Empirical Evidence on the Rational Expectations Hypothesis Using Reported Expectations

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Zusammenfassung

Die Arbeit versucht die Hypothese der Rationalen Erwartungen an Hand von empirisch erhobenen Erwartungsdaten zu testen. Diese Vorgangsweise stellt eine Alternative zu den indirekten Testmethoden dar, in denen die Rationalität der Erwartungen durch den Verlauf von "objektiven" Daten getestet wird (durch Überprüfung einer Erklärungshypothese, in der Erwartungen eine wohl definierte Rolle zukommt). In diesem Fall kann immer nur die gemeinsame Hypothese der Richtigkeit des Modells und der Rationalität der Erwartungen verifiziert werden. Bei Verwendung empirisch gemessener Erwartungen entfällt dieses Problem, doch kommt die Frage der Glaubwürdigkeit der gemessenen Erwartungen hinzu. Eine unvollständige Auskunft darüber gibt eine Untersuchung des Erklärungsbeitrags der Erwartungen und Antizipationen in Konsum und Investitionsfunktionen.

Die Hypothese der rationalen Erwartungen kann erst empirisch getest werden, wenn man eine Annahme über die vorhandene Informationsmenge trifft. Als minimaler Informationsstand wird die Kenntnis der vergangenen Entwicklung der zu prognostizierenden Zeitreihe angenommen. Unter dieser Annahme lassen sich die Merkmale "Unverzerrtheit", "Effizienz", "Suffizienz" und "Konsistenz" aus dem Vergleich erwarteter und tatsächlicher Entwicklungen ableiten und empirisch untersuchen.

Das empirische Material umfaßt 39 Zeitreihen über die erwartete (geplante) Entwicklung von Umsätzen, Investitionen und Preisen aus mehreren Ländern, wobei teilweise Unternehmensbefragungen, teils Konsumentenbefragungen und teilweise Prognosen von Experten zugrundeliegen.

Rationality of Expectations in the Muthian sense is one of the most popular innovations in the theory of economic policy in the seventies. Its implications on the effectiveness of economic policy depending on the information set available is surveyed f.e. by *Ramser* (1978), *Neumann* (1979), and *Friedman* (1979), some more objections to the rationality hypothesis are discussed in the papers of *Fair* (1978), *Frey* (1978), *Simon* (1978), *Kantor* (1979), *Katona* (1980), *Forman* (1980), *Buiter* (1980), *Mayes* (1981), and *Wagner* (1981).

Empirical tests of the hypothesis are performed many times without use of empirically surveyed expectations by means of testing its implications on some "objective" variables (indirect tests). The evidence seems supportive but is subject to some limitations (chapter 1.1).

The use of empirically surveyed expectational data (direct tests) is less popular because there is doubted whether they represent those expectations the economic agents actually act upon. To find out whether reported expectations are reliable the literature is surveyed with respect to the significance of their explanatory power mainly in investment and consumption functions. Readers who do not doubt the quality of reported expectations may skip chapter 1.2.

The Rational Expectations Hypothesis (REH) is a "principle" rather than a "rule", because its rationale can account for many complexities of economic life. It has to be made operational by concentration on some aspects thereby usually leaving out of consideration other important economic facts. In the original article by *Muth,* this results in a specification of REH, which is used in the following theoretical and empirical literature. We derive several characteristics of "mainstream" REH in chapter 2, most of which follow examples in the literature.

The empirical tests of these characteristics make use of 39 expectational variables collected in the US, Japan and European countries. The reported expectations refer partly to business, partly to consumers and partly to economic experts, they are short term in nature and deal with price and quantity changes in commodity markets, but not with financial markets or with policy parameters. The results for the characteristics of REH are developed in chapter 3. The tests, however are not independent of each other, so that we require a joint testing procedure. Univariate Box Jenkins technique and transfer functions are applied in chapter 3.7 to discover whether expectations and realisations in general follow the same stochastic processes, respectively if their difference is "white noise" after applying the "optimal" transfer functions. The results and their limitations are summarized in chapter 4.

1. Direct versus Indirect Tests of Rational Expectations

1.1 Indirect Tests

Most empirical tests of REH do not make use of reported expectations but apply the following procedure. A variable is assumed to be explained by a model involving some other "objective" variable and expectations. Since "expectations" are usually considered not to be measurable (e.g. *Rutledge,* 1964; *Mc Callum,* 1976) their generation has to be "explained" by an hypothesis, specifically by the hypothesis of rationality. This leads to testable

implications under the joint assumption that the model is correct and that expectations are rational. One frequently used model is *Fisher's* hypothesis that the nominal interest rate consists of a constant real rate of return plus expected inflation. The rationality assumption then implies that the differences between nominal interest rates and inflation cannot be explained by any other known piece of information (*Rutledge,* 1974, e.g. tests for the influence of past inflation rates and past money change). By the same token this difference should exhibit no serial autocorrelation. *Fama* (1975) stresses that this test is rather strict insofar, as even in the case of hypothetical contradiction of empirical facts, we must not necessarily hold inefficiency responsible. On the other hand *Nelson* and *Schwert* (1977) demonstrate that lack of autocorrelation in this "ex-post real rate" is also "consistent with variation in the ex-ante real rate which is purely random in nature and also consistent with market efficiency in the form of forecast errors which are larger than necessary given available information"(1).

Another frequently used model – the *Friedman Phelps* Model – purports output (as well as unemployment) to depend only on the difference between expected and actual inflation. Assuming rationality it follows that unemployment does not depend on any known variable(2). *Lucas* (1973) derives the testable implication that the parameter of unexpected inflation should vary with the variance of inflation in an international comparison, *Barro* (1977) and *Sargent* (1973) construct variables of unexpected inflation respectively money change using residuals of functions purported to incorporate economic knowledge of the determination of these variables.

Though not unequivocal(3) the results of these indirect tests of the rationality assumption are considered supportive(4). Evaluating this kind of tests we have to consider as advantageous that the data necessary for empirical tests are available for a considerable time span with no more than the usual measuremant errors. The data used are effective results of expectations, not only vague uncommital considerations. On the other hand indirect testing leaves open whether that confirmation follows from the "false" model plus "irrationality" and contradiction follows from a "false" model plus "rationality".

One more feature becomes important from the point of view of the later reported empirical evidence: the indirect tests usually test for covariance only (e.g. between real interest rates and possible determinants), while systematic but constant differences between "implied" expectations and "rational" expectations would be absorbed irrecognizably into some constant term ("real interest rate", "natural rate of unemployment", etc.).

1.2 Requirement of Direct Testing: Reliability of Reported Expectations

The number of empirically surveyed expectations is growing rapidly(5). Most of them refer to production, sales and investment anticipations as seen by the business sector and

price expectations from a consumer point of view. Furthermore expert forecasts on macroeconomic variables are available now for considerable time spans. Under these circumstances the often repeated statement that "expectations . . . are *per se* unobservable magnitudes" (*Rutledge,* 1974; *Mc Callum,* 1976) need not necessarily reflect unawareness of this bulk of data, but suspicion whether the reported expectations are those "held by individuals who transact in the (bond) market" (*Pyle,* 1972) and whether "they do influence the behavior of economic agents" (*Pesando,* 1975). *Mills* (1962) probably formulates the preference for indirect test sharpest: "Economists hold the strong presumption, probably justified, that observed behavior generally provides a better source of explanatory hypotheses than do verbal reports"(6).

As an ultimate criterion of the reliability of reported expectations *Mills* proposes to use their forecasting performance(7). Literature on the significance and forecasting quality of reported expectations is available mainly for business and consumption anticipations, much less on price and wage expectations.

Historically early investigations of sales anticipations reported unsatisfactory forecasting performance (*Modigliani – Sauerländer,* 1955, p. 306), at least not better than that of naive models (*Pashigan,* 1964). Later evidence reversed these last findings (*Hart – Sachs,* 1967) using the same expectational data, but for a longer time period. Traditionally investment anticipations are considered to be more accurate, especially if their systematic tendency to underestimate investment (the bias itself depending on firm size) is taken into account (*Foss – Natrella,* 1957; *Wimsatt – Woodward,* 1977; *Aiginger,* 1977). Significant explanatory power of anticipations is found (independently of the mean bias) in the overwhelming majority of studies on investment behavior partly representing a realisation function approach, partly as a means to improve forecasting quality(8). Consequently some studies even raise the question whether anticipations by themselves outperform causal investment functions. This is denied by *Evans* (1969) as far as total investment is concerned, and confirmed in case of manufacturing investment as well as in ex post predictions using only those determinants available in time of the formation of anticipations. *Okun* (1960), *Zarnowitz* (1973), and *Jorgenson – Hunter – Nadiri* (1970, in all but a very few of 15 industries) present evidence in favor of this "absolute superiority" of anticipations. Business anticipations which rely on the categorial formulation of the questions (qualitative data) are in general reported to be coinciding indicators or to show a very small lead (especially if compared to information available at the date of survey (*Strigel,* 1977; *Aiginger,* 1977; *Courtois – Goldria – Richter,* 1974). Their correlation with actual data is reported to be very close. Investment anticipations as well as qualitative business expectations are used in several econometric models (for an overview see *Aiginger,* 1977) mainly in the investment equations. *Crocket* and *Friend* (1967) as well as *Friend* and *Thomas* (1970) report the superiority of the expectations augmented models, comparisons of three versions of the *Wharton* model (standard, endogenous expectations, reported expectations used as far as available) reveal better forecasting at least for the equation

directly using anticipations. Total nominal GNP is improved only in version 3 (*Adam – Dugall,* 1972). *Fromm* and *Klein* (1973, p. 391) report smaller biasses, more accuracy in the prediction of turning points and better performance outside the sample period for the version including anticipations.

As far as consumer surveys are concerned early investigations (*Lansing – Withey,* 1955; *Mueller,* 1960) report poor performance on the micro level and conflicting evidence on the superiority of attitudes versus purchasing plans. Longer availability of survey data demonstrated their explanatory power in addition to "objective determinants" (*Dunkelberg,* 1972; *Tobin,* 1959; *Wüger,* 1979; *Gugerell,* 1979), even if restricted to the explanation of consumer durables (*Nerb,* 1975) or even to purchases of automobiles (*Okun,* 1960; *Biervert – Niessen,* 1972). Absolute superiority of anticipations is not reported, though *Juster* and *Wachtel* (1972) find that sentiment variables eliminate permanent income in consumption functions. Anticipations are considered as especially important in periods of rapid change as well as in the last recession (*Mishkin,* 1978). *Wachtel* (1977) demonstrates the explanatory power of survey data in explaining consumption, prices, wages and interest rates (specifying some extrapolative proxies as alternatives), *De Menil* and *Bhalla* (1975) find satisfactory results in two out of three wage models. In the literature on investment anticipations as well as consumer surveys empirical reports nowadays seem to favor survey data. Three causes may be responsible: first, the availability of longer surveys for a longer time period favored time series analysis (where many individual errors level out), second, we learned to adjust anticipations for their main biasses, explicitly by means of estimating realization functions or implicitly by using their covariance property only, and third, the relation between anticipations and realizations seems to be more stable than that between realizations and their main "objective" determinants. These causes, however, are not essential for the use of empirically surveyed expectations. Neither is it important whether we can agree with the tentative conclusion that investment anticipations proved "absolutely superior" to causal alternative, while consumer surveys do not. The most important conclusion of the cited studies seems to be that survey data have some explanatory power in explaining investment and consumption in addition to objective determinants. This leads us to the conclusion that we cannot reject that these data may be used for direct tests of REH.

2. Testable Characteristics of Mainstream REH

In this chapter we derive characteristics of the simplest version of the Rational Expectations Hypothesis, which can be tested by a confrontation of surveyed expectations with realizations (by this term we mean the actual values of that variable to which the expectations refer). These characteristics can be derived from *Muth's* statements about rationality. Most of them (criteria 1-5) are commonly accepted in the literature. It is doubtful however whether REH implies a causality relationship and whether the extent of the error term should be considered as criterium of rationality.

"Expectations are essentially the same as the predictions of the relevant economic theory" or more precisely "expectations of the firm tend to be distributed for the same information set about the predictions of theory" (*Muth,* 1961). At least insofar as the relevant economic theory on average predicts correctly (which is desirable under the usual symmetric loss functions and definitely assumed in ex post predictions by least square techniques), we derive as first testable characteristics that the respective averages should be equal: *"Identity of Means"* (Criterion 1). *Muth* confirms this characteristic in equation *(1),* which is an often repeated formula for the simplest version of REH: the expected value of the error term is zero(9).

(1) $$A_t = E_t + u_t; \quad E(E_t \cdot u_t) = \dot{0}, \quad E(u_t) = 0$$

A_t ..... realization (the symbol a_t will be used for relative changes of this series later on)

E_t ..... expectation (the symbol e_t will be used for relative changes of this series later on)

The same rationale, namely that expectations are purported to be an unbiassed predictor of the actual variable, constitutes the second test. Regressing the actual variable (realization) on the expectational series should yield a unity regression coefficient as well as a constant term not significantly different from zero. This criterion may be labelled as "unbiassedness" (Criterion 2). Though resulting from the same rationale this test is stronger than the comparison of averages because it includes the requirement of some variance between expectations and realizations. Variables independent of each other (given some minimal variance of the variables) may have similar averages, but will not pass the test of unity regression coefficients(10).

(2) $$A_t = k + b_1 E_t$$
$$k = 0 \ \cap \ b_1 = 1$$

Since "economy does not waste information" (*Muth,* 1961, p. 315) rational expectations incorporate all available information, which determines actual development (*"Sufficiency of Expectations",* Criterion 3). This implies that available information cannot be used any more to "explain" differences between expectations and realizations.

Among the set of exploitable information there are also past errors in forecasting, therefore "rational forecasting requires that forecast errors are serially uncorrelated"(11).

Serial correlation of errors is the most popular test of sufficiency. In principle we could test for the influence of the whole "universe of possible determinants" (*Mc Nees,* 1978B).

This may be too strict a criterion, because the rational agent can only incorporate the influence of variables which he considered to be important ex ante. Therefore we should limit ourselves to test for "obvious" determinants(12). Whichever variables are tested for

their influence, these tests of rationality are tests of the "strong" version (i.e. exploiting also information outside the history of the actual variable to be predicted) as compared to the above mentioned test, which used only information contained in the history of the variable itself.

Optimality requires not only to use all available information, but also to use it in an optimal way: *"Efficiency"* (Criterion 4). The optimal way is that one in which this information determines actual development. Again it is possible to test weak rational expectations for their efficiency searching if expectations fully reflect all information in the past history of the forecast variable(13) as well as strong rational expectations incorporating also the influence of variables outside of the set of past realizations.

Rationality of expectations has also some implications on the relation between the expectations referring to different horizons(14) (short term respectively long term expectations). "Although we may anticipate today that we may change our forecast in the future, we have no expectation today as to the direction and magnitude of these future changes in forecasts" (*Shiller,* 1978; *"Consistency of expectations",* Criterion 5). Therefore systematic differences between expectations referring to a more distant period respectively shorter run expectations will contradict rationality. Furthermore the long run expectations should use the same explanatory set as realizations, substituting the unknown information about the changes in the near future by the "rational" short run expectations.

In contrast to the criteria mentioned up to now (1-5), the following ones can not be strictly derived by the logic of the hypothesis itself, but they are open for evaluation and discussion. The size of "errors" in expectations is no refutational criterion by itself as long as the error does not show any exploitable characteristics. However when deciding how much search one should invest in looking for unused pieces of information (see sufficiency criterion) a larger extent of unexplained variance of actual data is an indicator that more search may be useful(15) (*"Size of Error Term"*).

The theory of Rational Expectations does not aim at asserting a one-sided causation running from expectations to realizations. In his verbal analysis *Muth* lookes for a hypothesis on the formation of expectations. In the context of *Muth*'s small model we can speak of interdependency between expectations and realizations. The restrictions of a zero covariance between the expectations and the error term (in equation *(1)*) however implies one-sided causality: If realizations influenced expectations it would be unreasonable to impose this restriction (*"One sided causality"*).

A possible interdependence of expectations and realizations would have implication on testing the other properties of rationality. Regressing actual data on expectations by the way of OLS will result in regression coefficients below unity, because of regression bias. On the other hand interdependence could revive the comparison of the respective variances

Table 1

Characteristics of the Data Used and Evidence on REH – Criteria

		Region	Period	Type of Data	Lenght of Forecasting Period	Horizon[1)]
Business Surveys						
(1.)	Investment	Austria	65–78	quantitative	annual	actual
	2. Anticipation					1 1/2
	1. Anticipation					7 1/2
(2.)	Capacity Increase	Austria	64–77	quantitative	annual	actual
	1. Anticipation					7 1/2
(3.)	Investment	USA	55–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(4.)	Sales	USA	61–75	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(5.)	Investment	Japan	63–76	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(6.)	Sales	Japan	63–76	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(7.)	Production	Japan	63–76	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(8.)	Exports	Japan	63–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(9.)	Stocks of Finished Goods	Japan	63–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(10.)	Liabilities (Stock)	Japan	63–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3

Table 1

Characteristics of the Data Used and Evidence on REH – Criteria

Source	Sector	Mean[2)]	Standard Deviation[2)]	A	B	C	D	E	F	G	H	I
WIFO	Manufacturing	8,30	13,69									
		4,16	12,01									
		– 4,55**	9,45*	R	R	R	R	NR	R	NR	R	R
WIFO	Manufacturing	4,92	1,90									
		3,99	1,46	NR	NR	NR	NR	NR	R	NR	–	–
OBE	Manufacturing	3,14	15,07									
		11,91**	12,60**									
		7,38**	13,28	R	R	NR	R	R	R	R	NR	R
OBE	Manufacturing	1,88	2,23									
		1,77	1,99									
		1,65	2,64*	NR	R	R	NR	R	R	R	NR	R
Bank of Japan	Big Business Manufacturing	2,51	6,91									
		10,37**	7,40									
		0,29*	3,55**	R	R	R	R	R	R	NR	R	R
Bank of Japan	Big Business Manufacturing	3,61	2,44									
		3,45	1,46**									
		3,03	0,98**	NR	R	R	R	R	R	R	R	R
Bank of Japan	Big Business Manufacturing	3,58	2,84									
		2,91	1,44**									
		2,87	0,85**	NR	R	R	R	R	R	R	NR	NR
Bank of Japan	Big Business Manufacturing	6,05	5,17									
		5,03	3,30**									
		3,18**	2,24**	R	R	R	R	NR	R	NR	R	R
Bank of Japan	Big Business Manufacturing	3,96	4,36									
		1,13**	0,91**									
		0,95**	0,76**	R	R	R	R	NR	R	R	R	R
Bank of Japan	Big Business Manufacturing	3,15	1,63									
		3,04	1,51									
		2,61**	1,18**	R	R	R	R	NR	R	R	R	R

Table 1/(Continued)

Characteristics of the Data Used and Evidence on REH – Criteria

		Region	Period	Type of Data	Lenght of Forecasting Period	Horizon[1)]
(11.)	Long Term Liabilities (Stock)	Japan	63–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(12.)	Cash and Deposits	Japan	63–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(13.)	Trade Receivables	Japan	63–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(14.)	Trade Payables	Japan	63–77	quantitative	quarter	actual
	2. Anticipation					Ø
	1. Anticipation					3
(15.)	Shippers' Forecast	USA	28–39	quantitative	quarter	actual
	1. Anticipation					3
(16.)	Selling Prices	USA	73–79	semiquantitative	quarter	actual
	1. Anticipation					3
(17.)	Production	France	63–78	qualitative	quarter	actual
	1. Expectation					1 1/2
(18.)	Export Orders	France	63–78	qualitative	quarter	actual
	1. Expectation					1 1/2
(19.)	Domestic Orders	Norway	74–78	qualitative	quarter	actual
	1. Expectation					1 1/2
(20.)	Export Orders	Norway	74–78	qualitative	quarter	actual
	1. Expectation					1 1/2
(21.)	Selling Prices	Norway	74–78	qualitative	quarter	actual
	1. Expectation					1 1/2
(22.)	Orders	Finland	66–78	qualitative	quarter	actual
	1. Expectation					1 1/2

Table 1/(Continued)

Characteristics of the Data Used and Evidence on REH – Criteria

Source	Sector	Mean[2)]	Standard Deviation[2)]	A	B	C	D	E	F	G	H	I
Bank of Japan	Big Business	3,60	2,09									
	Manufacturing	3,25	1,63**									
		2,88**	1,34**	R	R	R	R	NR	R	R	R	R
Bank of Japan	Big Business	3,38	2,33									
	Manufacturing	1,91**	1,13**									
		0,90**	0,81**	R	R	R	R	NR	R	R	R	R
Bank of Japan	Big Business	3,18	2,30									
	Manufacturing	2,97	1,15**									
		2,79	0,87**	NR	NR	R	R	R	R	R	R	NR
Bank of Japan	Big Business	3,90	3,58									
	Manufacturing	2,56**	1,30**									
		1,94**	0,89**	R	R	R	R	R	R	NR	NR	R
Midwest Shippers' Board	Manufacturing	– 1,18	19,85									
		2,02	9,79**	NR	R	R	NR	–	R	R	–	–
NFIB	Small Business	8,60	3,18									
	Total Economy	2,05	0,48**	R	R	R	R	NR	R	R	–	–
OECD	Manufacturing	13,40	17,01									
		11,41	25,50**	NR	R	R	R	NR	R	R	–	–
OECD	Manufacturing	5,33	17,09									
		5,00	10,48**	NR	NR	R	R	–	R	R	–	–
OECD	Manufacturing	– 1,72	11,37									
		– 0,94	13,11	NR	NR	NR	R	NR	NR	NR	–	–
OECD	Manufacturing	– 11,50	14,79									
		– 4,56	13,04	NR	R	NR	R	NR	R	NR	–	–
OECD	Manufacturing	19,39	22,29									
		22,67	20,53	NR	NR	NR	NR	NR	NR	NR	–	–
OECD	Manufacturing	3,88	22,24									
		1,10	18,15	NR	NR	R	R	NR	NR	NR	–	–

Table 1/(Continued)

Characteristics of the Data Used and Evidence on REH – Criteria

		Region	Period	Type of Data	Lenght of Forecasting Period	Horizon[1)]
(23.)	Production	Finland	66–78	qualitative	quarter	actual
	1. Expectation					1 1/2
Consumer Surveys						
(24.)	Prices	USA	61–77	semiquantitative	quarter	actual
	1. Expectation					6 1/2
(25.)	Financial Situation	Austria	72–78	qualitative	annual	actual
	1. Expectation					6
(26.)	Prices	Austria	72–78	qualitative	annual	actual
	1. Expectation					6
Experts						
(27.)	GNP real	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(28.)	Equipment Investment	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(29.)	Plant Investment	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(30.)	Inventory Investment	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(31.)	Exports (goods)	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(32.)	Imports (goods)	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2

Table 1/(Continued)

Characteristics of the Data Used and Evidence on REH – Criteria

Source	Sector	Mean[2)]	Standard Deviation[2)]	A	B	C	D	E	F	G	H	I
OECD	Manufacturing	16,37	20,18									
		17,61	19,97	NR	R	NR	NR	NR	NR	NR	–	–
University of Michigan	Sample	4,35	2,89									
	Consumer	3,05**	0,85**	R	R	R	R	NR	R	R	–	–
IFES	Sample	– 9,16	6,33									
	Consumer	– 12,14**	6,75	R	R	NR	R	NR	R	R	–	–
IFES	Sample	46,81	26,73									
	Consumer	29,19**	29,55	R	R	NR	R	NR	R	NR	–	–
WIFO	Total Economy	4,21	2,32									
		3,65	1,22**									
		3,89	1,23**	NR	NR	R	NR	NR	NR	NR	NR	NR
WIFO	Total Economy	4,89	7,66									
		4,35	4,33**									
		4,72	4,33**	NR	NR	R	NR	NR	NR	NR	NR	NR
WIFO	Total Economy	4,28	4,84									
		4,33	2,58**									
		4,57	2,21**	NR	NR	R	NR	NR	NR	NR	NR	NR
WIFO	Total Economy	6,99	5,18									
		5,47	2,39**									
		5,57	2,66**	NR	NR	R	NR	NR	R	NR	NR	NR
WIFO	Total Economy	7,97	6,34									
		6,23	2,88**									
		6,67	2,66**	NR	NR	R	NR	NR	R	NR	NR	NR
WIFO	Total Economy	7,29	7,21									
		6,45	3,22**									
		7,22	3,39**	NR	NR	R	NR	NR	R	NR	NR	NR

Table 1/(Continued)

Characteristics of the Data Used and Evidence on REH – Criteria

		Region	Period	Type of Data	Lenght of Forecasting Period	Horizon[1)]
(33.)	Private Consumption	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(34.)	Consumer Prices	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(35.)	Unemployment Rate	Austria	64–78	quantitative	annual	actual
	2. Forecast					6 1/2
	1. Forecast					9 1/2
(36.)	GNP (real)	Austria	70–78	quantitative	annual	actual
	2. Forecast					1
	1. Forecast					7
(37.)	GNP (real)	OECD–Total	68–78	quantitative	annual	actual
	2. Forecast					1
	1. Forecast					7
(38.)	Consumer Prices	USA	47–77	quantitative	semester	actual
	2. Forecast					3 1/2
	1. Forecast					6 1/2
(39.)	Wholesale Prices	USA	47–77	quantitative	semester	actual
	2. Forecast					3 1/2
	1. Forecast					6 1/2

1) Time span between data collection and the middle of target period in months.

2) * 95 %, ** 99 % degree of significance for the rejection of the hypothesis that the mean respective the variance of expected change is greater or equal to the mean respective the variance of actual change.

A = Identity of Averages, B = Unbiassedness, C = Identity of Variances, D = Sufficiency I,

Table 1/(Continued)

Characteristics of the Data Used and Evidence on REH – Criteria

Source	Sector	Mean[2)]	Standard Deviation[2)]	A	B	C	D	E	F	G	H	I
WIFO	Total Economy	4,15	2,59									
		4,43	1,38**									
		4,77	1,33**	NR	NR	R	NR	NR	NR	NR	NR	NR
WIFO	Total Economy	5,23	2,17									
		5,28	2,14									
		4,92	2,02	NR	NR	NR	NR	NR	NR	NR	NR	NR
WIFO	Total Economy	2,23	0,52									
		2,42	0,42									
		2,43	0,44	NR	NR	NR	NR	NR	R	NR	NR	NR
OECD	Total Economy	4,29	3,02									
		3,53	1,87**									
		3,30	1,41**	NR	NR	R	NR	NR	NR	NR	NR	NR
OECD	Total Economy	3,69	2,32									
		3,74	2,33									
		3,89	1,41**	NR	NR	R	NR	NR	NR	NR	NR	NR
Livingston	Total Economy	3,44	3,52									
		1,74**	2,57**									
		1,70**	2,68**	R	R	R	R	NR	R	NR	R	NR
Livingston	Total Economy	3,25	6,32									
		1,34*	3,61**									
		1,30**	3,37**	R	R	R	R	NR	R	NR	R	NR

Testing procedure see table 2.
R = Rejected (95 %)
NR = Non rejected (95 %)

E = Sufficiency II, F = Efficiency I, G = Efficiency II, H = Consistency I, I = Consistency II.

of expectations and realizations as a desirable criterion for expectations(16). In the empirical part of this study these comparisons are presented in the chapter on "unbiassedness".

3. Empirical Results of Direct Tests

We now report on empirical tests on these criteria, partly by reference to literature, partly by testing them one by one for a sample of 39 expectational variables ("expected changes"). See table 1 for origin, horizon, character and time period of these data(17).

3.1 Identity of Means

Systematic differences of the averages of expectations respectively realizations have been know in the literature for a long time. A tendency of "secular optimism" is reported for periods of declining sales(18) respectively for periods of decelerating growth(19). Comparisons of the respective means were used as a measure of this tendency, using mostly series referring to periods of 5 to 10 years length(20). The opposite bias (underestimation bias) dominates the large bulk of investment anticipations(21) and is analyzed also referring to macroeconomic forecasts (*Theil,* 1958; *Mincer – Zarnowitz,* 1969; *Zarnowitz,* 1978).

Investigations of price expectations in the seventies were the first to relate biasses explicitly to the Rational Expectations Hypothesis. The ASA-NBER Survey (*Wachtel,* 1977) as well as *Livingstons* survey on expected price changes is biassed down-ward, the same is true with restrictions(22) for the consumer price expectations surveyed by SRC in Michigan and NFIB's Survey on Small business (see also *Chan-Lee,* 1980).

The data set available for this study was used to test for differences in the arithmetic means of expected versus actual changes ($\mu_{a_t} = \mu_{e_t}$: two tailed t-statistics). Using the 95 % (99 %) level of significance identity of averages is rejected for 15 (13) time series, in all but two cases the mean of expectations was significantly *lower* than that of realizations. Among business surveys asking for quantitative expectations this criterion is rejected for a slight majority of the available variables, the same is true for consumer expectations(23). Identity can not be rejected in the case of qualitative survey methods, nor for most of experts' forecasts. For the later type of expectations underestimation seems to prevail, though they do pass the significance test (partly because these series are too short and mainly refer to the "seventies"). Over all 39 variables the mean of expectations is lower in 29 expectational variables. A binomial test would lead one to reject the hypothesis that this is a mere chance outcome(24).

The rejection of the identity-of-averages-criterion for a considerable subset of the data leads to several modifications and objections. It remains if we exclude current realiza-

Table 2

Test Criteria for Mainstream REH

	Criteria	Hypothesis	Test Statistic
1	Identiy of Averages	$H_0 \ldots \mu_{a_t} = \mu_{e_t}$	t
2	Unbiassedness	$H_0 \ldots k = 0 \cap b = 1$ in: $a_t = k + b\, e_t$	F
2 A	(Identity of Variance)[1]	$H_0 \ldots \sigma_{a_t} = \sigma_{e_t}$	χ^2
3	Sufficiency	$H_0^1 \ldots \text{cov}\,(u_t\ u_{t-1}) = 0$ $u_t = a_t - k - b\, e_t$ $H_0^2 \ldots c = d = 0$ in: $a_t = k + b\, e_t + c\, P_{t-1} + d\, P_{t-2}$	DW F
4	Efficiency	$H_0^1 \ldots B = B'$ $B \ldots K, b_1, b_2$ $B' \ldots K', b'_1, b'_2$ in: $a_t = k + b_1\, a_{t-1} + b_2\, a_{t-2}$ $e_t = k' + b'_1\, a_{t-1} + b'_2\, a_{t-2}$ $H_0^2 \ldots R^2 = 0$ in: $a_t - e_t = k + b_1\, a_{t-1} + b_2\, a_{t-2}$	F F
6	Consistency	$H_0^1 \ldots B' = B''$ $B'' \ldots k'', b''_1, b''_2,$ $^{t-1}e_t = k'' + b''_1\ {}^{t-1}e_{t-1} + b''_2\ a_{t-2}$ [2] $H_0^2 \quad k = 0 \cap b = 1$ in: $^{t}e_t = k + b\ {}^{t-1}e_t$	F

1) Valid only in case of interdependency

2) The long run expectation is for most variables used, that expectation refering to period t, held in period $t-1$ (sometimes however held in period $t-2$) or at beginning of period $t-1$. Parallel changes occur in the short run expectation.

tions(25), or use only past information(26). It is not due to a rising trend in the realizations (at least as far as expectations refer to quantities rather than prices). This tendency does not disappear if we use different measures of central tendency (as long as the implied loss functions are symmetric; e.g. medians, see *Aiginger,* 1979). Aggregation problems may be important in some surveys, less for forecasts of institutions. The underestimation tendency, however, can be demonstrated also on the micro level (for investment anticipations see *Aiginger,* 1977B)(27).

3.2 Unbiassedness

The specific test for "unbiassedness" (restriction of the coefficients to zero resp. one) is done for US sales anticipations by *Pashigan* (he could not reject it for the majority of his variables). Using longer time series *Hirsch* and *Lovell* (1969) had to reject unbiassedness especially for durables and for the longer term anticipations. The influence of the length of the time series is evident for price expectations: *Turnovsky* (1970) has to reject unbiassedness for the period 1954 to 1964, but not for 1962 to 1969, *Wachtel* (1977) finds unbiassed expectations for periods of stability (1975 to 1961) but has to reject it for periods of rapid inflation as well as for the whole period (*Livingston* as well as SRC data). Macroforecasts were found to be biassed by *Mincer* and *Zarnowitz* (1969) in the sixties. This is confirmed under several restrictions by *Mc Nees* for the seventies (*Mc Nees,* 1978A)(28).

Testing our own standard set for unbiassedness (joint assumption that constant term is zero and regression coefficient equals unity in equation *(2),* F-test) leads to rejection for 21 (16) variables. Among the subset of quantitative business anticipations unbiassedness is rejected for 14 (11) out of 16 expectational series, all consumer surveys available are biassed.

It is not surprising that unbiassedness is rejected far more often than identity of means, since systematic differences in the variances may also lead to rejection. Differences in the respective variances of expectations and realizations may be an implication of Rational Expectations but may also be an indication against rationality. If the "one sided causality" as supposed in equation *(1)* holds true the variance of realizations must exceed that of expectations for statistical reasons. Applying *Granger*'s technique to some of the variables in our data set showed that past realizations influence expectations as well as past expectations influence realizations, thereby throwing some doubt on the assumption of one sided causality for concurrent values of these variables and restoring the possibility that differences in variance may be a refutational criterion against REH. Furthermore it can be demonstrated that the differences in the variances are contributed partly by the systematic (cyclical) rather than only by the irregular component(29) (see also autocorrelation pattern in chapter 3.3). This difference is not implied by rationality even if the covariance

assumption in equation *(1)* were satisfied. Applying a χ^2 test on our standard set, the identity of variances is rejected in 29 (26) variables, among the quantitative business anticipations in 14 (12). The smoothing property is especially significant for experts' forecasts (11 out of 13)(30).

3.3 Sufficiency

Sufficiency of investment anticipations is tested by investigations of nearly all determinants of investment itself (realization function approach, see *Aiginger,* 1977). *Carlson* (1978, 1979) finds that price expectations could have been improved if past employment had been taken into consideration, *Lovell* and *Hirsch* (1969) report past sales not to be fully considered in sales anticipations. *Brown* and *Maital* (1980) report underutilization of information – particularly data on monetary growth – for *Livingston's* data.

Autocorrelation of residuals could have been used to improve US macroeconomic forecasts (see *Mc Nees,* 1978A).

The well known Durbin Watson Statistic was used to test for one period linear autocorrelation of the residuals between expectations and realizations for our standard set. Autocorrelation seems to be present even in this restricted sense in 23 (19) variables, mainly in business forecasts (this time also in qualitative surveys) and consumer surveys. Annual reference periods lower autocorrelation for experts' forecasts.

Searching for the existence of other "omitted" information was restricted to "manufacturing production" as an internationally available proxy for cyclical influence. This can be considered only as a very rough lower boundary of testing rather than as searching for the "whole universe" of possible determinants. However we can reject sufficiency in 7 (6) variables according to this crude method (F-test).

3.4 Efficiency

Testing whether expectations and realizations follow the same (stochastic) processes is usually restricted to the question whether expectations fully reflect all information in the history of the forecast variable (tests of weak rationality). Intensive investigations concentrated on the Livingston time series, using partly original data (labelled $L - 0$) partly using these series after correction for some flaws by *Carlson* (1977A; labelled $L - C$). *Pesando* (1975) could not reject efficiency (using $L - 0$ of consumer prices, period 1959 to 1969, *Chow* test), *Carlson* rejects efficiency for consumer prices, but not for expectations concerning wholesale prices (using $L-C$, period 1959 to 1969, *Chow* test).

Table 3

Overall Empirical Results of Testing
6 Criteria of REH

	Rejected 95 % (99 %)	Not Rejected 95 % (99 %)	Examples in Literature Authors	Evidence: Rejected = R Not Rejected = NR
Identity of Averages				
All Data	15 (13)	24 (26)		
Quantitative Business	10 (9)	6 (7)		
Qualitative Business	0 (0)	7 (7)	Literature on	R in majority
Consumer Surveys	3 (3)	0 (0)	investment	
Experts	2 (1)	11 (12)	anticipations	
Unbiassedness				
All Data	21 (16)	18 (23)	*Pashigan* (US-Sales)	NR in majority
Quantitative Business	14 (11)	2 (5)	*Hirsch-Lovell* (US-Sales)	partly NR, R
Qualitative Business	2 (1)	5 (6)	*Turnovsky* (LO CPI)	R (1954 to 1964), NR (1962 to 1969)
Consumer Surveys	3 (3)	0 (0)	*Wachtel* (several price	NR (period of stability)
Experts	2 (1)	11 (12)	expectations)	R (whole period)
			Mincer, Zarnowitz	predominantly R
			Mc Nees (GNP)	
Identy of Variance				
All Data	29 (26)	10 (13)		
Quantitative Business	14 (12)	2 (4)		
Qualitative Business	3 (2)	4 (5)		heavy evidence for R
Consumer Surveys	1 (1)	2 (2)		(but not seen as
Experts	11 (11)	2 (2)		rejection of REH)
Sufficiency I (Lack of autocorrelation)				
All Data	23 (18)	16 (21)		
Quantitative Business	13 (10)	3 (6)		
Qualitative Business	5 (3)	2 (4)		
Consumer Surveys	3 (3)	0 (0)		
Experts	2 (2)	11 (11)		

Sufficiency II (other informations; spec. industrial production)						
All data	7	(6)	30	(31)		
Quantitative Business	7	(6)	8	(9)	*Carlson* (1979)	R
Qualitative Business	0	(0)	6	(6)		
Consumer Surveys	0	(0)	3	(3)		
Experts	0	(0)	13	(13)		
Efficiency I						
All Data	29	(23)	10	(16)	*Pesando* (L-O, CPI)	NR
Quantitative Business	16	(15)	0	(1)	*Carlson* (L-C)	R (CPI), NR (WPI)
Qualitative Business	3	(2)	4	(5)		
Consumer Surveys	3	(3)	0	(0)	*Pesando* (Cash Flow)	R
Experts	7	(3)	6	(10)	*Turnovsky*	R
Efficiency II						
All Data	15	(13)	24	(26)	*Mullineaux* (1978)	NR (L-C, CPI), R (L-O, CPI)
Quantitative Business	11	(10)	5	(6)		
Qualitative Business	2	(2)	5	(5)		
Consumer Surveys	2	(1)	1	(2)		
Experts	0	(0)	13	(13)		
Consistency I						
All Data	11	(9)	15	(17)	*Pesando* (L-O, CPI)	R
Quantitative Business	9	(8)	4	(5)	*Carlson* (L-C)	R (CPI), NR (WPI)
Qualitative Business	–		–			
Consumer Surveys	–		–			
Experts	2	(1)	11	(12)		
Consistency II						
All Data	11	(9)	15	(17)		
Quantitative Business	11	(9)	2	(4)		
Qualitative Business	–		–			
Consumer Surveys	–		–			
Experts	0	(0)	13	(13)		

Mullineaux (1978) questions the applicability of these statistical tests (especially since the *Chow* test assumes identical distribution in the error terms in the equations explaining expectations respectively realizations) and proposes first to form the difference between expectations and realizations and then to test whether this difference is independent of any past realization rates. He then rejects efficiency for the original consumer price expectations(31) ($L - 0$) but not for the adjusted ones ($L - C$). *Pesando* (1976) rejects efficiency of cash flow expectations of US insurance companies, *Turnovsky* (1970) reports that price and wage expectations do not follow the same extrapolative pattern as realizations.

For our standard set of variables efficiency according to the *Chow* test (using 2 values of past inflation only, incorporating a constant term in regression as well as for testing procedure) is rejected for 29 (23) variables. Rejection is again overwhelming as far as quantitative business forecasts are concerned. Statistics seem to reject also efficiency of experts' forecast, but this should not be taken seriously because time series behavior is difficult to detect on an annual basis.

Using *Mullineaux's* method leads to 15 (13) rejections of efficiency mainly for quantitative business forecasts. This time for all variables where past realizations do not predict realizations well, efficiency cannot be rejected, because a forteriori(32) they do not predict differences between expectations and realizations well.

3.5 Consistency

The testing structure for consistency (*Chow* test, problems of its applicability, weak form tests only) is pretty similar to that of efficiency. *Pesando* (1975) has to reject consistency ($L - 0$, consumer prices only), *Carlson* (1977A) rejects again consistency as far as consumer price expectations are concerned ($L - C$). *Mullineaux* (1978) using a different testing procedure again(33), cannot reject consistency for either of the consumer price expectations ($L - 0$ resp. $L - C$)(34).

For our standard set (using a *Chow* test) we can reject consistency for 11 (9) variables, mainly for business anticipations, but also for *Livingston's* price forecast.

As an alternative test (avoiding the problems associated with the *Chow* test) we regressed short term expectations on their long term equivalent. If long term expectations were unbiassed predictors of short term expectations the joint hypothesis of a zero constant and a unity regression coefficient should hold(35). Among the subset of our standard set, for which expectations referring to different horizons are available (26 series), consistency is rejected in 11 (9) cases, among the rejections we find both *Livingston* series.

This result does not surprise since mean as well as variance of short term respective long term variance are different. Out of 26 variables the mean respectively the variance of long term expectations is lower in 17 cases, respectively in 18 cases as compared to the same moments of short term expectations.

3.6 Size of Error Term

Regressing actual changes on expected changes on the average yields coefficients of determination of 0,40 (average over all variables). For the majority of the variables the unexplained part of the variance is larger than the explained part. The explained part is somewhat higher for consumer surveys (0,69) as well as for qualitative business surveys (R^2 = 0,52). The coefficients of determination are too high to falsify the assumption that there is no covariance between expectations and realizations, on the other hand they indicate that it may be profitable to search for variables improving this relationship.

3.7 Transfer Function as a Comprehensive Test of Mainstream REH

The criteria developed in chapter 2. were tested one after the other in chapter 3.1 to 3.6. The different tests are, however, not independent of each other. In part the connection between different criteria is a matter of strict logic, in part the interrelation depends on the individual testing method of the respective criteria. For example, rejection of the criterion "identity of average" strictly implies that "unbiassedness" has to be rejected too (the reverse is not true, however). It is the actual or purported direction of causality which decides which regression is the "true" one and which differences in the variances between expectations and realizations should be considered as rejecting unbiassedness. A certain type of differences in the variances (namely in their systematic component) leads to rejection of unbiassedness independently of the chosen testing prodecure.

The criteria "sufficiency", "efficiency" and "consistency" are again very closely related to each other. While the term sufficiency is usually applied to the investigation of "omitted variables", efficiency concentrates on the question whether the influence of a subset of variables is the same on expectations as on realizations. To systematically over- or underestimate the influence of the most recent realization (which would be revealed by efficiency tests) in theory means the same as disregarding a relevant influence. Empirical tests however may bring different results(36). A logical connection between efficiency and consistency lies in the fact, that if short run as well as long run expectations are efficient, they will also be consistent (*Pesando*, 1975, p. 853).

Sometimes it is a matter of the exact test whether rejection of one criterion implies the rejection of another. This is especially important in case of biasses in the respective averages

Table 4

Univariate Box Jenkins Analysis

	Model Specification						Test Criteria				
	Mean (Y = yes, N = non)	Trend (Y = yes, N = non)	Difference operator	Autoregressiv operator 1 (order)	Autoregressive operator 2 (order)	Largest residual value of *ACF*	χ^2 of residual *ACF*	Moving average operator 1 (order)	Moving average operator 2 (order)	Moving average operator 3 (order)	Largest residual value of *PACF*
Optimal model for e_t											
applied to e_t	N	Y	Y	–	–	0,11	2,1	3	4	5	0,09
applied to a_t	N	Y	Y	–	–	0,20	9,5	3	4	5	0,20
Optimal model for a_t											
applied to e_t	Y	N	N	1	3	0,22	7,2	3	4	–	0,22
applied to a_t	Y	N	N	1	3	0,16	2,9	3	4	–	0,16

a_t . . . . actual inflation USA (*CPI*),

e_t . . . . . Livingston's expected inflation,

ACF . . . . . autocorrelation function,

PACF . . . . . partial autocorrelation function.

of expectations and realizations. Sufficiency, efficiency, consistency, unbiassedness and size of error term can be tested in a way including differences in the respective means and also in a way disregarding them(37). Interrelation of the individual tests means that variables which are not regarded as "rational" according to one criterion tend to be not "rational" according to others also. So most quantitative business variables are in conflict with nearly all criteria of REH, the same is true for consumer anticipations and *Livingston* price forecasts (with some restrictions). On the other hand there are very few variables which contradict only to one criterion.

This raises the question whether there is not a comprehensive technique to test some or all of the characteristics of Rational Expectations simultaneously. Time series analysis like the Box Jenkins Technique or transfer functions can be used for this purpose.

Applying univariate techniques allows us to study the time series characteristics of expectations and of realizations separately. REH implies that both series should follow the same stochastic process, since any difference would also infer a significant behavior in the error term between expectations and realizations. An investigation of a small subset of the variables (see table 4) in the standard sample shows that this implication of REH is not complied with: As far as *Livingston's* consumer expectations are concerned they exhibit rather strong trend elements and follow a moving average procedure (3^{rd}, 4^{th} and 5^{th} order)(38).

Realizations however (actual change in consumer prices) are far less influenced by trend terms (no differencing necessary, no trend term significant), they seem to follow an autoregressive process of first and third order; moving average processes add little to the explanation but pass the significant test only barely(39).

Transfer function models directly relate realizations and expectations. A testable implication of REH is that the noise model (second term on the right of equation *(3)*) should prove insignificant, since any systematic difference between expectations and realizations should be exploited for the formation of expectations. However with all variables which we tested(40), at least one term of the noise model proved significant (see table 5).

These time series tests are comprehensive tests insofar as they test aspects of efficiency, unbiassedness and sufficiency at the same time. Analyzing the significance of the error term may even be interpreted as assessing the probability that other factors than the subset of past information are omitted in the formation of expectations (strong rationality).

However we should keep in our mind that estimating such models contains a considerable degree of discretion(41) for the researcher, so that the presented results may be due to erroneous specification of the models.

Model

$$(3) \qquad a_t = k + \frac{\prod_{1}^{I0} \omega_i(B)}{\prod_{1}^{00} \nu_i(B)} B^b e_t + \frac{\prod_{1}^{MA} \theta_i(B)}{\prod_{1}^{AR} \phi(B)} u_t$$

a_t ..... realizations

e_t ..... expectations

u_t ..... noise

I0, 00, MA, AR respectively ω, ν, θ, ϕ, ... number respectively arguments of Inputlag-, Outputlag-, Moving Average-, Autoregressive Operators.

4. Concluding Evaluation of the Results

The empirical evidence gathered in this paper is not favorable to the mainstream version of Rational Expectations. This may be due to errors in measurement of expectations. Measurement problems undoubtedly arise when collecting expectations, anticipations and forecasts. We tried to reduce their overall responsibility for the poor evidence for mainstream REH demonstrating the reasonable performance of expectations and anticipations in explaining economic performance (consumption, investment, etc.).

To confront realizations with expectations is only one approach to test rationality. The indirect tests employing not surveyed expectations, but rather tests of the implications of rationality represent an alternative. Another way would be to specify the "information" used by rational agents and by this means to construct "Rational Expectations" and then to compare these "Rational Expectations" to measured expectations. For this procedure see for example *Pearce* (1979). It requires an individual specification for each variable (as opposed to our "overall" test for different variables in different countries). In case of refutation the question arises if this is due to the specification or to "irrationality" of the expectations. The comparison of expectations and realizations as performed in this paper can be interpreted as using a specific information set itself, namely (with few exceptions) the history of the variable to be forecast. The rationale for this small subset of information actually available is that at least this information set should be used exhaustively. It seems probable that a wider assumption about available information will strengthen the results, as well as a specific definition for different variables will enrich the picture, which information pieces are underutilized and why.

"Rationality is an assumption, that can be modified" (*Muth,* 1961, p. 330). Among the characteristics of mainstream REH developed and tested above, serial independence of

Table 5

Estimation of Transfer Functions

Summary of Model 1 — 60 Observations

Data: Y = Consumer Prices USA (Actual)
X = Livingston Expectations

Differencing on $Y - 1$ of Order 1 — Differencing on $X - 1$ of Order 1

Noise Model Parameters

Parameter Number	Parameter Type	Parameter Order	Estimated Value	95 per cent Lower Limit	95 per cent Upper Limit
1	Autoregressive 1	1	− 0,37193 + 00	− 0,64968 + 00	− 0,94006 − 01
2	Moving Average 1	3	0,38733 + 00	0,10502 + 00	0,66963 + 00
3	Moving Average 1	4	0,38974 + 00	0,12206 + 00	0,65742 + 00

Transfer Function Parameters

4	Output Lag 1	1	− 0,24602 + 00	− 0,93787 + 00	0,44583 + 00
5	Input Lag 1	3	− 0,23622 + 00	− 0,79054 + 00	0,31810 + 00
6	Input Lag 2	4	0,11377 + 00	− 0,41740 + 00	0,64494 + 00

Optimum Value of B is 1

Autocorrelation function — 50 Observations

Original Series: Mean of the Series = 0,21139 + 00 St.Dev. of Series = 0,14973 + 01 Number of Observations = 50

1–12	− 0,04	− 0,11	− 0,01	− 0,05	− 0,26	− 0,03	− 0,06	0,10	0,02	0,06	− 0,09	0,07
ST.E.	0,14	0,14	0,14	0,14	0,14	0,15	0,15	0,15	0,15	0,15	0,16	0,16
13–20	− 0,01	− 0,06	− 0,23	0,28	0,08	− 0,15	0,05	0,04				
ST.E.	0,16	0,16	0,16	0,16	0,17	0,17	0,18	0,18				

Mean Divided by St. Error = 0,99830 + 01 — *CHI*-square = 5,0428 (7 degrees of freedom)

Table 5/(Continued)

Estimation of Transfer Functions

Summary of Model 2 — 60 Observations

Data: Y = Wholesale Prices USA (Actual)
X = Livingston Expectations

Differencing on $Y - 1$ of Order 1 — Differencing on $X - 1$ of Order 1

Noise Model Parameters

Parameter Number	Parameter Type	Parameter Order	Estimated Value	95 per cent Lower Limit	95 per cent Upper Limit
1	Autoregressive 1	1	− 0,84763 + 00	− 0,11800 + 01	− 0,51526+00
2	Autoregressive 2	4	− 0,47410 + 00	− 0,97195 + 00	0,23753 - 01
3	Moving Average 1	1	− 0,43467 + 00	− 0,94367 + 00	0,74339 - 01
4	Moving Average 2	2	0,54333 + 00	0,12983 + 00	0,95683+00
5	Moving Average 3	4	0,77439 - 01	− 0,61039 + 00	0,76527+00
Transfer Function Parameters					
6	Output Lag 1	1	0,30607 + 00	− 0,31042 + 01	0,37163+01
7	Input Lag 1	1	0,44543 + 00	− 0,19626 + 01	0,28534+01
8	Input Lag 2	2	− 0,48610 + 00	− 0,23734 + 01	0,14011+01
9	Input Lag 3	4	0,94414 + 00	− 0,45458 + 00	0,23429+01

Optimum Value of B is 2

Autocorrelation function — 45 Observations

Original Series: Mean of the Series = 0,46235 + 00 St.Dev. of Series = 0,43007 + 01 Number of Observations = 45

1–12	− 0,02	0,06	0,05	− 0,07	0,12	− 0,32	− 0,17	0,09	0,01	− 0,04	− 0,07	− 0,02
ST.E.	0,15	0,15	0,15	0,15	0,15	0,15	0,17	0,17	0,17	0,17	0,17	0,17
13–20	0,14	− 0,09	− 0,06	0,06	0,11	− 0,04	− 0,00	− 0,01				
ST.E.	0,17	0,18	0,18	0,18	0,18	0,18	0,18	0,18				

Mean Divided by St. Error = 0,72117 + 00 — *CHI*-square = 7,6502 (5 degrees of freedom)

Table 5/(Continued)

Estimation of Transfer Functions

Summary of Model 3 — 58 Observations

Data: Y = Actual Sales USA
X = Expected Sales USA

Differencing on $Y - 1$ of Order 1 — Differencing on $X - 1$ of Order 1

Noise Model Parameters

Parameter Number	Parameter Type	Parameter Order	Estimated Value	95 per cent Lower Limit	95 per cent Upper Limit
1	Autoregressive 1	1	− 0,73408 + 00	− 0,14090 + 01	− 0,59115 - 01
2	Autoregressive 2	2	− 0,63491 + 00	− 0,15454 + 01	0,27560+ 00
3	Moving Average 1	1	− 0,97310 - 01	− 0,71675 + 00	0,52213+ 00
4	Moving Average 2	2	− 0,37077 + 00	− 0,15021 + 01	0,76056+ 00
Transfer Function Parameters					
5	Output Lag 1	1	− 0,10761 + 01	− 0,11368 + 01	− 0,10154+ 01
6	Output Lag 2	2	− 0,53582 + 00	− 0,13601 + 01	0,28844+ 00
7	Input Lag 1	1	− 0,59320 + 00	− 0,11274 + 01	− 0,59015 - 01
8	Input Lag 2	2	− 0,92563 + 00	− 0,15915 + 01	− 0,25974+ 00

Optimum Value of B is 1

Autocorrelation function — 50 Observations

Original Series: Mean of the Series = − 0,12908 + 00 St.Dev. of Series = 0,28867 + 01 Number of Observations = 50

1–12	− 0,01	0,06	0,05	0,12	− 0,10	− 0,14	− 0,02	− 0,29	− 0,11	− 0,12	− 0,11	− 0,13
ST.E.	0,14	0,14	0,14	0,14	0,14	0,15	0,15	0,15	0,16	0,16	0,16	0,16
13–20	0,07	0,01	0,11	− 0,06	0,24	− 0,01	0,07	0,10				
ST.E.	0,17	0,17	0,17	0,17	0,17	0,18	0,18	0,18				

Mean Divided by St. Error = 0,31619 + 00 *CHI*-square = 8,1216 (6 degrees of freedom)

Table 5/(End)

Estimation of Transfer Functions

Summary of Model 4 — 186 Observations

Data: Y = Actual Production France

X = Expected Production France

Differencing on $Y - 1$ of Order 1 — Differencing on $X - 1$ of Order 1

Noise Model Parameters

Parameter Number	Parameter Type	Parameter Order	Estimated Value	95 per cent Lower Limit	95 per cent Upper Limit
1	Autoregressive 1	1	− 0,44694 + 00	− 0,77101 + 00	− 0,12286+00
2	Autoregressive 2	4	− 0,34436 - 01	− 0,22827 + 00	0,15939+00
3	Moving Average 1	2	0,28710 + 00	− 0,31011 - 01	0,60520+00
4	Moving Average 2	3	− 0,13309 - 01	− 0,30709 + 00	0,28047+00

Transfer Function Parameters

5	Output Lag 1	1	− 0,36968 + 00	− 0,68234 + 00	− 0,56941 - 01
6	Input Lag 1	2	− 0,53939 - 01	− 0,36785 + 00	0,25998+00
7	Input Lag 2	3	− 0,11336 + 00	− 0,41889 + 00	0,19218+00

Optimum Value of B is 1

Autocorrelation function — 174 Observations

Original Series: Mean of the Series = − 0,24499 + 00 St.Dev. of Series = 0,97449 + 00 Number of Observations = 174

1–12	0,00	0,00	− 0,00	0,01	0,03	− 0,09	− 0,02	0,13	− 0,15	− 0,02	− 0,03	0,10
ST.E.	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08
13–20	− 0,11	− 0,25	− 0,07	− 0,05	0,01	− 0,18	− 0,02	0,08				
ST.E.	0,08	0,08	0,09	0,09	0,09	0,09	0,09	0,09				

Mean Divided by St. Error = 0,33163 + 00 — *CHI*-square = 8,4333 (6 degrees of freedom)

error terms is abandoned most frequently in recent literature. Autocorrelation of errors is rationalized by costs of information (*Darby,* 1976; *Shiller,* 1978) or due to physical limits of economic agents (*Simon,* 1978A; *Wachtel,* 1977).

Friedman (1979) shows that after incorporation of learning procedures mathematically optimal expectations have serially correlated error terms. *Brunner, Cukierman* and *Meltzer* (1979) show that only times reveal if shocks are permanent or transitory. Allowing for serial correlation of errors changes other criteria to some degree: past realizations as well as "other variables" now must not be incorporated to their full extent and with the same weight any more, the regression coefficients in testing of biassedness and consistency may be changed. As far as the significant difference between expectations and realizations on average is concerned, we must refer to other explanatory hypotheses (e.g. asymmetric loss function as applied in *Aiginger,* 1979). These modifications of mainstream REH can be easily accomodated within the broader "principle" of rationality in the sense of using all information in an optimal way. The principle itself however escapes refutability. Only a specific specification of the information set is refutable. This method was attempted in this paper for the small subset of past realizations.

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6. Notes

(1) *Carlson* (1977B) shows empirically (using *Livingston's* inflation expectations survey) that the expected real rate is actually not constant as well as that the market does not fully use past employment as information. *Fama* (1977) replies that problems in measured inflation may be responsible for autocorrelation and multicollinearity between interest rates and employment for the second contradiction to REH.

(2) *Sargent* (1973) cannot reject this joint hypothesis for a small set of possible determinants, however for a larger one, in another paper by *Sargents* (1976) rejection depends on the statistical technique used (*Sims* versus *Grangers* technique of discovering causality).

(3) *Carlson* (1977A, B) as well as the above mentioned findings by *Sargent* for the larger set of possible determinants; see also *Mc Nees* (1978), *Shiller* (1979).

(4) See *Poole* (1976, p. 467) ". . . no serious departure from the predictions of the hypothesis has been found. Thus there is very strong evidence in favor of the hypothesis"; *Sargent* (1976, p. 233) ". . . all in all, the empirical results provide some evidence that the causal structure imposed on the data . . . is not obscenely at variance with the data"; *Shiller* (1978, p. 21) ". . . the general impression one gets from this literature is that the assumption . . . is often borne out better than one would have expected".

(5) For an overview about available data see *Bonhoeffer – Strigel* (1976), *Ciret Information Letter* (1978), *Aiginger* (1977).

(6) *Mills'* specific suspicion that sales forecasts may be goals "to stimulate personell to better performance" may not be valid against the evidence that anticipations systematically underestimate performance, there may be other causes for biassing e.g. as *Löwe* and *Show* (1978) report that managers are paid according to the difference between the expected and the actual sales. *Hirsch* and *Lovell* (1969) discuss possible differences between the expectations of "controllers, treasurers and assistants" (which are presumed to answer the questionnaire) and the production planning or selling department, *Pyle* (1972) sees no guarantee that the reported expectations are those "held by individuals who transacted in the bond market". *Lahiri* (1976) wants to adjust reported expectations at least for their main biasses (regressing reported expectations on the unknown "true" expectations), *Shiller* (1978) seems to be less sceptical a priori, but is confronted with the problem that expectations are available only a short period ahead, so that for purposes of macro models, they have to be forecasted themselves.

(7) Other criteria for the importance of surveyed expectations may be an investigation by *Foss* showing that seven out of eight respondents answered that sales expectations play an important part in companies production and purchasing policies or that firms are ready to pay for the knowledge of other firms anticipations (see IFO-Institute in Munich or WIFO in Vienna for Business Tests).

(8) For an overview on forecasting with the help of investment anticipations see *Aiginger* (1977).

(9) See f.e. *Bossons – Modigliani* (1966, p. 349), *Turnovsky* (1970, p. 1.445), see also *Poole* (1976, p. 465): "One need only apply a very weak form of the rational expectations hypothesis to infer that inflation cannot be under- or overestimated year after year".

(10) Unbiassedness is implied also in equation *(1)* (absence of a constant term), see also *Turnovsky* (1970), *Pashigan* (1964), *Mc Nees* (1978A), *Hirsch – Lovell* (1969), in explicit reference to this criterion as feature of rational expectations.

(11) *Poole* (1976, p. 465); see also *Bossons – Modigliani* (1966), *Carlson* (1977A), *Shiller* (1978), *Mc Nees* and others. A forteriori systematic differences in the respective averages of expectations and realizations contradict sufficiency (see criterion 1). Thus they can be seen as special cases of sufficiency. However the sufficiency tests are designed to search for covariance of errors in successive periods or in relation to some determining variable and not for the same size of the error term in all periods.

(12) *Mc Nees* (1978B) e.g. considers *Okun*'s Law as an "obvious relationship between unemployment and growth" and restricts his test to this relationship.

(13) See *Pesando* (1975, 1976), *Carlson* (1977A), *Turnovsky* (1977), *Mullineaux* (1978).

(14) This is *Wald*'s "chain principle of forecasting", it is stated in context to REH by *Pesando* (1975), *Carlson* (1977A), and *Mullineaux* (1978).

(15) *Mc Nees* (1978A): "However larger differences between expectations and realizations may also be an indicator that reported expectations are not reliable".

(16) As long as realizations can be considered as the sum of expectations and errors (while these are independent of each other) it is rational that the variance of realizations is larger than that of the expectations. In case of interdependency this mechanically implication is no longer valid.

(17) Unless stated otherwise in the case of availability of expectations referring to different horizons the longer term expectations were chosen ($_{t+1}e_t$ instead of $_{t}e_t$ for most data; $_{t+2}e_t$ instead of $_{t+1}e_t$ in some other cases).

(18) *Ferber* (1960) reports it for Shippers' sales anticipations between the wars and to a lesser extent after the second war, *Modigliani* and *Sauerländer* (1955) report the same tendency for Fortune's sales expectations.

(19) See also *Streissler* and *Hoschka* (1964) referring to production plans in Austrian Business Test in a period of stabilization after the growth in the reconstruction phase after World War II.

(20) *Carlson* (1967) uses a longer sales anticipations series (OBE) but restricts his test (in tradition of *Foss*, 1961) to the comparison of errors in peaks versus troughs.

(21) With the exception of surveys dominated by large firms. For an overview investment anticipations see *Aiginger* (1977).

(22) For SRC Data see *Juster* and *Wachtel* (1972B, p. 768). The survey method was changed several times, so that construction of a time series can be done in several ways. *Juster* and *Wachtel* (1963) as well as *Juster* (1979) meritouriously invested much effort into this problem. The last unrevised series was used in this study however. As far as NFIB's data are concerned there exists the well known problem of confusing one period versus annual changes.

(23) We did not analyze this tendency for different variables (e.g. quantity versus prices) because the methods of surveying these variable in different surveys and countries are very different.

(24) The significance of this test may be limited by the fact that the variables are not strictly independent of each other.

(25) In this case the averages of e_t versus those of a_{t-1} are compared.

(26) The realizations of the "seventies" were not known in the "sixties". However as long as volumes are considered, this widens the differences.

(27) It is difficult to argue whether the underestimation tendency is given only "on average" or even "in equilibrium". Apart from the possible definition of equilibrium as identity of expectation and realization, which eliminates the problem, it is hard to define equilibrium empirically. It can be demonstrated that expectations catch up only very slowly even for a period of constant growth rates of industrial production in Japan (contrary to REH's assumption). Furthermore identity of expectation and realization "in equilibrium" is consistent with different averages in the long term only if the economy deviates from equilibrium in an asymmetric way.

(28) *Mc Nees* investigates unbiassedness of three US forecasting institutions for different variables and time horizons, partly using OLS partly GLS techniques. In general he tends to see unbiassedness to be rejected.

(29) The importance of this argument is stressed by *Eckstein* and *Warburg* (1978).

(30) Another objection against the test of unbiassedness by the means of OLS arises in case of forecasts for several periods ahead. In these cases forecast errors will be serially correlated (without contradiction to the rationality notion), the estimated covariance matrix is inconsistent even if the regression coefficients will be consistent (*Brown – Maital,* 1980).

(31) He does not test wholesaleprice expectations.

(32) Strictly speaking in this case the precondition of the test, namely that realizations follow an autoregressive pattern, is not fulfilled. Statistically this tends to bias the first test against, the second in favor of efficiency.

(33) The difference between long term and short term expectations depends on last period's error (*Meiselman*'s error learning model), but on no other past realization. The regression coefficient should be equal to that of the most recent past realization alone. The joint hypothesis of this equality and the restriction that there is no influence from more distant past realizations is now tested.

(34) *Pesando* (1976) cannot reject consistency as far as cash flow expectations are concerned.

(35) This test is completely analogous to the relation between realizations and expectations purported by REH (see equation *(1)*).

(36) See for example the variable US sales expectations, where the errors are correlated, but efficiency cannot be rejected. Especially if actual data do not follow autoregressive processes efficiency will be difficult to reject. This does not imply that sufficiency has to be fullfilled.

(37) Tests based on coefficients of determination as well as Durbin Watson Tests disregard differences in the constant term. Testing individual regression coefficients may be constructed either excluding or including tests for the constant term. Testing in this study included the constant term for "unbiassedness", the first test of efficiency, either tests of consistency, but not as far as sufficiency, size of error term and the second efficiency test was concerned. To be able to check the influence of the constant term on efficiency we repeated the first test of efficiency (which included the influence of different constant terms) disregarding this influence. The results changed for a few variables, but the overall picture did not change.

(38) The "optimality" of this structure is checked by the minimum of the autocorrelation function (χ^2 = 2,13) and minimizing the partial autocorrelation coefficients (largest one + 0,09).

(39) The "optimal" process yields a maximum autocorrelation coefficient for noise of 2,9, the highest partial autocorrelation coefficient is 0,16.

Forcing expectations to follow the process proven optimal for realizations, respectively forcing realizations to follow the process proven optimal for expectations increases the autocorrelation of the residuals (χ^2 = 7,2 respectively 9,5 instead of 2,1 and 2,9).

(40) The transfer functions shown in the tables contain insignificant coefficients. The purpose is that we want to demonstrate that even a large effort did fail to capture the significant relationship between realizations and expectations in the transfer model. If we restrict to significant coefficients in the transfer model, the significance of the noise model is even more evident. However we should take in mind that the published criteria for significance are not strictly valid because of the mentioned strategy.

(41) This remains true despite all the test criteria provided by modern computer programms. The tests used in this chapter follow closely the studies of *Ledolter, Schebeck* and *Thury* (1977) and *Thury* (1980A) who made the programs and techniques available to the author.