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The importance of time series extrapolation for macroeconomic expectations[1]

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Abstract

This paper presents a simple experiment on how laypeople form macroeconomic expectations. Subjects have to forecast inflation and GDP growth. By varying the information provided in different treatments, we can assess the importance of historical time-series information versus information acquired outside the experimental setting such as knowledge of expert forecasts. It turns out that the availability of historical data has a dominant impact on expectations and wipes out the influence of outside-lab information completely. Consequently, backward-looking behavior can be identified unambiguously as a decisive factor in expectation formation.

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1 Introduction

How do laypeople form expectations about macroeconomic variables? In theory there is no dispute that rational expectations is the most compelling model for the formation of economic expectations. Numerous econometric and experimental studies (e.g. Pyle 1972, Cargill 1976, Wallis 1980, Baillie et al. 1983, Turnovski and Wachter 1972, McNees 1978, Friedman 1980, Zarnowitz 1985, Thomas 1999, Mankiw et al. 2003, Souleles 2004, Schmalensee 1976, Dwyer et al. 1993, Hey 1994, see also related experiments of Hommes et al. 2005, 2008, Bernasconi et al. forthcoming, Adam 2007) tested the Rational Expectations Hypothesis (REH). In most cases, the evidence obtained in these papers does not support rational expectations.

Given the strong theoretical assumption underlying the REH, it is not really surprising that the available evidence does not support rational expectations. It is central to the REH that theoretical models of the economy are part of the information set on which people base their expectations. In macroeconomic theory it is typically assumed that all agents in the model economy share the same knowledge about the model and form model-consistent expectations. In practice, however, even economists disagree about the right economic model so that laypeople's expectations may be formed using a multitude of models, of which many may even be very different from the standard models of experts.

Laypeople have different strategies available when they have to form expectations about macroeconomic variables such as GDP or the rate of inflation. First, people may simply guess if they know little about the economy

and the costs of acquiring information outweigh the benefits of good expectations. Second, people can adopt the expectations of experts published in the news media, as proposed by Carroll (2003). Third, they might behave like intuitive econometricians that try to identify trends or patterns in past data and extrapolate them into the future. Fourth, they can use their own subjective mental models of the economy and combine them with recalled information.

Instead of providing another test of rational expectations, the goal of the present study is to investigate how people who are not economic experts form macroeconomic expectations. In particular, we are interested in the effect of time-series information provided in charts as this is a very common way to present historical data about the macroeconomy in the news media.

Recently, researchers in the field of finance have reported that agents seem to use simple intuitive methods to extrapolate time-series (see De Bondt, 1993, Barberis et al., 1998, and Bloomfield and Hales 2002). Building on that work, Rötheli (1998, 2007, forthcoming) proposes a model in which agents use visual pattern recognition in time-series charts to form expectations. His experimental work documents that subjects rely on very simple visual patterns such as runs and zigzags when forming expectations. This kind of work is very informative and may be especially relevant for financial variables like a stock price or an exchange rate. For short forecast horizons, simple forecasts like the no-change forecast or a trend extrapolation may be the best prediction possible given the near-random-walk behavior of these variables.

For macroeconomic variables such as GDP or the rate of inflation, forecasting based on univariate time-series does not seem to be optimal (see Forni

et al. 2003). Several empirical studies show that research institutes generally produce better GDP and inflation forecasts than naive models that extrapolate past patterns in univariate time series (Öller and Barot 2000, ZEW 2002, Dovern 2006, Heilemann and Stekler 2010). This evidence suggests that there exists information that is not contained in the time series of GDP and inflation, but helps to predict these variables. In addition, economic experts in research institutes have access to this information and know how to use it in order to produce forecasts that beat naive univariate time-series forecasts.

For this reason it is probably a sensible idea for laypeople to use the published forecast of economic experts when asked to predict GDP or the rate of inflation. However, people may not recall this information all the time or have little trust in the the predictive skills of economists. Alternatively, they may use other information that they have available and apply their subjective model of the economy to generate predictions themselves.

We want to disentagle the various possible ways in which laypeople predict GDP and the rate of inflation. Using an experiment, we can control some of the information available to subjects which is not possible with field data. We asked students to predict future values of the inflation rate and of GDP growth in Germany. By controlling the information available to them when making their predictions in different treatments, we can assess the importance of past time-series information versus the information they acquired outside the experimental setting. Our method is, thus, different to previous approaches and aims at isolating the effects of unobservable knowledge and beliefs that subjects use to make predicitions in addition to any informa-

tion provided to them by experimenters or interviewers. The usual way to control for those effects in experimental settings is to create artificial data so that subjects cannot reasonably expect information from outside to be helpful. While this approach is useful to eliminate real-world information as a confounding factors it does not allow to assess its importance. It is exactly our aim to analyze the effect of such unobservable outside information and beliefs.

2 Experimental design and procedure

We conducted an in-class survey experiment with three treatment groups that differed in the amount of information they received. One group of participants was shown time-series charts of the German inflation rate and the rate of GDP growth over the last 60 periods (months and quarters respectively). The subjects in this full-information group (FI) were asked to predict the rate of inflation in April and May 2008 and the rate of GDP growth in the first and second quarter of 2008. Notice that the time series of inflation has a very strong trend in the last 15 periods, while the time series of GDP growth appears stationary. The trend is very salient in the inflation chart and might induce participants to use the chart more than in the case of the GDP growth prediction.

The second group (TS for time series) received the same charts, but *without information about the depicted variables and the calendar time*. The time series were labelled variable X and variable Y and the units on the time axis ran from 1 to 60. In this group, we asked for predictions for time 61 and 62.

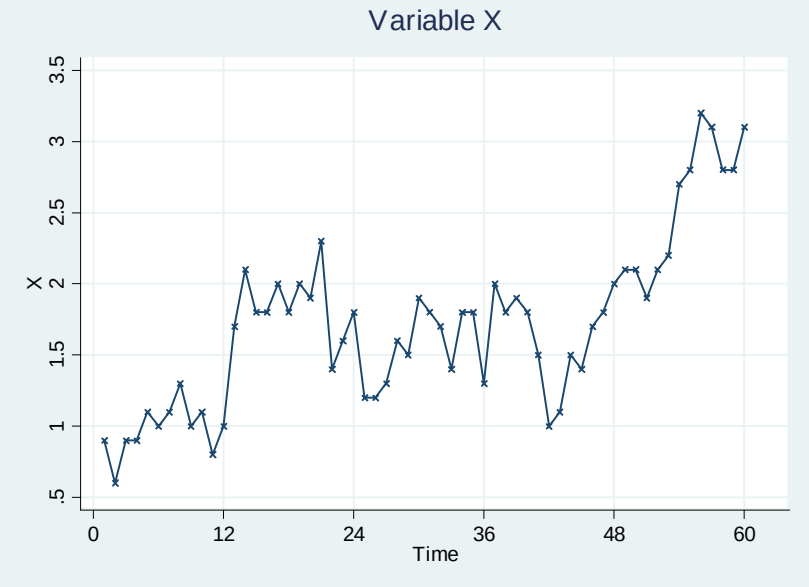

Figure 1: Time-series chart of the rate of inflation in the TS group.

The time series are depicted in Figure 1 and Figure 2.

The subjects in the third group (NI for no information) received no information at all and were asked to predict the rate of inflation in April and May 2008 and the rate of GDP growth in the first and second quarter of 2008. The wording of the questions was identical to the wording in group FI.

The idea of this design is to control the information that subjects use to make their predictions. In group NI, subjects have only their private information about inflation and GDP growth, which is not directly observable. In group TS, this information is not relevant, because subjects cannot link it to the time-series shown to them. Basically, TS subjects are forced to do some kind of visual time-series analysis and prediction, as they have no additional information on the variables. In principle, the time series could represent any variables or even artificially created data. The FI group is our focus

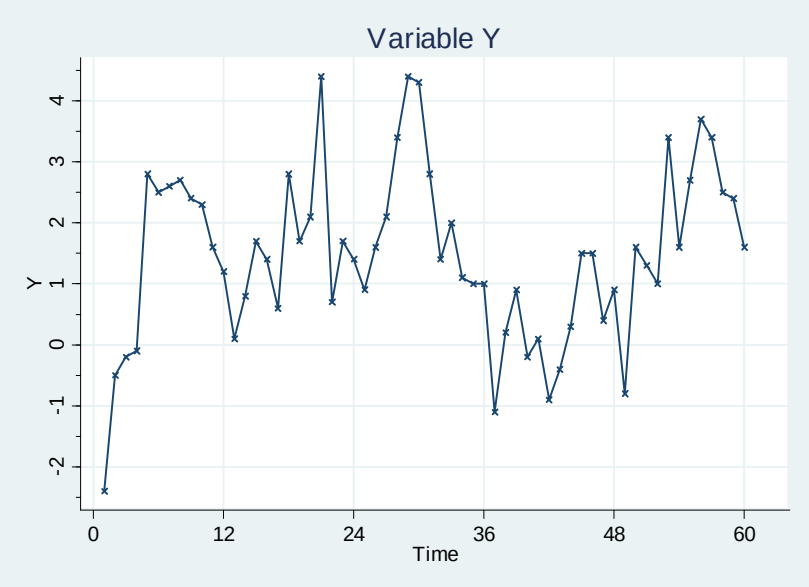

Figure 2: Time-series chart of the rate of GDP growth in the TS group.

group, because these subjects can use both their private information and the information provided by us. By comparing their predictions with predictions from the other groups, we can analyze which information is most important to them. If they only perform some kind of visual time-series analysis or pattern recognition, their predictions should be equal to those in group TS. If they ignore the provided chart and completely rely on their private information, their predictions will equal the NI predictions. Finally, if FI subjects use all information, their predictions will lie between the predictions of the two other groups.

There are at least two ways in which subjects might use the knowledge of the calender time and the variables and their private information about the economy to make inflation and GDP growth predictions. First, they might remember expert predictions and either adopt them or combine them

with the available time-series information. This is in the spirit of Carroll (2003), who develops and tests a model in which households update their own expectations by using expert expectations published in the news. Second, subjects might have their own conceptions of which factors drive the variables of interest and use those mental models to transform known data into predictions about the future. In order to analyze these possibilities, we also asked subjects in groups FI and NI to provide estimates of expert expectations for inflation and GDP growth and some variables that might be important in laypeoples subjective mental models of the economy.

A very accurate expert prediction of the monthly rate of inflation in Germany is the preliminary estimate of the German Federal Statistical Office. At the end of every month, the German Federal Statistical Office releases a preliminary estimate of inflation rate for the current month which is based on the final results of six states. Those six states comprise the three largest states and account for about 60 percent of the German population. The preliminary estimates are reported in many radio and TV news broadcasts. Final results are released about two weeks later and often do not differ much from the preliminary estimates. According to the German Federal Statistical Office the maximal deviation of the estimate from the final results in the recent years was 0.1 percentage points and the average absolute deviation is 0.03 percentage points (Statistisches Bundesamt 2002). We ran the experiment on 6 May 2008 and the preliminary inflation estimate was released on 28 April so that it is quite likely that some subjects recalled this figure.

It is a bit more difficult to find an expert prediction GDP growth with a similar degree of news coverage. A prediction that is widely discussed in

the news media is contained in the *Joint Diagnosis* (*Gemeinschaftsdiagnose*) of the leading German economic research institutes. Every fall and spring, a consortium of German economic research institutes publishes a report on economic conditions which contains a prediction of GDP growth for the current year[1]. In 2008 this prediction was made public about three week before our experiment on 17 April.

How laypeople's subjective mental models of the economy look like and which variables they contain is hard to know. A plausible conjecture is that many people believe that the oil price and the euro-dollar nominal exchange rate influence both GDP growth and inflation. Both variables are often mentioned in the news so that they are relatively salient. On 5 May 2008, for example, in was reported in the news (e.g. Spiegel online) that the oil price had reached a new record high and that this was a reason for soaring fuel prices. We argue that it is not unreasonable for laypeople to believe that these variables affect output and inflation since they receive so much attention in the news. Furthermore, economists also believe that both variables at least potentially affect GDP growth and inflation (see Goldberg and Campa 2010, Kilian 2008, Schmidt and Zimmermann 2007) For Germany, the Council of Economic Advisors estimates that an increase in the real euro price of oil by 10 percent reduces output growth by 0.1 percentage points per year and increase the rate of inflation roughly by the same magnitude (SVR 2006/7.p 85). Using VAR models, the Council of Economics Advisors also estimates a significantly negative effect of an appreciation of the euro against the dollar

[1] Although the expert prediction is a prediction for the whole year and we asked for predictions of two quarters, the expert's prediction is probably a good informed guess.

on output (SVR 2004/5, p. 794-805). Finally, high oil prices and the euro appreciation were discussed as a reason for slowed GDP growth and rising inflation in the Joint Diagnosis of spring 2008 (GD 2008, ch. 3).

We hence asked subjects about their estimates of the percentage changes of the oil price and the nominal exchange rate of the Euro in terms of US$ over the last year. Even if subjects do not know the correct figures, we should expect correlations between the variables to be predicted and those developments, if subjects share the economists' belief that the price of oil and the exchange rate affect output and prices. In addition, we also asked subjects to explain briefly how they formed their expectations and about how often they watched news on TV and how often they read a newspaper. As a check of whether they report their exposure to media truthfully, we asked them to estimate the current unemployment rate in Germany. However, we did not find any influence of exposure to the media.

The previous discussion can be summarized in the following hypotheses:

H1 If subjects' expectations about GDP growth and inflation are formed ignoring the information in the charts, predictions in group FI will be equal to those in group NI, but different from those in group TS.

H2 If subjects' expectations are formed only with the time-series information in the charts, predictions in group FI will be equal to those in group TS, but different from those in group NI.

H3 If subjects' expectations are formed only with the time-series information in the charts, they are not correlated with any other variables.

One might argue that our design induces the use of time-series data in the FI treatment due to an experimenter effect (Rosenthal 1966). While this effect may work against a rejection of Hypothesis 2, it is rather unlikely to wipe out any correlation with other variables as tested in Hypothesis 3.

The experiment was conducted with undergraduate students of economics at the University of Kiel. At the beginning of a lecture, the students were randomly assigned to the three groups and brought to three different lecture theaters. There were 81 participants in the full information group FI, 79 in the no information group NI, and 96 in the time series group. The participants received one sheet of paper with the provided information and the questions to be answered[2]. Instructions were projected on screens and read aloud. In each group the were two subgroups in which the order of the requested predictions was reversed. Using Kolmorov-Smirnov tests we could not find any order effects. The predictions were incentivized. We decided to use a very simple scheme and announced to pay €50 for the best predictions for each of the four values (inflation and GDP two periods ahead) in each group, yielding a total payoff of €600. We are aware of the fact that our payoff-scheme may induce subjects to report more extreme predictions. But if we assume that subjects' predictions are drawn from symmetric distributions, potential individual biases cancel out in the aggregate on which we focus in our analysis. Even if there were a bias in the aggregate predictions, possible distortions can be expected to be similar across treatments. Since we are not interested in the quality of the predictions but only in the differences

[2]English translations of the survey sheets and the instructions are available upon request from the authors.

between the single treatments we preferred our simple scheme.

3 Results

3.1 Distributions of predictions

Hypotheses 1 and 2 can be tested by comparing the distributions of the predictions across the three groups. We use F-tests to test for the equality of variances of the predictions, nonparametric K-sample tests on the equality of medians, and Kolmogorov-Smirnov tests on the equality of distributions. Tables 1 and 2 contain the results[3].

The predictions of the inflation rates clearly differ between the group without information and the full information group. Median predictions in groups FI and TS, however, are equal, as are the distributions. Not surprisingly, the standard deviation of the predictions is highest in the group without information and lowest in the TS group. These findings strongly reject Hypothesis 1 and support Hypothesis 2. The participants in the full information group make the same inflation predictions as those in the time series group. The information which variable is represented in the graph was not used. Inflation expectations in group FI are backward-looking in the sense that they are based on the historic information contained in the time-series only.

The findings for the growth rate of GDP confirm the previous results. Again, the information about the variable and the time in the chart is not

[3]The actual realization were: growth rate of GDP 1.8% in 2008:Q1 and 1.7% in 2008:Q2 and rate of inflation 2.4% in April 2008 and 3.0% in May 2008.

Table 1: Inflation predictions

	1 month			2 months		
Group	σ	m	KS	σ	m	KS
NI	1.44	2.6		1.36	2.65	
FI	.77	3.2		.83	3.1	
TS	.41	3.2		.45	3.04	
p(NI=FI)	.00	.00	.00	.00	.00	.00
p(FI=TS)	.00	.30	.13	.00	.55	.15

Notes: σ standard deviation, m median, KS: p-value of Kolmogorov-Smirnov test on the equality of the distributions, p(NI=FI): p-values of tests on the equality of variances and medians between groups NI and FI, p(FI=TS): p-values of tests on the equality of variances and medians between groups FI and TS

relevant for the predictions made in group FI. Only the information contained in the chart itself was used. Those participants who had to rely on their own information, as they did not have a chart available, made clearly different predictions for the one-quarter-ahead prediction.

Figures 3 and 4 show the distributions of deviations of subjects' 1-period predictions from the realized values. The visual impressions confirm the finding that the predictions in the FI and TS treatments have the same distributions, which are different from the distributions in NI. Furthermore, the FI deviations are quite dispersed, but with a mean close to zero which means that the aggregate forecasts of this group were close to the realized values.In the FI group, the distribution of inflation forecasts is skewed to the left and the one of the GDP forecasts is skewed to the right. Both findings are consistent with the hypothesis that most subjects in this group derived their forecasts from the graphs in Figure 1 and Figure 2. The last observation of the rate of inflation is 3.1 and the median forecast in the FI treatment is

Table 2: GDP growth predictions

	1 quarter			2 quarters		
Group	σ	m	KS	σ	m	KS
NI	1.51	2.0		1.77	1.9	
FI	.9	1.5		.92	1.8	
TS	.88	1.56		1.09	1.8	
p(NI=FI)	.00	.03	.02	.00	.83	.21
p(FI=TS)	.82	.95	.45	.13	.88	.28

Notes: σ standard deviation, m median, KS: p-value of Kolmogorov-Smirnov test on the equality of the distributions, p(NI=FI): p-values of tests on the equality of variances and medians between groups NI and FI, p(FI=TS): p-values of tests on the equality of variances and medians between groups FI and TS

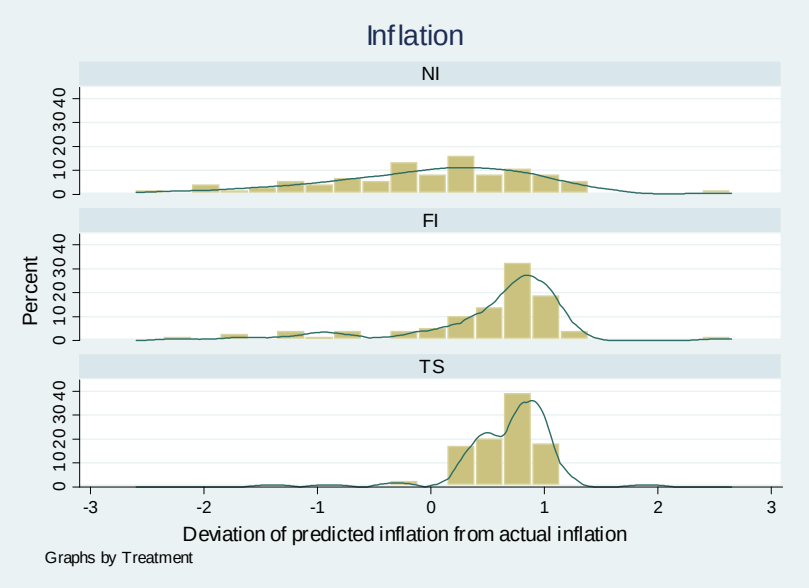

Figure 3: Deviations of subjects' predicted rate of inflation from the actual rate of inflation

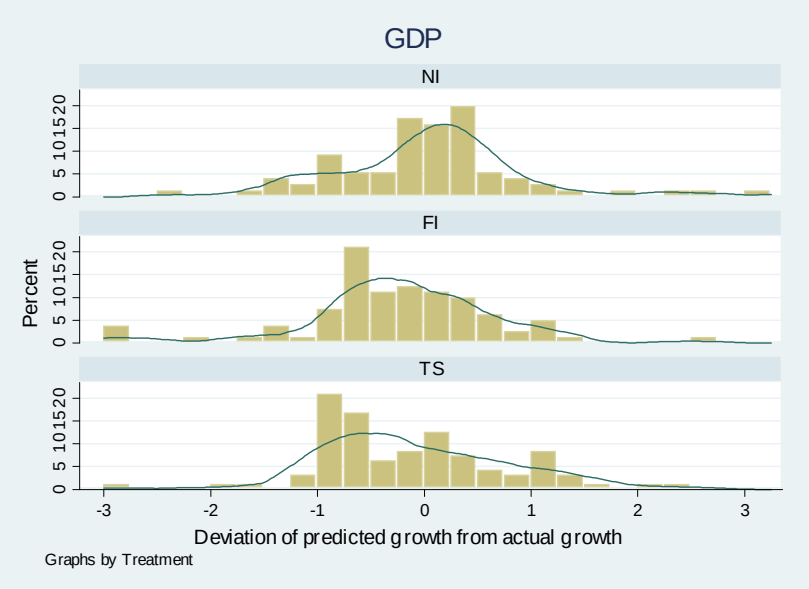

Figure 4: Deviations of subjects' predicted rate of GDP growth froma actual rate of GDP growth

3.2 which results from an extrapolation of the last two or three observations in the inflation chart into the future. Similarly, the median GDP growth forecast of 1.5 is slightly lower than the last observation of 1.6, which can again be explained by a trend extrapolation.

Both for inflation and GDP growth the information that subjects brought to the experiment from outside did not matter when they received a time-series chart to help them forming expectations. The visual information of the chart was so strong that it dominated other information. Ex post this resulted in biased forecasts in the FI group.

3.2 Self-reports

We presumed that subjects in the NI group relied on their own economic knowledge and beliefs when they made their predictions. But the difference between the expectations in this group and the two other groups could also result from subjects simply guessing in group NI. Potentially, subjects did not use any information at all in this group and only made random guesses. An obvious way to find out which information subjects had used is to ask them directly. We asked subjects in groups NI and FI to describe briefly how they had formed their expectations. The answers can broadly be classified into three categories: guessing, using recalled information from the news and and experts, and using the chart where available[4].

Table 3 shows the percentages of participants reporting to have used information in those categories. Indeed, in the group without information provided by us, a slight majority of subjects reported to have guessed a prediction. This is consistent with the high variance of the predictions in that group. About one quarter of participants reported that they had used (expert) information from the news. Note that the fraction of subjects using expert information is not statistically different between the two groups. However, in the FI group, the fraction of guesses is clearly lower than in the NI group. The difference in the fraction of guessed predictions between the two groups is almost identical to the fraction of subjects reporting to have used the chart in group FI.

[4]These three categories account for about 80% of all answers. Many answers were very short and therefore hard to interpret. Other answers could be summarized under the heading economic reasoning.

Table 3: Self-reported use of information

	Inflation			GDP growth		
	guess	experts	chart	guess	experts	chart
NI	.53	.25	0	.53	.30	0
FI	.27	.19	.33	.32	.25	.35
p	.00	.30		.00	.42	

Notes: Figures indicate shares of respondents whose answers fit into one of the three categories, p is the empirical significance level of a test on the equality of means between the two groups NI and FI

These findings suggests the following interpretation. There was an equal-sized fraction of subjects in both groups that had recalled expert information and had used it independent of the provided information. Those who had used the chart would have guessed otherwise. The provided time-series information hence is especially important to those subjects who have little own economic knowledge.

3.3 Outside information

In order to assess the significance of different kinds of information, we regress the one-step-ahead predictions on recalled expert predictions and subjects' estimates of the change of the Euro-dollar exchange rate and the change of the oil price. Table 4 contains the results.

Consistent with the self-reports, the predictions in the no-information group are correlated with the recalled expert predictions. In the case of inflation, subjects' predictions are statistically identical to the expert predictions as the OLS coefficient of 0.62 is not statistically different from one at the 5% level. Ex post this was a good choice as both expert predictions

were exactly identical to the realized values of 1.8% for GDP growth in the first quarter and 2.4% for the rate of inflation in April 2008. The regression result indirectly confirms that many subjects really had guessed in group NI, because guesses should be randomly distributed so that the regression picks up the correlation between the expert prediction and the prediction of subjects that had actually used this information. If we restrict the sample to those subjects who reported to have used expert information, the point estimate of the coefficient of expert inflation predictions rises to 0.76 and the R^2 of the regression increases to 0.69. The estimated correlation between subjects' growth predictions and assumed expert predictions is significantly smaller than one which makes sense as the expert prediction refers to annual instead of quarterly growth.

Very interestingly, we do not find a significant correlation between subjects' predictions and expert predictions in the full information group, even if we restrict the sample the those subjects that explicitly reported to have used expert information. This result is further support for the hypothesis that expectations heavily depend on the time-series charts when this is available.

The evidence on the reliability of subjects' estimates of expert predictions is mixed, see Table 5. The preliminary inflation release of the Statistical Office at the end of April was 2.4% and the mean estimates of those subjects that reported to have used expert expectations for their inflation prediction was 2.77% in group NI and 2.85% in group FI. Both means are not statistically different from each other at 5%, but strongly greater than 2.4 ($p <$ .01). The mean estimates of the subjects that did not report to have used

Table 4: Outside information

	Inflation		GDP growth	
	NI	FI	NI	FI
expert	.62***	-.03	.30***	.03
	(.22)	(.17)	(.10)	(.05)
ExR	-.02	-.03**	-.03	-.00
	(.03)	(.01)	(.02)	(.01)
Oil	.01	.01	-.00	.01
	(.01)	(.01)	(.01)	(.01)
const	.84**	3.11***	1.61***	1.44***
	(.55)	(.51)	(.28)	(.21)
R^2	.26	.12	.26	.02
#obs	78	77	76	79

Notes: Regression of predictions on estimates of expert predicts (expert), of the change in the exchange rate (ExR), and of the change in the price of oil (Oil), [*,**,***] indicate significantly different from zero at [10%, 5%, 1%]

expert predictions are 2.93% and 2.94%. While these values are higher than the previous ones, they are not statistically different from them. Subjects' estimates of expert predictions are biased and there is no evidence that the bias is smaller for those who claim to have used expert predictions in the case of inflation. For GDP growth predictions, we do find a significant difference between apparent users and non-users. The apparent users estimate the expert growth forecast to be 1.82% in group NI and 1.79% in group FI which are clearly not different from the actual value of 1.8%. In both groups, the estimates of the non-users (2.95% and 2.31%) are significantly higher than 1.8% at least at p=0.013. An explanation for the discrepancy between the inflation and the growth forecast may be that the latter receives much more public attention, especially so because the particular one, which we asked for, is only published twice a year.

That subjects use their estimates of the past changes of the oil price and the exchange rate to forecast output growth and inflation is not supported by our data. The estimated change of the oil price is never a significant predictor of subjects' expectations. While subjects' growth forecasts cannot be explained by their estimate of the exchange rate change, their inflation expectations in the FI group are negatively correlated with it. This would make sense as an appreciation of the home currency makes imports less expensive. However, this correlation is only found in the FI group, but not in group NI. Furthermore, we believe that this correlation is spurious and only due to some outliers with relatively high estimates of the change of the exchange rate and low inflation predictions. If we exclude those subjects whose estimate of the current unemployment rate is 50% or more off the actual value, the correlation vanishes. The estimate of the current unemployment rate serves as a reliability check of the estimates of the change in the oil price and of the exchange rate. The unemployment rate is a very salient figure in the news and many people have relatively precise perceptions of it. In fact, the mean estimate of the unemployment rate in groups NI and FI are both not statistically different from each other and from the true value of 8.1% in April 2008. In contrast, both the estimated oil price change and the estimated change of the exchange rate are significantly higher in group FI than in group NI. This suggests that subjects on average estimated larger changes of these variables after having seen the evolution of the inflation rate.

Summing up we do not have strong evidence that would allow us to reject Hypothesis 3. We hence conclude that subjects in the full information group only used the historical information in the chart, even if they reported to

Table 5: Subjects' estimates of expert predictions

	Inflation		GDP growth	
	FI	NI	FI	NI
Subjects using expert predictions	2.85	2.77	1.79	1.82
Subjects not using expert predictions	2.94	2.93	2.31	2.95
True expert predictions	2.4		1.8	

have used other information as well. Except for very prominent information, such as the rate of unemployment or the half-yearly growth forecast of the major research institutes that receive a lot of public attention, subjects do not seem to have very precise information about economic figures.

4 Conclusions

The centerpiece of this analysis is to assess the importance of subjects' unobservable economic knowledge and beliefs they use when asked to make economic predictions. We find that their importance is negligible. When economic students are asked to make predictions for future GDP growth and inflation without being given any further information, many of them simply guess. This is what they report themselves and what is reflected in our data. About one quarter of our participants reported to have used expert information, but at least in the case of inflation expectations, students' estimates of expert predictions are biased. We do not find a significant correlation between estimated expert predictions and the own predictions of subjects in the group which was provided with the time-series chart. Surprisingly, this is even true for those subjects who reported to have used expert predictions for their forecasts. Other potentially relevant variables such as the change in

the oil price and the change in the exchange rate do not explain predictions either and are also biased. In the full information group the most important information used - and apparently the only one - was the chart. The predictions in this group are not different from those in the control group that could not identify the time series.

That even subjects who claimed to have used expert forecasts to form their own expectations do little else than intuitive univariate time-series prediction may be the result of the well-known anchoring effect (Tversky and Kahneman, 1974). The chart with past data could serve as an anchor for the formation of expectations and lead to an insufficient adjustment by additional information. The way in which our subjects used the time-series charts may be similar to the mechanisms described by the literature visual pattern recognition mentioned in the introduction. This suggests that pattern-based time series forecasting may not only be relevant for financial variables, but also for other forecasts, especially if they are formed by laypeople or households.

We argue that our results are important for the formation of expectations outside the economic laboratory. Charts are often used and very salient in news reports about the economy. As they contain a lot of information in a condensed form they are also often shown to decision makers in presentations and typically included in executive reports and publications of research institutions on the current state of the economy. In other words, time series charts are salient economic information and are very likely to be recalled by economic decision makers, even by consumers. Since we have demonstrated the power of charts to influence the formation of economic expectations, we also expect a strong backward-looking element in published survey expec-

tations. As a matter of fact, Roos (2005) using such data confirms this econometrically.

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