.19	RW
pmo	.36	-.03	.09	.10	-.22	-.22	.03	.10	-.03	-.04	.20	.04	19.22	AR(1)
tax	.93	.83	.70	.55	.38	.23	.10	-.02	-.11	-.15	-.18	-.19	169.64	AR(1)
pc	-.05	.20	.15	.02	.19	.01	.22	-.07	-.21	.10	-.19	-.09	16.24	RW
x	-.30	.18	.21	-.43	.21	-.27	.01	.00	-.07	.05	-.07	-.09	31.29	RW
m	-.51	.14	-.14	.12	.06	-.04	-.13	.01	.12	-.25	.31	-.31	38.28	AR(1)
c	-.12	-.07	.08	-.07	.14	.04	.02	-.27	-.10	.18	-.13	.08	11.15	RW
ih	-.30	.01	-.03	-.14	.13	.06	-.04	.11	.02	-.01	.00	.13	10.45	RW
if	-.46	.13	.09	-.10	.08	.07	-.02	-.20	.29	-.13	-.02	-.16	27.14	AR(1)
l	-.17	-.24	.04	.12	.06	.09	-.03	-.30	.18	.13	-.15	-.39	27.35	RW
w	.20	.29	.33	.24	.25	.19	.22	-.07	-.13	.08	-.07	-.19	32.43	RW
pc	.66	.59	.50	.52	.42	.20	.19	.16	.10	.01	-.05	.03	102.66	AR(2)
pi	.20	.13	.19	.42	.09	-.13	.11	.17	.04	-.12	.12	.07	23.52	RW
pg	.21	.12	.14	.33	.37	.04	-.11	-.07	.22	-.21	-.22	-.30	37.03	RW
px	.42	.27	.19	.10	-.01	-.18	-.10	.01	-.04	-.04	-.01	-.09	21.96	AR(1)
r	.93	.85	.77	.65	.50	.36	.25	.12	.03	-.04	-.08	-.11	195.95	AR(1)
q	-.29	-.08	.19	.09	-.00	.21	-.18	-.08	.08	.03	-.07	-.15	16.02	ARMA(2,1)

The first 12 columns correspond to the autocorrelation coefficients, BP denotes the Box-Pierce statistic with 12 lags and ARMA the ARMA model specification which is obtained when the Schwartz Bayesian Information Criterion is used. The data are expressed as first log differences. In the case of r, rd, and tax, however, the untransformed data are used. If, instead, the first difference data are used, the following Box-Pierce autocorrelation statistics emerge: r 11.87; rd 12.23; tax 88.99. The asymptotic 5 per cent critical values of r_i and BP are: .25 and 21.03.

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