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ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

KOF

ETH Zurich
KOF Swiss Economic Institute
WEH D 4
Weinbergstrasse 35
8092 Zurich
Switzerland

Phone +41 44 632 42 39
Fax +41 44 632 12 18
www.kof.ethz.ch
kof@kof.ethz.ch

Rationality of Direct Tax Revenue Forecasts under Asymmetric Losses : Evidence from Swiss cantons*

Florian Chatagny** Boriss Siliverstovs**
KOF, ETH Zürich *KOF, ETH Zürich*

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Abstract

Abstract The current debt crisis has shed light on the importance of accurate fiscal forecasts. In particular, the accuracy of revenue forecasts is central since they set the limit within which expenditure should remain in order to reach fiscal balance. Therefore, forecasting tax revenue accurately is a key step in the implementation of sound fiscal policies. The current paper contributes to the empirical literature on budget predictions by providing new evidence about Swiss cantons. Using data from 26 Swiss cantons over 1944-2010, we apply the method developed by Elliott et al. (2005) to test the rationality of direct tax revenue forecasts. We mainly find that 1) when considering the percent forecast error, loss functions are asymmetric in a majority of cantons, 2) allowing for asymmetric losses, results of rationality tests are substantially altered in the sense that more cantons turn out to produce rational forecasts 3) when considering forecasts of growth rates, almost no evidence of asymmetric loss function is found and finally 4) forecasts of tax revenue growth rate turn out to be rational in a higher number of cantons than forecasts of levels of tax revenue.

Keywords: Tax Revenue Forecasts; Rationality Tests; Asymmetric loss function; Swiss cantons;

JEL Classification Numbers: C23 · H68 · H71

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**ETH Zürich, KOF Swiss Economic Institute, Weinbergstrasse 35, 8092 Zürich, Switzerland, e-mail: *chatagny@kof.ethz.ch* and *siliverstovs@kof.ethz.ch*

Contents

1 Introduction

Forecasting and budgeting government revenue and expenditure accurately is a key component of an efficient fiscal policy. Misforecasting and misbudgeting either revenue or expenditure may create or amplify fiscal disequilibrium, i.e. deficits or surpluses. Both of which may not be desirable. In particular, forecasting and budgeting of tax revenue is the first step in the budgetary decision-making process. It is supposed to set the budgetary limits within which public spending should remain in order to reach a fiscal balance. While underestimated tax revenues may lead to a situation where taxpayers are overtaxed with respect to the quantity of public goods they receive, overestimated tax revenues may lead to a situation where governments overproduce public goods with respect to the available financial resources.

A popular way of assessing whether government do a good job in predicting revenue is to perform rationality tests on the forecasts or on the forecast errors. Empirical rationality tests flourished in many areas after the formal development of the rational expectation theory, including the area of government revenue. According to rational expectations theory, a forecast is said to be rational if it exhibits the two following properties : 1) the forecast is unbiased and 2) the forecast incorporate all available information at the time when it is made - which also means that errors should not be serially correlated. Some authors have analysed whether revenue forecasts were fulfilling these two properties. They often conclude that revenue forecasts are either biased or do not incorporate information efficiently or both. A limitation of most rationality tests performed on public revenue is that no explicit assumption is made about the underlying loss function of the forecaster. Indeed, these studies do implicitly assume the loss function to be symmetric and quadratic.

For many reasons, one might think that considering a symmetric loss function is not the most appropriate assumption to make. For instance, creating huge deficits may be politically costly for the finance minister who is usually in charge of revenue forecasts. Therefore, he may put pressure on forecasters in order to have more conservative forecasts. One may also think that, in an election year, politicians may put pressure on forecasters to make optimistic forecasts such that more resources are apparently available to spend. These non-exhaustive examples suggest that the forecasters' loss function may very well not be symmetric. This issue has been addressed by many authors but not treated when it comes to revenue forecasts.

In the current paper, we extend the empirical literature on the rationality of revenue forecasts by providing evidence of asymmetric losses underlying direct tax revenues forecasts in Swiss cantons. Analysing series of tax revenue forecasts and outcomes in 26 Swiss cantons over 1944-2010, we find that allowing for asymmetric loss substantially alters the outcome of rationality tests in the sense that a higher number of cantons turns out to produce rational forecasts when percent forecast errors are considered. Conversely, whenever forecasts of tax revenue growth rate are considered, almost no evidence of asymmetric loss is found and forecasts turn out to be rational in a higher number of cantons.

2 Literature Review

Since Muth (1961) and his seminal paper on rational expectations, empirical tests of rationality have been performed in very diverse fields of economics where expectations have to be formed and are observable. It took however some time before this method was first applied to fiscal forecasts in general and revenue forecasts in particular. Feenberg et al. (1989) first suggested a rigorous and tractable method to test the rationality of American states revenue forecasts. Applying rational expectations theory to state revenue forecasts, they define conditions for revenue forecasts to be rational. They differentiate between the *strong* form of the rationality test, which regresses the forecast errors on the information set available at the time the forecast is made, and the *weak* form of the test, which regresses the actual revenue directly on the forecast. They apply their methods to the States of New Jersey, Maryland and Massachusetts. They provide evidence that forecasts of own revenue are downward biased and fail to incorporate efficiently the information available to the forecaster at the time the forecast is made.

The above mentioned results may depend on some factors that are peculiar to American States and may therefore not generalize to other jurisdictions. As Muth pointed out: *"The* *way expectations are formed depends specifically on the structure of the relevant system describing the economy"*.(Muth, 1961, p.316) There is no reason why this remark would not apply to revenue forecasts. Indeed, the formation of revenue forecasts not only depends on how revenue are related to the economy but also on the design of budgetary institutions among others. Therefore, it is of interest to perform rationality test on revenue forecasts made in other jurisdictions in a different economic system and having different institutions.

Some authors have indeed applied the framework developed by Feenberg et al. (1989) in different contexts. For instance, Reilly and Witt (1992) perform rationality tests on the UK Treasury forecasts of three categories of taxes : income tax, customs and corporate tax. They find that only the forecasts of the income tax can be considered weakly but not strongly rational. They also find that rationality does fail particularly strongly for corporate tax.

A shortcoming of the studies performed by Feenberg et al. (1989) and Reilly and Witt (1992) is the relatively short time series used. To overcome this problem, Mocan and Azad (1995) have performed rationality tests by applying panel data methods to a dataset of 20 American states over 1986-1992 which substantially increases the number of observations. They use the random effect estimator to perform weak and strong rationality tests on general fund revenue forecasts. Unlike Feenberg et al. (1989), they do not find any systematic under- or overestimation of the forecasts. However, strong rationality is rejected indicating that the forecasts could be improved by using the available information efficiently. A weakness of the panel data approach is that the situation of the individual states cannot be disentangled. It could be that downward and upward biases in different states offset each other.

To overcome the problem of having a small number of observations without pooling several time series into a panel, non-parametric methods can be used. For instance, Campbell and Ghysels (1997) use non-parametric methods to test for the rationality of Canadian budget forecasts over 1976-1992. More precisely, they rely on : *"sign and signed rank tests for unbiasedness of forecasts and for the orthogonality of forecast errors both to past forecast errors and to available macroeconomic information."*(Campbell and Ghysels, 1997, p.556).

Among other results, they find that corporate tax forecasts are biased. They also find first-order auto-correlation of the errors for income and corporate tax revenue as well as for total revenue forecasts. This points at an inefficient use of the available information. Finally, they also find that information about unemployment rate is inefficiently incorporated into income tax revenue forecasts.

Finally, Auerbach (1999) uses the revision of federal revenue forecasts by three different agencies to perform rationality tests. While he does not find any significant bias, he finds out that government forecasts fail the efficiency tests. In his study, Auerbach importantly points out that : *"A basic implication of the theory of optimal forecast behavior is that forecasts should have no systematic bias,* ***at least if the perceived costs of forecast errors are symmetric****."* The relation between forecast errors and their perceived costs by the forecaster is called a loss function. Indeed, the properties defining rational forecasts depend on the shape of the loss function of the forecaster. Therefore a forecast may be biased but still be rational under an asymmetric loss function. In many cases, assuming symmetric losses may not be the most appropriate assumption. In fact one may expect that forecasters producing fiscal forecasts to be particularly prone to having asymmetric losses. For instance, in a jurisdiction where the ministry of finance is responsible for the revenue forecasts, the existence of a fiscal rule may cause the loss function of the forecaster to be asymmetric. Indeed most fiscal rules do only sanction deficits and not surpluses. In such a case, overestimating tax revenue would be more costly than underestimating it.

A common limitation of all the aforementioned studies is that they implicitly assume tax revenue forecasts to be produced under symmetric losses. The only exception is the non-parametric approach by Campbell and Ghysels (1997). By choosing a non-parametric approach, the authors implicitly allow for asymmetric losses. They, however, do not explicitly quantify the loss function. In that respect, the approach developed by Elliott et al. (2005) is particularly appealing since not only it allows to perform rationality tests allowing for an asymmetric loss function but it provides one with a method to quantify the forecaster's loss function explicitly.

Interestingly, Elliott et al. (2005) illustrated their method by applying it to fiscal deficit forecasts produced by the IMF and the OECD for the G7 countries from 1975 to 2001. They find that the IMF and OECD systematically overpredict budget deficits but they also show that, in some cases, this is due to an underlying asymmetric loss function. For some countries they find that underpredictions are considered up to three time costlier than overpredictions. Then they show that, when rationality tests are performed under asymmetric loss functions, the evidence against rationality of fiscal forecasts becomes weaker than when symmetric loss is assumed. The application made by Elliott et al. (2005) suffers from mainly two limitations. First, the number of observations for each country is relatively low with around 25 observations. As they recognize themselves : *"These are not large samples, so some caution should be exercised in the interpretation of the results."*(Elliott et al., 2005, p.1116) Then, the tests are performed on the budget deficit forecasts. Therefore, the results do not tell anything about the rationality and the shape of the loss functions for revenue and expenditure forecasts respectively.

In the current paper, we propose to extend the empirical literature on fiscal forecasts by applying the method developed by Elliott et al. (2005) to direct tax revenue series for the 26 Swiss cantons [1] over 1944-2010. The objective is twofold. Firstly, we provide evidence about the shape of loss functions in the field of tax revenue forecasts, which has, to the best of our knowledge, not been done yet. Secondly, we show how allowing for the loss function to be asymmetric alters the outcome of the rationality tests for tax revenue forecasts. Given the relative high number of observations for each canton (around 66), we expect our results to be highly reliable. Before presenting how we adapted the econometric framework proposed by Elliott et al. (2005) to our particular case, we present the empirical field of Swiss cantons and the dataset in the next section.

[1] Swiss cantons are the sub-national jurisdictions in Switzerland and can be viewed as the equivalent of States in the US or Länder in Germany.

3 Empirical field

The current study refers to the context of the 26 Swiss cantons. Cantons constitute the sub-national level of the state in Switzerland. Each of them has its own authorities and institutions (government, parliament, court, etc.). As such Swiss cantons enjoy a high degree of budgetary autonomy and directly levy an important share of their revenue. This tax sovereignty also imply for cantonal states to predict the different revenue items by themselves and to enact their own budgets. The most important revenue source for cantons are direct taxes representing around 60 percent of total revenue. Given the importance of these aspects for the analysis, the current section offers a description of the tax revenue budgeting process in the Swiss cantons and provide a description of the data used in the analysis.

3.1 Tax Revenue Budgeting Process

Broadly defined, the tax revenue forecasting and budgeting process is a succession of technical, administrative and political steps ending with the enactment of a budget law by the parliament stating the amount of tax revenue that is expected to be collected over the next fiscal year. In Swiss cantons, departments of finance - headed by an elected finance minister - are in charge of producing tax revenue forecasts. There do not exist official, publicly published, competing forecasts.[2] The process starts with the production of a technical forecast of tax revenue made by revenue officers. This technical forecast is then forwarded - via the finance minister - to the executive branch of the government that designs a budget proposal for the subsequent fiscal year. This proposal is finally submitted to the parliament that enacts a budget law. This budget law serves as a starting point to implement fiscal policy during the subsequent fiscal year. To quantify loss functions and perform rationality tests, an ideal situation would be to rely on forecasts issued at every step of the budgeting process. This would have allowed us to assess the loss functions of the different actors in the budgeting process (tax officers, finance minister, government, etc.). However, most of the Swiss cantons do not produce documents containing such information. Consequently

[2]Cantonal parliaments do not have resources to produce their own forecasts.

we restricted our analysis to the actual and predicted amounts of tax revenue reported in published cantonal accounts.

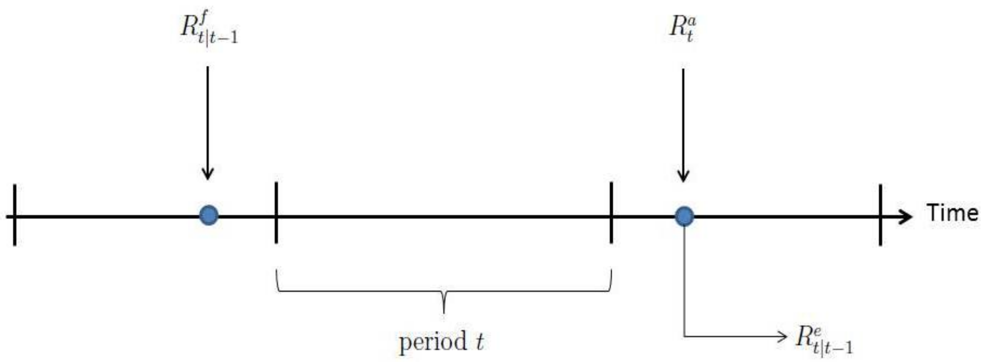

Figure 1: Timing of the Tax Revenue Budgeting Process in Swiss cantons

The timeline of the tax revenue budgeting process is sketched in Figure (1), where period t is the period for which revenue have to be predicted, R denotes $Tax\ Revenue$, subscript a stands for $actual$, subscript f stands for $forecast$ and subscript e stands for $forecast\ error$. $R^f_{t|t-1}$ is the forecast of actual tax revenue collected in period t – R^a_t – made in period $t-1$. First note that, in the current study, we only have one year ahead forecasts. The forecast for period t is published at the end of the preceding year, i.e in period $t-1$. Although the exact point in time may vary, this is similar to all cantons. Then the actual value – R^a_t – and, by definition, the forecast error – $R^e_{t|t-1}$ – are known at the beginning of period $t+1$. It is important to note that, at the time the forecast is made, the forecaster does not know the forecast error for period $t-1$ but only the error for period $t-2$. This will be important for the construction of the information set.[3]

[3]In Swiss cantons, taxpayers start paying taxes for fiscal year t around spring of fiscal year t. They can choose to pay either as mensual payments or as a one-shot annual payment. This means that, at the time revenue officers make a forecast for year $t+1$, they already have information about how much revenue is going to be collected in year t and, therefore, what the forecast error for year t will be. However, to be on the safe side we will assume that forecasters have no information about fiscal year t when they try forecasting $t+1$

3.2 Data

To construct the dataset, we collected budgeted and actual revenue that are reported in public accounts of Swiss cantons over 1944-2010. Over the period of interest, public accounts do not distinguish between personal and corporate tax revenue for every canton and/or every year. For this reason, we used the aggregate that we call "direct taxes", i.e.the addition of both personal and corporate tax. Using this aggregate enables the use of a complete and homogeneous dataset across both cantons and years. The analysis will be performed using two different specifications of the tax revenue forecast errors: the percent forecast error and the growth rate forecast error. Both series are displayed for each canton individually in Figures 2—6. These specifications are standard in the literature and are particularly interesting in the case of Swiss cantons since the results will substantially differ depending on which specification is adopted. We now present the summary statistics associated with these specifications.

3.2.1 Percent forecast error

The percent forecast error is defined as follows:

$$R^e_{t|t-1} \equiv \frac{R^a_t - R^f_{t|t-1}}{R^a_t} \times 100 \tag{1}$$

It measures discrepancy between actual tax revenues collected in period t and projected tax revenue for that period made in period $t-1$. Since the level of tax revenue R^a_t grows over time, we scaled the level forecast error $R^a_t - R^f_{t|t-1}$ by R^a_t in order to avoid problem of heteroscedasticity. As a result of multiplication by 100, the reported percent forecast error is measured in percentage points.

The summary statistics of the percent forecast error are reported in Table 1. The column called *"Mean"* shows that, in all cantons the mean percent forecast error over the time span 1944-2010 is positive, implying that on average actual outturn of tax revenue exceeds forecasts. From the reported summary statistics it is also evident that the percent forecast

Table 1: Percent forecast error : summary statistics

	N	Span	Mean	Std. dev.	Share neg.	Share pos.	Mean neg.	Mean pos.
ZH	67	1944-2010	1.81	5.18	0.31	0.69	-3.91	4.42
BE	67	1944-2010	2.15	6.01	0.42	0.58	-3.04	5.87
LU	67	1944-2010	4.77	5.23	0.18	0.82	-2.68	6.40
UR	67	1944-2010	8.95	12.42	0.21	0.79	-5.18	12.69
SZ	67	1944-2010	6.78	6.89	0.16	0.84	-4.37	8.96
OW	67	1944-2010	8.95	10.10	0.16	0.84	-5.51	11.79
NW	67	1944-2010	7.51	7.03	0.16	0.84	-1.81	9.34
GL	67	1944-2010	8.88	7.19	0.13	0.87	-2.36	10.63
ZG	67	1944-2010	7.53	8.02	0.15	0.85	-5.55	9.82
FR	67	1944-2010	6.68	6.08	0.09	0.91	-2.39	7.57
SO	67	1944-2010	5.29	7.47	0.21	0.79	-4.04	7.76
BS	67	1944-2010	5.71	6.07	0.18	0.82	-3.08	7.63
BL	67	1944-2010	4.64	7.55	0.25	0.75	-3.17	7.29
SH	66	1945-2010	0.06	7.89	0.39	0.61	-6.28	4.18
AR	67	1944-2010	4.20	4.78	0.21	0.79	-2.50	5.97
AI	67	1944-2010	9.36	8.62	0.10	0.90	-5.21	11.06
SG	67	1944-2010	4.07	4.81	0.21	0.79	-2.46	5.79
GR	67	1944-2010	5.17	4.79	0.10	0.90	-1.87	6.00
AG	67	1944-2010	4.63	5.54	0.18	0.82	-3.01	6.29
TG	67	1944-2010	4.13	6.21	0.25	0.75	-3.48	6.72
TI	67	1944-2010	8.10	7.85	0.10	0.90	-6.12	9.76
VD	63	1948-2010	4.82	6.02	0.25	0.75	-2.64	7.36
VS	67	1944-2010	7.35	7.34	0.12	0.88	-4.08	8.90
NE	67	1944-2010	8.03	11.28	0.19	0.81	-4.78	11.12
GE	67	1944-2010	3.35	6.88	0.30	0.70	-4.25	6.59
JU	32	1979-2010	0.68	2.64	0.50	0.50	-1.45	2.81

The following canton abbreviations are used: Aargau (AG), Appenzell Innerrhoden (AI), AR Appenzell Ausserrhoden (AR), Bern (BE), Basel-Landschaft (BL), Basel-Stadt (BS), Fribourg (FR), Genève (GE), Glarus (GL), Graubünden (GR), Jura (JU), Luzern (LU), Neuchâtel (NE), Nidwalden (NW), Obwalden (OW), St. Gallen (SG), Schaffhausen (SH), Solothurn (SO), Schwyz (SZ), Thurgau (TG), Ticino (TI), Uri (UR), Vaud (VD), Valais (VS), Zug (ZG), Zürich (ZH).

error exhibits strong heterogeneity across cantons and variability over time. For instance, the mean percent forecast error ranges from 0.06 for the canton of Schaffhausen (SH) to 9.36 for Appenzell Innerrhoden (AI). Furthermore, the percent forecast error in some cantons like Uri (UR) or Neuchâtel (NE) exhibits strong intertemporal variation with 12.42 and 11.28 standard deviation respectively. Also interesting is the fact that, except for the canton of Jura (JU), the share of positive versus negative errors is relatively far from 0.5 and, for the majority of cantons, the mean of positive percent forecast error is larger in absolute value than the mean of negative percent forecast error. These preliminary statistics suggest that cantons tend to systematically underestimate their planned tax revenues. It also suggests that the loss function underlying forecasts of total amount of direct tax revenues in the next year may be asymmetric, as losses associated with over- and underprediction of the level of future tax revenue are likely to be strongly differential.

3.2.2 Growth rate forecast error

We now turn to the summary statistics of the growth rate forecast error. The growth rate forecast error is defined as follows:

$$r^e_{t|t-1} \equiv r^a_t - r^f_{t|t-1} \equiv \left[\frac{R^a_t - R^a_{t-1}}{R^a_{t-1}}\right] - \left[\frac{R^f_{t|t-1} - R^f_{t-1|t-2}}{R^f_{t-1|t-2}}\right], \tag{2}$$

which is the difference between the growth rate of actual revenue and the growth rate of predicted revenue. Table 2 presents the summary statistics for the growth rate forecast

Table 2: Growth rate forecast error : summary statistics

	N	Span[a]	Mean	Std. dev.	Share neg.	Share pos.	Mean neg.	Mean pos.
ZH	66	1945-2010	0.25	6.72	0.55	0.45	-4.51	5.97
BE	66	1945-2010	-0.50	5.61	0.55	0.45	-4.66	4.49
LU	66	1945-2010	-0.27	5.73	0.47	0.53	-5.02	3.93
UR	66	1945-2010	-0.02	13.51	0.56	0.44	-8.03	10.20
SZ	66	1945-2010	-0.09	9.38	0.53	0.47	-6.54	7.20
OW	66	1945-2010	0.18	13.15	0.53	0.47	-8.74	10.24
NW	66	1945-2010	0.00	10.37	0.52	0.48	-7.32	7.78
GL	66	1945-2010	-0.21	7.76	0.53	0.47	-5.86	6.17
ZG	66	1945-2010	-0.13	9.29	0.47	0.53	-7.54	6.43
FR	66	1945-2010	-0.28	6.60	0.44	0.56	-6.28	4.42
SO	66	1945-2010	0.04	9.24	0.52	0.48	-6.46	6.95
BS	66	1945-2010	0.19	6.88	0.48	0.52	-5.23	5.29
BL	66	1945-2010	-0.24	9.85	0.56	0.44	-6.25	7.42
SH	65	1945-2010	0.05	6.32	0.45	0.55	-4.90	4.04
AR	66	1945-2010	-0.02	5.09	0.47	0.53	-4.20	3.67
AI	66	1945-2010	0.50	13.02	0.50	0.50	-9.02	10.02
SG	66	1945-2010	-0.16	5.29	0.44	0.56	-4.97	3.61
GR	66	1945-2010	-0.16	6.70	0.50	0.50	-4.64	4.33
AG	66	1945-2010	-0.16	6.39	0.52	0.48	-5.12	5.12
TG	66	1945-2010	-0.15	7.51	0.52	0.48	-5.20	5.22
TI	66	1945-2010	-0.04	8.74	0.47	0.53	-7.16	6.26
VD	62	1949-2010	-0.26	5.33	0.47	0.53	-4.32	3.30
VS	66	1945-2010	-0.23	7.00	0.41	0.59	-6.14	3.86
NE	66	1945-2010	-0.23	9.78	0.56	0.44	-6.05	7.20
GE	66	1945-2010	-0.15	7.06	0.55	0.45	-4.88	5.53
JU	31	1980-2010	0.20	4.04	0.45	0.55	-3.48	3.24

[a] One observation is lost due to first-order differencing of the variables.

errors and depicts a very different situation than for the percent forecast errors. Indeed, the mean growth rate forecast errors is now negative in a majority of cantons and much closer to zero than the mean percent forecast error. With a value ranging from -0.5 to

+0.5, the mean growth rate forecast error exhibits much less heterogeneity across cantons while the intratemporal variability seems relatively larger. Finally, the share of positive versus negative errors is much closer to 0.5 than for percent forecast error while the mean of positive errors is not systematically larger than the mean of negative errors in absolute value. These preliminary statistics tend to suggest that on average cantons do not commit any systematic error when predicting the growth rates of tax revenue. As a consequence, the loss function underlying the growth rate forecast error seems to be rather symmetric than asymmetric.

The raw statistics presented in the current section are of course not sufficient to draw any conclusion about the shape of the loss function or the rationality of the forecasts. In order to sort this out in a formal way, we applied the econometric method developed by Elliott et al. (2005). We present their methodology and show how we adapted it to our particular case in the next section.

4 Econometric method

In order to allow the underlying loss function of a forecast to potentially be asymmetric, Elliott et al. (2005) propose a tractable econometric framework to test forecasts rationality under more general family of loss functions than traditionally assumed. Their method is particularly appropriate when one has a sequence of point forecast estimates and does not observe the underlying forecast model, which is our case. This method allows to back out the parameters of the loss function from the observed time series of forecast errors and then to perform rationality tests under the new estimated loss function. In the current section we first present the method developed by Elliott et al. (2005) and show how it adapts to the particular case of direct tax revenue forecasts in Swiss cantons. (Elliott et al., 2005, p.1110). As a starting point to their analysis, Elliott et al. (2005) formulate the following generalized loss function:

$$L(p, \alpha, \delta) \equiv \left[\alpha + (1-2\alpha)\cdot \mathbb{1}\left(\frac{R_t^a - R_{t|t-1}^f}{R_t^a} < 0\right)\right] \left|\frac{R_t^a - R_{t|t-1}^f}{R_t^a}\right|^p, \tag{3}$$

with $R^f_{t|t-1} \equiv \delta W_{t-1}$, where W_{t-1} is a measure of the information set available to the forecaster at time $t-1$, δ is a vector of parameters, $p \in \mathbb{N}^*$ and $\alpha \in (0,1)$. $\mathbb{1}\left(\frac{R^a_t - R^f_{t|t-1}}{R^a_t} < 0\right)$ is an indicator function taking value of one when the forecast error, $R^e_{t|t-1}$, is strictly negative and zero otherwise. The loss function described by equation (3) provides one with a more generalised form of loss functions than the traditional linear or quadratic loss functions. Indeed, the linear and quadratic loss functions traditionally encountered in the literature on forecasting are particular cases of the loss function described in equation (3). For instance, when $\alpha = \frac{1}{2}$ and $p = 1$ we are back with a symmetric and linear loss function. When $\alpha = \frac{1}{2}$ and $p = 2$ we have a symmetric and quadratic loss function. Elliott et al. (2005) use equation (3) to derive an estimator for α. We show how in the next subsection.

4.1 Estimator of the asymmetry parameter

In order to produce an optimal tax revenue forecast for period t at period $t-1$, called $R^*_{t|t-1}$, the forecaster chooses δ such that the expected value of the loss function $L(p, \alpha, \delta)$ in equation (3) is minimized, given p, α and the information set W_{t-1}. Therefore, the subsequent condition for the forecast to be optimal is

$$R^f_{t|t-1} = R^*_{t|t-1} \Leftrightarrow E\left[W_{t-1}(\mathbb{1}(R^{e*}_{t|t-1} < 0) - \alpha)|R^{e*}_{t|t-1}|^{p-1}\right] = 0, \tag{4}$$

where $R^{e*}_{t|t-1}$ is defined as $\frac{R^a_t - R^*_{t|t-1}}{R^a_t}$. This condition says that, for a forecast to be optimal, the information set available at the time the forecast is made must be uncorrelated to the forecast error.

In our case, $R^e_{t|t-1}$ is known and can be used as a measure of $R^{e*}_{t|t-1}$. Therefore the key step to assess whether forecasters' underlying loss function is symmetric or not is to consistently estimate the parameter α, assuming p as given, and test whether it is statistically different from $\frac{1}{2}$. Elliott et al. (2005) propose a consistent IV estimator ($\hat{\alpha}$) for α. It can be expressed as follows

$$\hat{\alpha}_T \equiv \frac{\left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} W_{t-1}|R^e_{t|t-1}|^{p-1}\right]' \hat{S}^{-1} \left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} W_{t-1}\mathbb{1}(R^e_{t|t-1} < 0)|R^e_{t|t-1}|^{p-1}\right]}{\left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} W_{t-1}|R^e_{t|t-1}|^{p-1}\right]' \hat{S}^{-1} \left[\frac{1}{T}\sum_{t=\tau}^{T+\tau-1} W_{t-1}|R^e_{t|t-1}|^{p-1}\right]}, \qquad (5)$$

with T the number of forecasts available, τ the number of observations used to produce the first forecast and $\hat{S}$ a consistent estimate of $S \equiv E[W_{t-1}W'_{t-1}(\mathbb{1}(R^{e*}_{t|t-1} < 0) - \alpha)^2 |R^{e*}_{t|t-1}|^{2p-2}]$. In practice, since $\hat{\alpha}$ depends on $\hat{S}$ and $\hat{S}$ itself depends on α, the estimation has to be performed iteratively. In the first iteration round the covariance matrix S is assumed to be equal to the identity matrix. Concerning the choice of the instruments to include into the information set W_{t-1}, we follow Elliott et al. (2005) and use the following k sets of instruments: (i) a constant, (ii) a constant and the twice lagged forecast error, (iii) a constant and the twice lagged actual tax revenue and (iv) a constant, the twice lagged forecast error and the twice lagged actual tax revenue. Note that the use of the second lag is justified by the timing of the tax revenue budgeting process in the Swiss cantons. As mentioned in section 3, the lagged actual tax revenue and the lagged forecast error are not known to the forecaster at the time the forecast is made. Therefore the first lag of these variables would not have been valid instruments. Note importantly that, the actual value of growth rate of tax revenue is used as an instrumental variable whenever the growth rate forecast error is concerned.

It can be shown that the estimator in equation (4.1) is consistent and asymptotically normal under some assumptions.[4] Thus standard hypothesis testing can be performed, in particular for the null hypothesis of $\alpha = \frac{1}{2}$. Finally, given the estimated value of the parameter α, a test of rationality of the forecast under a (possibly) asymmetric loss function can be performed. Elliott et al. (2005) also provide such a test which is presented in the next subsection.

[4]For proofs of the consistency and asymptotic normality of this estimator see Elliott et al. (2005, p.112).

4.2 Forecast rationality test

Given the asymptotic normality of the IV estimator of the parameter α, a joint test of rationality and of asymmetric loss function can be performed with more than one instrument. The test statistic is expressed as follows:

$$J = \frac{1}{T}\left[\left(\sum_{t=\tau}^{T+\tau-1} W_{t-1}[\mathbb{1}(R^e_{t|t-1} < 0) - \hat{\alpha}_T]|R^e_{t|t-1}|^{p-1}\right)' \hat{S}^{-1}\left(\sum_{t=\tau}^{T+\tau-1} W_{t-1}[\mathbb{1}(R^e_{t|t-1} < 0) - \hat{\alpha}_T]|R^e_{t|t-1}|^{p-1}\right)\right] \quad (6)$$

where the parameter α is estimated, the J-test statistic follows a χ^2 asymptotic distribution with $k-1$ degrees of freedom, $k > 1$ being the number of instruments (Elliott et al., 2005, p.113). Under the assumption of a symmetric loss function with $\alpha = 0.5$, the J-test statistic has a $\chi^2(k)$ asymptotic distribution. The value of p is to be determined by the researcher. In our case, we alternatively set it as equal two and one in order to check for the robustness of our results. The results are reported in the next section.

5 Tests of Rationality

The current section presents results obtained from the application of the method described in Section 4. We first present the results for the model specified in levels, i.e. when the forecast error is measured by the percent forecast errors. We then present the results for the model specified in growth rates. For each specification, the results are presented in two steps. In a first step we report the results for the estimator of the parameter α together with a test for the null hypothesis that $\alpha = \frac{1}{2}$. In a second step, we report the results of the test for the rationality of direct tax revenue forecasts in the Swiss cantons conditional on the loss function shaped by the parameter α as estimated in the first step. To check for the robustness of our results we perform the analysis assuming alternatively a linear loss function - with $p = 1$ - and a quadratic loss function - with $p = 2$. We also check for alternative specifications of the information set. We alternatively use i) a constant - $k = 1$ - , ii) a constant and the twice lagged forecast error - $k = 2$ -, iii) a constant and the twice lagged actual tax revenue - $k = 3$ - and iv) a constant, the twice lagged forecast error and the twice lagged actual tax revenue - $k = 4$, as described above in section 4.1.

5.1 Rationality of the percent forecast error : results

5.1.1 Estimation of the asymmetry parameter under linear loss

Table 3 reports the results obtained for the estimates of the symmetry parameter, α, and for the null hypothesis of a symmetric loss, $\alpha = \frac{1}{2}$, under the assumption of a linear loss ($p = 1$). The columns headed by α report, for each canton, the estimated value of the asymmetry parameter. The results of the test are reported in the columns headed with a p. These columns report the $p - value$ of the test for the hypothesis that $\alpha = \frac{1}{2}$. These results provide strong evidence for asymmetric loss functions. Over the 26 Swiss cantons,

Table 3: Estimates of the asymmetry parameter α under lin-lin loss

	k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.31	0.06	0.00	0.32	0.06	0.00	0.31	0.06	0.00	0.30	0.06	0.00
BE	0.42	0.06	0.17	0.41	0.06	0.13	0.37	0.06	0.04	0.37	0.06	0.03
LU	0.18	0.05	0.00	0.14	0.04	0.00	0.12	0.04	0.00	0.10	0.04	0.00
UR	0.21	0.05	0.00	0.08	0.03	0.00	0.05	0.03	0.00	0.03	0.02	0.00
SZ	0.16	0.05	0.00	0.10	0.04	0.00	0.11	0.04	0.00	0.08	0.03	0.00
OW	0.16	0.05	0.00	0.15	0.04	0.00	0.16	0.05	0.00	0.15	0.04	0.00
NW	0.16	0.05	0.00	0.16	0.05	0.00	0.08	0.03	0.00	0.07	0.03	0.00
GL	0.13	0.04	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZG	0.15	0.04	0.00	0.14	0.04	0.00	0.14	0.04	0.00	0.13	0.04	0.00
FR	0.09	0.03	0.00	0.08	0.03	0.00	0.08	0.03	0.00	0.08	0.03	0.00
SO	0.21	0.05	0.00	0.21	0.05	0.00	0.15	0.04	0.00	0.11	0.04	0.00
BS	0.18	0.05	0.00	0.13	0.04	0.00	0.05	0.03	0.00	0.03	0.02	0.00
BL	0.25	0.05	0.00	0.26	0.05	0.00	0.26	0.05	0.00	0.26	0.05	0.00
SH	0.39	0.06	0.08	0.39	0.06	0.07	0.40	0.06	0.09	0.38	0.06	0.06
AR	0.21	0.05	0.00	0.21	0.05	0.00	0.20	0.05	0.00	0.20	0.05	0.00
AI	0.10	0.04	0.00	0.07	0.03	0.00	0.06	0.03	0.00	0.05	0.03	0.00
SG	0.21	0.05	0.00	0.21	0.05	0.00	0.21	0.05	0.00	0.21	0.05	0.00
GR	0.10	0.04	0.00	0.10	0.04	0.00	0.10	0.04	0.00	0.07	0.03	0.00
AG	0.18	0.05	0.00	0.17	0.05	0.00	0.13	0.04	0.00	0.13	0.04	0.00
TG	0.25	0.05	0.00	0.21	0.05	0.00	0.24	0.05	0.00	0.21	0.05	0.00
TI	0.10	0.04	0.00	0.08	0.03	0.00	0.09	0.04	0.00	0.07	0.03	0.00
VD	0.25	0.05	0.00	0.13	0.04	0.00	0.23	0.05	0.00	0.13	0.04	0.00
VS	0.12	0.04	0.00	0.11	0.04	0.00	0.11	0.04	0.00	0.11	0.04	0.00
NE	0.19	0.05	0.00	0.07	0.03	0.00	0.08	0.03	0.00	0.05	0.03	0.00
GE	0.30	0.06	0.00	0.28	0.06	0.00	0.28	0.06	0.00	0.26	0.05	0.00
JU	0.50	0.09	1.00	0.47	0.09	0.71	0.47	0.09	0.71	0.47	0.09	0.71

The entries in columns p are p-values for testing the null hypothesis $H_0 : \alpha = \frac{1}{2}$.

only the estimate for the canton of Jura (JU) with one instrument ($k = 1$) exhibit a value for α of $\frac{1}{2}$ or above. All other cantons exhibit a value of α below $\frac{1}{2}$. Furthermore, the null hypothesis of a symmetric loss function is strongly rejected for 23 cantons and for any set of instruments. The only exceptions are the cantons of Jura (JU) and Schaffhausen (SH) for which the null hypothesis of symmetry is never rejected at the 5% level. Somewhat weaker evidence of asymmetry is also found for the canton of Bern (BE) when $k = 1$ and $k = 2$. Overall, Table 3 shows that, for a clear majority of Swiss cantons, loss functions turn out to be asymmetric.

5.1.2 Rationality test under linear loss : results

Given the shape of the loss functions in the Swiss cantons implied by the estimates of α above and by $p = 1$, rationality tests as described in the methodology have been performed. To see how asymmetry alters the outcome of the rationality tests, we first perform the test by fixing $\alpha = \frac{1}{2}$ and then we relax this assumption by allowing α to take the value estimated above. Table (4) shows the results for both sets of rationality tests. When $\alpha = \frac{1}{2}$ the rationality hypothesis is strongly rejected for 23 cantons over 26.

For BE H_0 is not rejected for $k = 1$ only. For SH, rationality is not rejected when $k = 3$. Rejection is weaker when $k = 1$ but rationality is still rejected at the 10% level. JU is the only canton for which forecasts are always rational. When α is allowed to take any value between zero and one, thereby allowing for asymmetry in the loss function, results of the rationality tests are altered for a substantial number of cantons. For instance, when $k = 2$ the rationality hypothesis is rejected at the 5% level for ten cantons only : BE, UR, SZ, GL, BS, SH, TG, VD, NE and GE. For sixteen cantons rationality holds. These results clearly show that the assessment of whether tax revenue are rationally predicted is massively altered if one allows for an asymmetric loss. Indeed, for eleven cantons the outcome of the rationality tests is completely reversed for any set of instruments. Note that considering $k = 3$ or $k = 4$ does not modify the main results. One could however argue that those results particularly depend on the assumption of a linear loss function. Therefore, to check the robustness of our results, the estimations have be redone by assuming $p = 2$ instead of $p = 1$. Results are

Table 4: Rationality test under linear loss

	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	10.84	0.00	10.31	0.01	14.43	0.00	17.29	0.00	0.60	0.44	2.89	0.09	4.31	0.12
BE	1.86	0.17	10.56	0.01	19.03	0.00	20.04	0.00	8.24	0.00	14.64	0.00	15.28	0.00
LU	46.93	0.00	70.79	0.00	99.41	0.00	116.04	0.00	3.73	0.05	5.81	0.02	6.62	0.04
UR	34.34	0.00	170.32	0.00	309.33	0.00	486.93	0.00	10.56	0.00	12.08	0.00	12.77	0.00
SZ	55.06	0.00	121.85	0.00	110.26	0.00	174.99	0.00	5.65	0.02	5.15	0.02	7.18	0.03
OW	55.06	0.00	63.59	0.00	58.91	0.00	65.25	0.00	1.71	0.19	1.16	0.28	1.90	0.39
NW	55.06	0.00	58.42	0.00	171.14	0.00	207.36	0.00	1.09	0.30	7.10	0.01	7.75	0.02
GL	77.04	0.00	955.49	0.00	19019	0.00	20610	0.00	8.21	0.00	8.96	0.00	8.96	0.01
ZG	64.91	0.00	74.25	0.00	69.11	0.00	81.18	0.00	1.54	0.22	1.04	0.31	2.13	0.35
FR	138.44	0.00	153.35	0.00	147.69	0.00	168.49	0.00	0.85	0.36	0.68	0.41	1.27	0.53
SO	34.34	0.00	32.61	0.00	69.25	0.00	113.20	0.00	0.37	0.54	6.14	0.01	8.93	0.01
BS	46.93	0.00	86.60	0.00	268.85	0.00	516.44	0.00	5.02	0.03	9.57	0.00	10.72	0.00
BL	21.46	0.00	19.31	0.00	19.47	0.00	19.54	0.00	0.07	0.80	0.13	0.72	0.16	0.92
SH	3.11	0.08	7.98	0.02	3.77	0.15	9.78	0.02	4.73	0.03	0.90	0.34	6.14	0.05
AR	34.34	0.00	32.12	0.00	38.58	0.00	39.49	0.00	0.25	0.62	1.74	0.19	1.93	0.38
AI	112.03	0.00	187.02	0.00	229.38	0.00	303.76	0.00	1.70	0.19	2.44	0.12	3.27	0.19
SG	34.34	0.00	34.21	0.00	31.85	0.00	34.24	0.00	0.76	0.38	0.18	0.67	0.77	0.68
GR	112.03	0.00	109.69	0.00	124.65	0.00	197.47	0.00	0.30	0.58	1.00	0.32	3.04	0.22
AG	46.93	0.00	53.72	0.00	80.88	0.00	82.55	0.00	1.75	0.19	4.60	0.03	4.73	0.09
TG	21.46	0.00	38.93	0.00	23.88	0.00	38.95	0.00	4.47	0.03	0.45	0.50	4.47	0.11
TI	112.03	0.00	158.28	0.00	132.28	0.00	196.13	0.00	2.15	0.14	1.31	0.25	3.02	0.22
VD	20.13	0.00	83.98	0.00	28.60	0.00	85.55	0.00	10.86	0.00	3.18	0.07	10.95	0.00
VS	92.30	0.00	95.71	0.00	97.54	0.00	99.89	0.00	0.70	0.40	0.82	0.37	0.96	0.62
NE	40.11	0.00	183.31	0.00	153.25	0.00	305.44	0.00	9.64	0.00	9.01	0.00	10.96	0.00
GE	12.99	0.00	20.25	0.00	20.39	0.00	27.50	0.00	4.32	0.04	4.38	0.04	6.98	0.03
JU	0.00	1.00	0.18	0.91	0.18	0.91	0.23	0.97	0.05	0.83	0.05	0.83	0.09	0.96

H_0 : rationality holds

presented in the subsequent sections.

5.1.3 Estimation of the asymmetry parameter under quadratic loss

For robustness check, we now assume that the loss function is quadratic, i.e. that $p = 2$. Table (5) shows the estimates of the parameter α when the loss function is assumed to be quadratic $p = 2$. Except for the cantons of SH and JU, the hypothesis of $\alpha = \frac{1}{2}$ is strongly rejected for at least 23 cantons for any set of instruments. As under linear loss functions, we find very strong evidence for asymmetry. Given the estimated value of α, we ran rationality tests as for linear loss functions.

Table 5: Estimates of the asymmetry parameter α under quad-quad loss

	k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.29	0.07	0.00	0.29	0.07	0.00	0.30	0.07	0.00	0.27	0.06	0.00
BE	0.27	0.06	0.00	0.20	0.06	0.00	0.16	0.04	0.00	0.15	0.04	0.00
LU	0.08	0.03	0.00	0.04	0.02	0.00	0.07	0.03	0.00	0.01	0.02	0.00
UR	0.10	0.03	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
SZ	0.09	0.03	0.00	0.03	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.00
OW	0.08	0.03	0.00	0.05	0.02	0.00	0.06	0.03	0.00	0.05	0.02	0.00
NW	0.04	0.01	0.00	0.04	0.01	0.00	0.02	0.01	0.00	0.02	0.01	0.00
GL	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZG	0.09	0.03	0.00	0.04	0.02	0.00	0.09	0.03	0.00	0.04	0.02	0.00
FR	0.03	0.02	0.00	0.03	0.02	0.00	0.03	0.02	0.00	0.03	0.02	0.00
SO	0.12	0.04	0.00	0.11	0.04	0.00	0.02	0.02	0.00	0.02	0.02	0.00
BS	0.08	0.03	0.00	0.04	0.02	0.00	0.01	0.01	0.00	0.00	0.01	0.00
BL	0.13	0.04	0.00	0.14	0.04	0.00	0.14	0.04	0.00	0.14	0.04	0.00
SH	0.49	0.10	0.95	0.41	0.09	0.32	0.47	0.08	0.73	0.43	0.08	0.37
AR	0.10	0.04	0.00	0.08	0.03	0.00	0.07	0.03	0.00	0.07	0.03	0.00
AI	0.05	0.03	0.00	0.00	0.01	0.00	0.05	0.03	0.00	0.01	0.01	0.00
SG	0.10	0.03	0.00	0.10	0.03	0.00	0.11	0.03	0.00	0.10	0.03	0.00
GR	0.04	0.02	0.00	0.03	0.01	0.00	0.04	0.02	0.00	0.03	0.01	0.00
AG	0.09	0.03	0.00	0.04	0.02	0.00	0.03	0.02	0.00	0.02	0.01	0.00
TG	0.15	0.04	0.00	0.08	0.03	0.00	0.11	0.04	0.00	0.07	0.03	0.00
TI	0.07	0.03	0.00	0.05	0.02	0.00	0.04	0.02	0.00	0.03	0.02	0.00
VD	0.11	0.04	0.00	0.03	0.02	0.00	0.05	0.02	0.00	0.03	0.02	0.00
VS	0.06	0.03	0.00	0.04	0.02	0.00	0.02	0.02	0.00	0.01	0.01	0.00
NE	0.09	0.05	0.00	0.02	0.01	0.00	0.01	0.04	0.00	0.01	0.01	0.00
GE	0.22	0.06	0.00	0.12	0.05	0.00	0.20	0.06	0.00	0.07	0.05	0.00
JU	0.34	0.10	0.10	0.31	0.10	0.04	0.31	0.10	0.05	0.30	0.10	0.04

The entries in columns p are p-values for testing the null hypothesis $H_0 : \alpha = \frac{1}{2}$.

5.1.4 Rationality test under quadratic loss : results

Under quadratic loss functions, assuming $\alpha = \frac{1}{2}$ leads to the clear rejection of the rationality hypothesis for 24 cantons over 26 for any set of instruments. Only for JU and SH rationality always holds. When we allow α to take any value between zero and one, we find that rationality is strongly rejected for, at most ($k = 2$), twelve cantons. For fourteen ($k = 2$) to seventeen ($k = 4$) cantons rationality cannot be rejected. When $k = 2$ for instance, the result of the rationality test is reversed for ten cantons (ZH, OW, NW, FR, SO, BL, AR, AI, SG, GR, TI and VS) when one allows for an asymmetric loss function. Clearly, when errors are specified in level, i.e. in percent forecast errors, we find strong evidence for asymmetric losses and we show that allowing for asymmetric loss function substantially alters the outcome of rationality tests. We now investigate whether similar evidence is found for errors expressed in growth rates.

Table 6: Rationality test under quadratic loss

	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	10.50	0.00	11.01	0.00	10.04	0.01	16.86	0.00	1.18	0.28	1.03	0.31	3.50	0.17
BE	12.69	0.00	37.32	0.00	65.21	0.00	73.61	0.00	9.95	0.00	8.24	0.00	10.66	0.00
LU	184.67	0.00	379.82	0.00	200.12	0.00	865.2	0.00	4.39	0.04	2.79	0.09	7.93	0.02
UR	150.45	0.00	3265	0.00	1541.2	0.00	4554.8	0.00	8.73	0.00	8.50	0.00	8.96	0.01
SZ	147.60	0.00	537.20	0.00	1600.4	0.00	2216.7	0.00	4.45	0.03	5.78	0.02	5.91	0.05
OW	176.00	0.00	387.59	0.00	300.60	0.00	388.97	0.00	2.89	0.09	2.04	0.15	2.89	0.24
NW	1057.4	0.00	950.86	0.00	2197.4	0.00	2197	0.00	0.45	0.50	4.68	0.03	4.76	0.09
GL	1012.3	0.00	25789	0.00	311960	0.00	335260	0.00	6.73	0.01	5.31	0.02	6.31	0.04
ZG	147.00	0.00	392.73	0.00	156.88	0.00	394.18	0.00	4.08	0.04	0.31	0.58	4.14	0.13
FR	926.62	0.00	783.00	0.00	769.31	0.00	783.98	0.00	0.72	0.40	0.57	0.45	0.89	0.64
SO	72.11	0.00	87.28	0.00	389.24	0.00	402.91	0.00	1.21	0.27	6.49	0.01	6.56	0.04
BS	226.79	0.00	579.89	0.00	2951	0.00	6808.3	0.00	5.66	0.02	7.62	0.01	8.34	0.02
BL	81.84	0.00	65.88	0.00	63.99	0.00	67.50	0.00	0.05	0.83	0.11	0.75	0.23	0.89
SH	0.00	0.95	4.82	0.09	0.28	0.87	5.05	0.17	3.82	0.05	0.16	0.69	4.26	0.12
AR	128	0.00	166.23	0.00	202.27	0.00	208.81	0.00	2.70	0.10	3.40	0.07	3.63	0.16
AI	198.75	0.00	2105.5	0.00	259.25	0.00	4240.1	0.00	2.33	0.13	0.18	0.67	3.14	0.21
SG	153.42	0.00	139.20	0.00	129.24	0.00	139.26	0.00	0.57	0.45	0.23	0.63	0.57	0.75
GR	780.11	0.00	1014.7	0.00	698.97	0.00	1033.1	0.00	0.64	0.43	0.00	0.96	1.38	0.50
AG	144.72	0.00	435.49	0.00	943.24	0.00	1664.4	0.00	5.26	0.02	5.64	0.02	6.38	0.04
TG	64.31	0.00	213.83	0.00	114.95	0.00	233.12	0.00	5.64	0.02	2.13	0.14	5.89	0.05
TI	228.34	0.00	378.55	0.00	412.14	0.00	601.72	0.00	1.71	0.19	3.73	0.05	4.07	0.13
VD	98.10	0.00	748.61	0.00	406.26	0.00	999.31	0.00	5.45	0.02	3.96	0.05	5.45	0.07
VS	296.20	0.00	374.91	0.00	1010.30	0.00	1648.5	0.00	2.18	0.14	3.14	0.08	4.19	0.12
NE	79.55	0.00	1930.1	0.00	161.76	0.00	4095.9	0.00	16.35	0.00	8.74	0.00	13.52	0.00
GE	21.76	0.00	60.18	0.00	24.87	0.00	100.13	0.00	8.91	0.00	1.88	0.17	10.37	0.01
JU	2.65	0.10	4.57	0.10	4.10	0.13	4.95	0.18	0.51	0.47	0.29	0.59	0.72	0.70

H_0 : rationality holds

5.2 Rationality of the forecast error of tax revenue growth rate : results

We now redo the same estimation as above when considering the tax revenue growth rate forecast error instead of the percent forecast error. We first present results for a linear loss function ($p = 1$) and then for quadratic loss function ($p = 2$).

5.2.1 Estimation of the asymmetry parameter under linear loss

The results for the estimation of the parameter α and for the asymmetry test when the forecast error is expressed in growth rates are reported in Table 7. Assuming a linear loss function, we do not find evidence of asymmetric loss. Indeed, the hypothesis of symmetry ($\alpha = \frac{1}{2}$) is strongly rejected in the only case of the canton of Valais (VS) when $k = 3$ and

$k = 4$. For the 25 other cantons we find strong evidence supporting symmetry. This result

Table 7: Estimates of the asymmetry parameter α under lin-lin loss

	k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.55	0.06	0.46	0.55	0.06	0.44	0.55	0.06	0.42	0.55	0.06	0.42
BE	0.55	0.06	0.46	0.55	0.06	0.45	0.55	0.06	0.45	0.55	0.06	0.45
LU	0.47	0.06	0.62	0.47	0.06	0.60	0.47	0.06	0.61	0.47	0.06	0.59
UR	0.56	0.06	0.32	0.58	0.06	0.21	0.57	0.06	0.27	0.58	0.06	0.21
SZ	0.53	0.06	0.62	0.52	0.06	0.80	0.52	0.06	0.80	0.52	0.06	0.80
OW	0.53	0.06	0.62	0.53	0.06	0.60	0.53	0.06	0.58	0.53	0.06	0.57
NW	0.52	0.06	0.81	0.52	0.06	0.80	0.52	0.06	0.80	0.52	0.06	0.80
GL	0.53	0.06	0.62	0.53	0.06	0.62	0.53	0.06	0.62	0.53	0.06	0.62
ZG	0.47	0.06	0.62	0.47	0.06	0.61	0.47	0.06	0.61	0.47	0.06	0.61
FR	0.44	0.06	0.32	0.44	0.06	0.31	0.44	0.06	0.30	0.44	0.06	0.30
SO	0.52	0.06	0.81	0.52	0.06	0.73	0.52	0.06	0.76	0.52	0.06	0.72
BS	0.48	0.06	0.81	0.50	0.06	1.00	0.50	0.06	1.00	0.50	0.06	1.00
BL	0.56	0.06	0.32	0.55	0.06	0.45	0.55	0.06	0.45	0.55	0.06	0.45
SH	0.45	0.06	0.38	0.46	0.06	0.52	0.45	0.06	0.45	0.46	0.06	0.52
AR	0.47	0.06	0.62	0.47	0.06	0.61	0.47	0.06	0.61	0.47	0.06	0.61
AI	0.50	0.06	1.00	0.50	0.06	1.00	0.50	0.06	1.00	0.50	0.06	1.00
SG	0.44	0.06	0.32	0.44	0.06	0.30	0.44	0.06	0.31	0.44	0.06	0.30
GR	0.50	0.06	1.00	0.50	0.06	1.00	0.50	0.06	1.00	0.50	0.06	1.00
AG	0.52	0.06	0.81	0.52	0.06	0.79	0.52	0.06	0.79	0.52	0.06	0.78
TG	0.52	0.06	0.81	0.52	0.06	0.79	0.52	0.06	0.76	0.52	0.06	0.75
TI	0.47	0.06	0.62	0.47	0.06	0.61	0.47	0.06	0.60	0.46	0.06	0.57
VD	0.47	0.06	0.61	0.47	0.06	0.60	0.46	0.06	0.52	0.47	0.06	0.60
VS	0.41	0.06	0.13	0.39	0.06	0.08	0.36	0.06	0.02	0.35	0.06	0.01
NE	0.56	0.06	0.32	0.58	0.06	0.18	0.58	0.06	0.18	0.58	0.06	0.17
GE	0.55	0.06	0.46	0.56	0.06	0.31	0.58	0.06	0.22	0.58	0.06	0.22
JU	0.45	0.09	0.59	0.48	0.09	0.85	0.48	0.09	0.85	0.48	0.09	0.84

The entries in columns p are p-values for testing the null hypothesis $H_0 : \alpha = \frac{1}{2}$.

is very different from what we observed for the percent forecast error. Therefore, conversely to the rationality tests for the percent forecast errors, we do not expect that assuming $\alpha = \frac{1}{2}$ or not will substantially alter the outcome of the rationality tests.

5.2.2 Rationality tests under linear loss : results

As for the percent forecast error, we now compare the results of the rationality tests for the growth rate of tax revenue forecasts when $\alpha = \frac{1}{2}$ and when α can take any value between zero and one. Table 8 shows that the hypothesis of rationality holds for a clear majority of Swiss cantons irrespective of whether $\alpha = \frac{1}{2}$ is imposed. When $\alpha = \frac{1}{2}$, the null hypothesis of rationality is strongly rejected only for VS ($k = 2, 3, 4$), UR ($k = 2$), GE ($k = 3$), and SO ($k = 2, 3, 4$). When relaxing the assumption that $\alpha = \frac{1}{2}$, the results are slightly modified since rationality is rejected in three more cases : TG ($k = 3, 4$) and BS ($k = 3$). These results provide us with strong evidence for rationality of growth rate of direct tax revenue forecasts in the Swiss cantons. As for the percent forecast errors, we check for the robustness of our

Table 8: Rationality test under linear loss

	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	0.55	0.46	1.45	0.48	2.52	0.28	2.63	0.45	0.85	0.36	1.88	0.17	1.98	0.37
BE	0.55	0.46	0.60	0.74	0.69	0.71	0.75	0.86	0.03	0.86	0.12	0.73	0.18	0.91
LU	0.24	0.62	2.09	0.35	1.15	0.56	2.28	0.52	1.81	0.18	0.89	0.35	1.99	0.37
UR	0.98	0.32	7.44	0.02	3.80	0.15	7.57	0.06	5.90	0.02	2.60	0.11	6.01	0.05
SZ	0.24	0.62	0.10	0.95	0.06	0.97	0.11	0.99	0.04	0.85	0.00	1.00	0.05	0.98
OW	0.24	0.62	1.83	0.40	2.99	0.22	3.72	0.29	1.55	0.21	2.69	0.10	3.40	0.18
NW	0.06	0.81	0.07	0.97	0.10	0.95	0.13	0.99	0.00	0.95	0.04	0.85	0.06	0.97
GL	0.24	0.62	0.25	0.88	0.27	0.88	0.27	0.97	0.00	0.99	0.01	0.90	0.02	0.99
ZG	0.24	0.62	0.54	0.77	0.63	0.73	0.68	0.88	0.28	0.60	0.37	0.54	0.42	0.81
FR	0.98	0.32	1.43	0.49	1.98	0.37	2.05	0.56	0.39	0.53	0.90	0.34	0.97	0.62
SO	0.06	0.81	8.65	0.01	6.22	0.04	9.75	0.02	8.53	0.00	6.13	0.01	9.63	0.01
BS	0.06	0.81	0.99	0.61	4.64	0.10	4.79	0.19	0.99	0.32	4.64	0.03	4.79	0.09
BL	0.98	0.32	0.78	0.68	0.82	0.67	0.88	0.83	0.21	0.65	0.24	0.63	0.31	0.86
SH	0.76	0.38	0.94	0.62	0.58	0.75	1.01	0.80	0.53	0.47	0.01	0.91	0.59	0.74
AR	0.24	0.62	0.97	0.62	0.50	0.78	1.00	0.80	0.71	0.40	0.24	0.62	0.74	0.69
AI	0.00	1.00	0.00	1.00	0.03	0.98	0.07	1.00	0.00	0.97	0.03	0.86	0.07	0.97
SG	0.98	0.32	1.73	0.42	1.06	0.59	1.73	0.63	0.67	0.41	0.04	0.84	0.67	0.72
GR	0.00	1.00	0.17	0.92	0.02	0.99	0.19	0.98	0.17	0.68	0.02	0.90	0.19	0.91
AG	0.06	0.81	2.45	0.29	1.65	0.44	2.91	0.41	2.38	0.12	1.58	0.21	2.83	0.24
TG	0.06	0.81	2.72	0.26	5.98	0.05	6.76	0.08	2.65	0.10	5.89	0.02	6.66	0.04
TI	0.24	0.62	0.79	0.67	1.54	0.46	3.77	0.29	0.53	0.47	1.27	0.26	3.45	0.18
VD	0.26	0.61	0.68	0.71	0.41	0.81	0.79	0.85	0.40	0.53	0.00	0.99	0.51	0.78
VS	2.26	0.13	7.54	0.02	17.00	0.00	18.78	0.00	4.38	0.04	11.20	0.00	12.26	0.00
NE	0.98	0.32	3.61	0.16	3.50	0.17	3.96	0.27	1.80	0.18	1.71	0.19	2.12	0.35
GE	0.55	0.46	1.40	0.50	7.31	0.03	7.33	0.06	0.36	0.55	5.78	0.02	5.80	0.06
JU	0.29	0.59	0.05	0.98	0.64	0.73	0.96	0.81	0.01	0.91	0.60	0.44	0.92	0.63

H_0 : rationality holds

results when the loss functions are assumed to be quadratic instead of linear.

5.2.3 Estimation of the symmetry parameter under quadratic loss

When assuming a quadratic loss function, evidence supporting the symmetry of the loss functions is even stronger. Indeed Table 9 shows that the null hypothesis of symmetry ($\alpha = \frac{1}{2}$) cannot be rejected for any canton. Therefore, as under linear loss function, we do not expect that relaxing the assumption that $\alpha = \frac{1}{2}$ will make a big difference for the outcome of the rationality tests.

Table 9: Estimates of the asymmetry parameter α under quad-quad loss

	k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.48	0.08	0.76	0.49	0.08	0.86	0.48	0.08	0.80	0.48	0.08	0.82
BE	0.55	0.07	0.46	0.53	0.07	0.64	0.54	0.07	0.64	0.53	0.07	0.64
LU	0.53	0.08	0.70	0.53	0.08	0.75	0.53	0.08	0.70	0.53	0.08	0.66
UR	0.50	0.09	0.99	0.55	0.09	0.56	0.53	0.09	0.71	0.54	0.09	0.60
SZ	0.51	0.08	0.94	0.47	0.09	0.74	0.49	0.09	0.88	0.47	0.08	0.74
OW	0.49	0.09	0.91	0.50	0.09	0.97	0.51	0.09	0.94	0.50	0.09	0.99
NW	0.50	0.08	1.00	0.52	0.08	0.84	0.52	0.09	0.81	0.52	0.08	0.81
GL	0.52	0.08	0.83	0.50	0.08	0.96	0.50	0.08	0.98	0.50	0.08	0.97
ZG	0.51	0.08	0.91	0.52	0.08	0.80	0.52	0.08	0.79	0.52	0.08	0.79
FR	0.53	0.08	0.73	0.51	0.08	0.86	0.52	0.08	0.79	0.52	0.08	0.79
SO	0.50	0.09	0.97	0.37	0.08	0.09	0.42	0.08	0.29	0.39	0.08	0.15
BS	0.48	0.08	0.82	0.48	0.08	0.82	0.47	0.08	0.75	0.47	0.08	0.70
BL	0.52	0.09	0.84	0.52	0.09	0.82	0.52	0.09	0.87	0.52	0.09	0.83
SH	0.49	0.09	0.95	0.50	0.09	0.97	0.50	0.09	0.99	0.47	0.09	0.76
AR	0.50	0.08	0.97	0.49	0.08	0.93	0.50	0.08	1.00	0.49	0.08	0.94
AI	0.47	0.08	0.75	0.48	0.08	0.77	0.47	0.09	0.72	0.48	0.08	0.78
SG	0.52	0.08	0.81	0.51	0.08	0.88	0.51	0.08	0.91	0.51	0.08	0.92
GR	0.52	0.09	0.85	0.46	0.08	0.60	0.45	0.08	0.58	0.45	0.08	0.58
AG	0.52	0.08	0.84	0.52	0.08	0.81	0.50	0.08	0.97	0.50	0.08	0.99
TG	0.51	0.09	0.87	0.49	0.08	0.87	0.50	0.08	0.96	0.49	0.08	0.87
TI	0.50	0.08	0.97	0.50	0.08	0.99	0.50	0.08	0.97	0.50	0.08	0.97
VD	0.53	0.09	0.69	0.51	0.09	0.88	0.50	0.09	0.99	0.51	0.09	0.88
VS	0.52	0.09	0.79	0.49	0.09	0.93	0.40	0.08	0.23	0.40	0.08	0.22
NE	0.52	0.09	0.85	0.57	0.09	0.45	0.55	0.09	0.63	0.55	0.09	0.55
GE	0.51	0.08	0.86	0.52	0.09	0.78	0.51	0.09	0.88	0.50	0.08	0.98
JU	0.47	0.11	0.78	0.49	0.11	0.92	0.50	0.11	0.97	0.44	0.11	0.60

The entries in columns p are p-values for testing the null hypothesis $H_0 : \alpha = \frac{1}{2}$.

5.2.4 Rationality tests under quadratic loss : results

Given the parameter α estimated above and given $p = 2$, we run rationality tests first imposing $\alpha = \frac{1}{2}$ and then relaxing it. Table 10 clearly shows that rationality is not rejected in a large majority of cases. The rationality hypothesis is rejected only for SO ($k = 2, 3, 4$) and VS ($k = 3, 4$). Relaxing $\alpha = \frac{1}{2}$ does not alter the results

6 Evolution over time

Since the information displayed in Figures 2—6 reveals that the systematic underestimation of actual tax revenues tend be less pronounced over time, we splitted the sample roughly in halves (1944–1978 and 1979–2010)and redone all estimations for every sub-sample. The choice of the starting year for the second sub-sample coincides with the year when the canton

Table 10: Rationality test under quadratic loss

	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	0.10	0.76	2.93	0.23	1.98	0.37	3.36	0.34	2.91	0.09	1.91	0.17	3.31	0.19
BE	0.54	0.46	0.24	0.89	0.24	0.89	0.25	0.97	0.02	0.87	0.02	0.90	0.04	0.98
LU	0.15	0.70	2.37	0.31	1.39	0.50	2.83	0.42	2.27	0.13	1.24	0.27	2.64	0.27
UR	0.00	0.99	5.29	0.07	3.55	0.17	5.30	0.15	4.96	0.03	3.41	0.06	5.03	0.08
SZ	0.01	0.94	3.55	0.17	0.36	0.83	3.56	0.31	3.44	0.06	0.34	0.56	3.44	0.18
OW	0.01	0.91	0.37	0.83	1.18	0.55	1.40	0.71	0.37	0.54	1.17	0.28	1.40	0.50
NW	0.00	1.00	0.05	0.97	0.65	0.72	0.65	0.89	0.01	0.92	0.59	0.44	0.59	0.74
GL	0.05	0.83	0.93	0.63	0.56	0.76	0.95	0.81	0.93	0.34	0.56	0.45	0.95	0.62
ZG	0.01	0.91	0.43	0.81	0.29	0.86	0.44	0.93	0.36	0.55	0.22	0.64	0.37	0.83
FR	0.12	0.73	3.37	0.19	0.42	0.81	3.71	0.29	3.33	0.07	0.35	0.55	3.64	0.16
SO	0.00	0.97	10.29	0.01	5.05	0.08	10.28	0.02	7.40	0.01	3.93	0.05	8.18	0.02
BS	0.05	0.82	0.50	0.78	2.16	0.34	2.31	0.51	0.45	0.50	2.06	0.15	2.16	0.34
BL	0.04	0.84	3.29	0.19	1.21	0.54	3.46	0.33	3.24	0.07	1.19	0.28	3.42	0.18
SH	0.00	0.95	0.65	0.72	0.10	0.95	1.87	0.60	0.65	0.42	0.10	0.76	1.78	0.41
AR	0.00	0.97	2.33	0.31	0.24	0.88	3.31	0.35	2.32	0.13	0.24	0.62	3.30	0.19
AI	0.10	0.75	0.30	0.86	0.14	0.93	0.34	0.95	0.22	0.64	0.02	0.89	0.26	0.88
SG	0.06	0.81	0.03	0.99	0.14	0.93	0.14	0.99	0.00	0.96	0.12	0.72	0.13	0.94
GR	0.04	0.85	0.71	0.70	0.86	0.65	0.90	0.82	0.43	0.51	0.55	0.46	0.59	0.74
AG	0.04	0.84	0.86	0.65	1.37	0.50	1.77	0.62	0.80	0.37	1.37	0.24	1.77	0.41
TG	0.03	0.87	1.20	0.55	4.64	0.10	5.15	0.16	1.17	0.28	4.64	0.03	5.12	0.08
TI	0.00	0.97	0.56	0.76	0.77	0.68	1.49	0.69	0.56	0.46	0.76	0.38	1.49	0.48
VD	0.15	0.69	0.54	0.76	0.25	0.88	0.58	0.90	0.51	0.47	0.25	0.62	0.56	0.76
VS	0.07	0.79	3.56	0.17	7.38	0.02	7.82	0.05	3.55	0.06	5.95	0.01	6.31	0.04
NE	0.04	0.85	3.22	0.20	3.29	0.19	3.51	0.32	2.66	0.10	3.06	0.08	3.16	0.21
GE	0.03	0.86	0.25	0.88	2.69	0.26	5.70	0.13	0.17	0.68	2.66	0.10	5.70	0.06
JU	0.08	0.78	0.12	0.94	1.68	0.43	4.29	0.23	0.11	0.73	1.68	0.20	4.02	0.13

H_0 : rationality holds

of Jura was established. The corresponding estimation results are reported in Tables 11–14 for percent forecast errors and Tables 15–18 for growth forecasts errors in Appendix.

The median estimates of the asymmetry parameter α for percent forecast errors are 0.11 for $p = 1$ and 0.04 for $p = 2$ for the first sub-sample and 0.28 for $p = 1$ and 0.20 for $p = 2$ for the second subsample. The comparable median estimates of the asymmetry parameter α for growth rate forecast errors are 0.50 for $p = 1$ and 0.52 for $p = 2$ for the first sub-sample and 0.50 for $p = 1$ and 0.49 for $p = 2$ for the second subsample. The information about time evolution of the estimates of α is summarised in Figures 11–12 and 13–14 for percent- and growth rate forecast errors. Estimates of the parameter α for the second sub-sample (1979–2010) at the y-axis are plotted against corresponding estimates for the first sub-period (1944–1978). In each figure the straight line corresponds to a 45-degree line. If a point lies on this line than it means that estimates of α are identical for both the periods. If a point lies below this line than it means that an estimate of α for the second period is lower than that for the first period. For points above the line—the opposite is the case. As seen from Figures 11–12 concerning percent forecast errors, for most cantons the estimates of α obtained for the second period are larger than those obtained for the first period. It is also remarkable that for the following three cantons—Basel-Stadt (BS), Glarus (GL) and Uri (UR)—,for which in the first period in every single year the actual outturn was larger than predicted values, the corresponding estimates of α for the second sub-sample are 0.38, 0.28 and 0.44, respectively, under the assumption of a linear loss function. As expected, for growth rate forecast errors there is no much change that takes place for estimates of α obtained for these two sub-samples. In fact, the estimates are centered around $\alpha = 0.50$ value, as shown in Figures 13–14.

7 Conclusion

Forecasting and budgeting government revenue and expenditure accurately is a key component of an efficient fiscal policy. Misforecasting and misbudgeting either revenue or expenditure may create or amplify fiscal disequilibrium, i.e. deficits or surpluses. Forecasting and budgeting tax revenue is particularly important since it sets the budgetary limits within which public spending should remain in order to reach a fiscal balance. Therefore, in order to implement sound fiscal policy, it is crucial for the government to have accurate and reliable revenue estimates. In the current paper, we extend the literature on revenue forecasts by testing the rationality of direct tax revenue using a new dataset on Swiss cantons over 1944-2010. We apply the method developed by Elliott et al. (2005) which allows one to relax the assumption of a symmetric loss function of the forecaster. We find that, when the percent error of direct tax revenue forecasts is considered, loss functions underlying the forecasts are strongly asymmetric. Indeed, in a majority of cantons, revenue forecasters seem to consider positive error (underestimation) as less costly than negative errors (overestimation) of the same absolute size. In the most extreme cases, negative errors are considered up to more than 30 times costlier than positive errors. We also show that relaxing the assumption of a symmetric loss function does substantially alter the outcome of the rationality tests. Directs tax revenue forecasts which turned out to not be rational when assuming a symmetric loss function turned out to be rational in a majority of cases when we allow for a more general class of loss functions.

Another striking result is that we find a completely different picture when we consider the direct tax revenue forecast expressed in growth rate. Indeed we show that assuming the loss functions to be symmetric is an empirically realistic assumption when considering growth rates. Consequently, relaxing the symmetric loss assumption when we perform rationality tests does not substantially alter the outcome. The direct tax revenue forecasts expressed in growth rates turn out to be rational in a majority of cases.

We also investigate how estimates of asymmetry parameter α depend on the sample used for estimation. To this end, we divided the whole sample into two sub-samples: from 1944 until 1978 and from 1979 until 2010. In the case of percent forecast errors, we observe that the systematic bias of underestimation of future tax revenues attenuates over time but has not vanished yet. In case of growth rate forecasts, estimation for either sub-sample are very similar to the results obtained for the whole sample.

To conclude, our empirical results tend to show that revenue officers do a good job in predicting the growth rate of direct tax revenue but do so at a level that is systematically lower than the level of actual revenue. We also show that, in most cantons, this systematic underestimation is primarily due to an underlying asymmetric loss function rather than a poor utilization of information. Finally, our empirical results also suggest that, overall, Swiss cantons have been reducing underestimation over time. On a fiscal policy point of view, showing that underestimating tax revenue may be rational is in line with results showing that underestimating tax revenue may reduce fiscal deficits (Chatagny and Soguel, 2012). Since department of finances are in charge of predicting tax revenue and since they are headed by the finance minister, our empirical results are also in line with theoretical analyses that suggest appointing a prudent and fiscally conservative finance minister may be fiscally optimal (van der Ploeg, 2010) (Swank, 2002). Finally, while underestimating tax revenue may be fiscally desirable one have to bear in mind that such a strategy also detracts resources from the political debate. The use of the corresponding revenue windfalls may therefore not reflect citizens' fiscal preferences. On the long run, we would rather advocate unbiased revenue predictions combined with fiscal rules that take prudence explicitly into account.

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Appendix

Table 11: Parameter estimates under linear loss and tests of symmetry: percent forecast errors

	1944-1978												1979-2010											
	k=1			k=2			k=3			k=4			k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.23	0.07	0.00	0.23	0.07	0.00	0.24	0.07	0.00	0.22	0.07	0.00	0.41	0.09	0.28	0.40	0.09	0.27	0.40	0.09	0.25	0.40	0.09	0.23
BE	0.14	0.06	0.00	0.15	0.06	0.00	0.15	0.06	0.00	0.15	0.06	0.00	0.72	0.08	0.01	0.72	0.08	0.01	0.72	0.08	0.01	0.72	0.08	0.01
LU	0.06	0.04	0.00	0.04	0.04	0.00	0.05	0.04	0.00	0.00	0.00	0.00	0.31	0.08	0.02	0.31	0.08	0.02	0.30	0.08	0.01	0.30	0.08	0.01
UR[a]	0.00	.	.	0.00	.	.	0.00	.	.	0.00	.	.	0.44	0.09	0.48	0.41	0.09	0.29	0.43	0.09	0.40	0.39	0.09	0.19
SZ	0.06	0.04	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.08	0.01	0.18	0.07	0.00	0.21	0.07	0.00	0.12	0.06	0.00
OW	0.11	0.05	0.00	0.11	0.05	0.00	0.10	0.05	0.00	0.09	0.05	0.00	0.22	0.07	0.00	0.21	0.07	0.00	0.21	0.07	0.00	0.21	0.07	0.00
NW	0.03	0.03	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.08	0.02	0.31	0.08	0.02	0.24	0.08	0.00	0.24	0.08	0.00
GL[a]	0.00	.	.	0.00	.	.	0.00	.	.	0.00	.	.	0.28	0.08	0.01	0.11	0.06	0.00	0.02	0.02	0.00	0.02	0.02	0.00
ZG	0.20	0.07	0.00	0.16	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.05	0.00	0.09	0.05	0.00	0.08	0.05	0.00	0.00	0.01	0.00
FR	0.09	0.05	0.00	0.06	0.04	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.09	0.05	0.00	0.09	0.05	0.00	0.07	0.05	0.00	0.07	0.05	0.00
SO	0.09	0.05	0.00	0.03	0.03	0.00	0.09	0.05	0.00	0.01	0.02	0.00	0.34	0.08	0.06	0.34	0.08	0.05	0.33	0.08	0.05	0.33	0.08	0.03
BS[a]	0.00	.	.	0.00	.	.	0.00	.	.	0.00	.	.	0.38	0.09	0.14	0.37	0.09	0.14	0.37	0.09	0.14	0.37	0.09	0.14
BL	0.26	0.07	0.00	0.26	0.08	0.00	0.25	0.08	0.00	0.20	0.07	0.00	0.25	0.08	0.00	0.20	0.07	0.00	0.24	0.08	0.00	0.20	0.07	0.00
SH	0.38	0.08	0.16	0.36	0.09	0.11	0.38	0.08	0.16	0.34	0.08	0.05	0.41	0.09	0.28	0.41	0.09	0.28	0.40	0.09	0.23	0.40	0.09	0.23
AR	0.14	0.06	0.00	0.13	0.06	0.00	0.15	0.06	0.00	0.13	0.06	0.00	0.28	0.08	0.01	0.28	0.08	0.01	0.28	0.08	0.00	0.27	0.08	0.00
AI	0.09	0.05	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.00	0.00	0.00	0.13	0.06	0.00	0.11	0.06	0.00	0.00	0.01	0.00	0.00	0.01	0.00
SG	0.20	0.07	0.00	0.21	0.07	0.00	0.20	0.07	0.00	0.20	0.07	0.00	0.22	0.07	0.00	0.16	0.07	0.00	0.21	0.07	0.00	0.16	0.06	0.00
GR	0.09	0.05	0.00	0.05	0.04	0.00	0.05	0.04	0.00	0.04	0.04	0.00	0.13	0.06	0.00	0.09	0.05	0.00	0.01	0.01	0.00	0.01	0.01	0.00
AG	0.11	0.05	0.00	0.12	0.06	0.00	0.06	0.04	0.00	0.06	0.04	0.00	0.25	0.08	0.00	0.22	0.07	0.00	0.16	0.06	0.00	0.08	0.05	0.00
TG	0.23	0.07	0.00	0.17	0.07	0.00	0.20	0.07	0.00	0.16	0.06	0.00	0.28	0.08	0.01	0.25	0.08	0.00	0.28	0.08	0.01	0.25	0.08	0.00
TI	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.07	0.00	0.19	0.07	0.00	0.17	0.07	0.00	0.17	0.07	0.00
VD	0.19	0.07	0.00	0.09	0.05	0.00	0.10	0.05	0.00	0.09	0.05	0.00	0.31	0.08	0.02	0.17	0.07	0.00	0.31	0.08	0.02	0.16	0.06	0.00
VS	0.11	0.05	0.00	0.11	0.05	0.00	0.04	0.03	0.00	0.02	0.02	0.00	0.13	0.06	0.00	0.12	0.06	0.00	0.12	0.06	0.00	0.11	0.06	0.00
NE	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.09	0.14	0.37	0.09	0.14	0.37	0.09	0.12	0.37	0.09	0.12
GE	0.20	0.07	0.00	0.09	0.05	0.00	0.12	0.06	0.00	0.09	0.05	0.00	0.41	0.09	0.28	0.40	0.09	0.27	0.40	0.09	0.26	0.40	0.09	0.25
JU													0.50	0.09	1.00	0.47	0.09	0.71	0.47	0.09	0.71	0.47	0.09	0.71

[a] For these cantons estimation was not possible due to the fact that for all years in the first sub-sample (1944–1978) the percent forecast errors are negative; i.e. for each year the outturn was higher than predicted values. The value of the parameter α is set to zero.

Table 12: Rationality test under linear loss: percent forecast errors

	1944-1978													
	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	14.62	0.00	14.48	0.00	12.64	0.00	15.56	0.00	0.80	0.37	0.24	0.63	1.10	0.58
BE	36.46	0.00	31.18	0.00	32.24	0.00	32.27	0.00	0.00	0.98	0.13	0.72	0.13	0.94
LU	127.41	0.00	160.25	0.00	147.01	0.00	3.7e08	0.00	0.57	0.45	0.45	0.50	16.68	0.00
UR[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	0.00
SZ	127.41	0.00	186.41	0.00	3.1e04	0.00	2.8e08	0.00	0.76	0.38	1.99	0.16	13.14	0.00
OW	51.44	0.00	54.25	0.00	62.21	0.00	73.71	0.00	0.61	0.43	0.99	0.32	1.41	0.49
NW	280.26	0.00	248.99	0.00	2.9e08	0.00	2.9e08	0.00	0.00	0.94	12.58	0.00	12.66	0.00
GL[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	0.00
ZG	19.69	0.00	30.00	0.00	1.2e04	0.00	1.2e04	0.00	2.42	0.12	6.99	0.01	6.99	0.03
FR	76.65	0.00	108.47	0.00	1.8e03	0.00	2.9e03	0.00	1.06	0.30	2.87	0.09	2.92	0.23
SO	76.65	0.00	235.07	0.00	67.74	0.00	632.38	0.00	2.08	0.15	0.04	0.85	2.65	0.27
BS[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	0.00
BL	10.81	0.00	10.67	0.00	12.41	0.00	21.72	0.00	0.84	0.36	1.47	0.23	3.85	0.15
SH	1.99	0.16	7.50	0.02	3.75	0.15	10.74	0.01	4.96	0.03	1.78	0.18	6.87	0.03
AR	36.46	0.00	42.71	0.00	33.28	0.00	42.81	0.00	1.10	0.29	0.24	0.62	1.11	0.57
AI	76.65	0.00	1.3e04	0.00	193.31	0.00	1.6e08	0.00	1.98	0.16	0.81	0.37	8.39	0.02
SG	19.69	0.00	16.41	0.00	18.22	0.00	18.32	0.00	0.01	0.92	0.44	0.50	0.47	0.79
GR	76.65	0.00	139.59	0.00	135.84	0.00	167.01	0.00	1.47	0.22	1.43	0.23	1.71	0.42
AG	51.44	0.00	44.73	0.00	108.26	0.00	114.48	0.00	0.02	0.89	2.19	0.14	2.28	0.32
TG	14.62	0.00	27.77	0.00	19.67	0.00	30.21	0.00	2.13	0.14	0.76	0.38	2.45	0.29
TI	280.26	0.00	5.9e08	0.00	2.5e08	0.00	5.9e08	0.00	24.71	0.00	11.11	0.00	24.74	0.00
VD	18.65	0.00	63.95	0.00	60.29	0.00	67.42	0.00	4.14	0.04	3.86	0.05	4.23	0.12
VS	51.44	0.00	54.81	0.00	202.30	0.00	470.02	0.00	0.64	0.42	3.00	0.08	3.57	0.17
NE	280.26	0.00	1.8e08	0.00	6.6e08	0.00	6.8e08	0.00	8.28	0.00	27.33	0.00	28.31	0.00
GE	19.69	0.00	71.96	0.00	48.19	0.00	73.00	0.00	4.89	0.03	3.95	0.05	4.93	0.09
JU														

	1979-2010													
	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	1.17	0.28	1.72	0.42	2.20	0.33	2.91	0.41	0.48	0.49	0.89	0.35	1.48	0.48
BE	7.57	0.01	7.85	0.02	7.75	0.02	8.07	0.04	0.12	0.73	0.08	0.78	0.22	0.89
LU	5.24	0.02	5.36	0.07	7.66	0.02	7.78	0.05	0.07	0.79	1.28	0.26	1.34	0.51
UR[a]	0.51	0.48	6.18	0.05	3.11	0.21	8.91	0.03	5.07	0.02	2.41	0.12	7.18	0.03
SZ	7.57	0.01	26.35	0.00	19.39	0.00	48.69	0.00	4.94	0.03	3.78	0.05	6.71	0.03
OW	14.81	0.00	16.73	0.00	16.40	0.00	17.50	0.00	0.49	0.48	0.41	0.52	0.67	0.72
NW	5.24	0.02	6.30	0.04	16.12	0.00	16.13	0.00	0.59	0.44	4.41	0.04	4.41	0.11
GL[a]	7.57	0.01	55.17	0.00	393.74	0.00	473.11	0.00	6.97	0.01	8.72	0.00	8.76	0.01
ZG	62.16	0.00	64.55	0.00	74.46	0.00	3.9e03	0.00	0.10	0.76	0.44	0.51	2.95	0.23
FR	62.16	0.00	63.60	0.00	85.98	0.00	85.98	0.00	0.06	0.81	0.75	0.39	0.75	0.69
SO	3.46	0.06	4.73	0.09	4.78	0.09	6.19	0.10	0.83	0.36	0.86	0.35	1.72	0.42
BS[a]	2.13	0.14	2.15	0.34	2.15	0.34	2.18	0.54	0.01	0.91	0.01	0.92	0.03	0.98
BL	10.67	0.00	19.62	0.00	12.39	0.00	20.26	0.00	2.46	0.12	0.59	0.44	2.59	0.27
SH	1.17	0.28	1.21	0.55	3.03	0.22	3.16	0.37	0.04	0.84	1.58	0.21	1.69	0.43
AR	7.57	0.01	7.70	0.02	8.55	0.01	8.59	0.04	0.06	0.81	0.43	0.51	0.45	0.80
AI	41.14	0.00	49.98	0.00	1.7e03	0.00	1.9e03	0.00	0.60	0.44	3.89	0.05	3.90	0.14
SG	14.81	0.00	29.25	0.00	15.98	0.00	30.99	0.00	2.64	0.10	0.30	0.58	2.84	0.24
GR	41.14	0.00	71.08	0.00	1.3e03	0.00	1.3e03	0.00	1.50	0.22	3.85	0.05	3.86	0.15
AG	10.67	0.00	15.61	0.00	33.00	0.00	81.17	0.00	1.53	0.22	4.36	0.04	6.44	0.04
TG	7.57	0.01	12.51	0.00	7.66	0.02	12.53	0.01	1.95	0.16	0.04	0.84	1.95	0.38
TI	20.51	0.00	21.12	0.00	26.46	0.00	27.10	0.00	0.11	0.74	0.98	0.32	1.07	0.59
VD	5.24	0.02	32.44	0.00	6.14	0.05	35.14	0.00	6.98	0.01	0.50	0.48	7.22	0.03
VS	41.14	0.00	43.21	0.00	45.43	0.00	50.37	0.00	0.16	0.69	0.31	0.58	0.62	0.73
NE	2.13	0.14	2.20	0.33	3.13	0.21	3.25	0.35	0.05	0.82	0.76	0.38	0.85	0.65
GE	1.17	0.28	1.43	0.49	1.80	0.41	2.24	0.52	0.23	0.63	0.55	0.46	0.92	0.63
JU	0.00	1.00	0.18	0.91	0.18	0.91	0.23	0.97	0.05	0.83	0.05	0.83	0.09	0.96

[a] For these cantons estimation was not possible due to the fact that for all years in the first sub-sample (1944–1978) the percent forecast errors are negative; i.e. for each year the outturn was higher than predicted values.

Table 13: Parameter estimates under quadratic loss and tests of symmetry: percent forecast errors

	1944-1978												1979-2010											
	k=1			k=2			k=3			k=4			k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.24	0.08	0.00	0.26	0.09	0.01	0.22	0.08	0.00	0.19	0.07	0.00	0.36	0.11	0.19	0.35	0.10	0.15	0.36	0.10	0.16	0.35	0.10	0.15
BE	0.05	0.03	0.00	0.06	0.03	0.00	0.03	0.02	0.00	0.03	0.02	0.00	0.79	0.08	0.00	0.79	0.08	0.00	0.81	0.08	0.00	0.83	0.07	0.00
LU	0.03	0.03	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.20	0.07	0.00	0.18	0.06	0.00	0.20	0.07	0.00	0.18	0.06	0.00
UR[a]	0.00	.	.	0.00	.	.	0.00	.	.	0.00	.	.	0.48	0.11	0.87	0.49	0.11	0.90	0.48	0.11	0.85	0.48	0.11	0.88
SZ	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.08	0.00	0.09	0.06	0.00	0.05	0.05	0.00	0.02	0.04	0.00
OW	0.04	0.03	0.00	0.03	0.02	0.00	0.04	0.02	0.00	0.03	0.02	0.00	0.17	0.08	0.00	0.12	0.06	0.00	0.14	0.07	0.00	0.12	0.06	0.00
NW	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.04	0.00	0.09	0.04	0.00	0.03	0.02	0.00	0.03	0.02	0.00
GL[a]	0.00	.	.	0.00	.	.	0.00	.	.	0.00	.	.	0.12	0.05	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.01	0.00
ZG	0.12	0.05	0.00	0.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FR	0.03	0.02	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00
SO	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.33	0.11	0.13	0.33	0.11	0.12	0.32	0.11	0.09	0.32	0.11	0.08
BS[a]	0.00	.	.	0.00	.	.	0.00	.	.	0.00	.	.	0.24	0.08	0.00	0.24	0.08	0.00	0.24	0.08	0.00	0.24	0.08	0.00
BL	0.13	0.05	0.00	0.15	0.06	0.00	0.08	0.05	0.00	0.04	0.03	0.00	0.13	0.06	0.00	0.13	0.06	0.00	0.12	0.05	0.00	0.11	0.05	0.00
SH	0.53	0.12	0.82	0.43	0.12	0.57	0.56	0.10	0.58	0.51	0.10	0.92	0.38	0.10	0.22	0.38	0.10	0.22	0.33	0.10	0.07	0.33	0.10	0.07
AR	0.05	0.03	0.00	0.05	0.03	0.00	0.05	0.03	0.00	0.05	0.03	0.00	0.23	0.09	0.00	0.23	0.09	0.00	0.23	0.09	0.00	0.22	0.08	0.00
AI	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SG	0.08	0.03	0.00	0.09	0.04	0.00	0.08	0.04	0.00	0.06	0.03	0.00	0.14	0.06	0.00	0.07	0.04	0.00	0.13	0.06	0.00	0.07	0.04	0.00
GR	0.04	0.02	0.00	0.02	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.03	0.02	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AG	0.02	0.01	0.00	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.24	0.09	0.00	0.21	0.08	0.00	0.16	0.07	0.00	0.06	0.06	0.00
TG	0.12	0.05	0.00	0.05	0.03	0.00	0.07	0.03	0.00	0.04	0.03	0.00	0.22	0.08	0.00	0.19	0.08	0.00	0.22	0.08	0.00	0.19	0.08	0.00
TI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.07	0.00	0.17	0.07	0.00	0.14	0.06	0.00	0.13	0.06	0.00
VD	0.03	0.02	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.22	0.08	0.00	0.07	0.05	0.00	0.22	0.08	0.00	0.07	0.05	0.00
VS	0.04	0.02	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.07	0.00	0.03	0.03	0.00	0.02	0.03	0.00	0.03	0.03	0.00
NE	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.09	0.04	0.26	0.08	0.00	0.31	0.09	0.04	0.26	0.08	0.00
GE	0.15	0.07	0.00	0.00	0.02	0.00	0.10	0.07	0.00	0.00	0.02	0.00	0.32	0.11	0.09	0.32	0.10	0.08	0.29	0.10	0.03	0.29	0.10	0.03
JU													0.34	0.10	0.10	0.31	0.10	0.04	0.31	0.10	0.05	0.30	0.10	0.04

[a] For these cantons estimation was not possible due to the fact that for all years in the first sub-sample (1944–1978) the percent forecast errors are negative; i.e. for each year the outturn was higher than predicted values. The value of the parameter α is set to zero.

Table 14: Rationality test under quadratic loss: percent forecast errors

1944-1978

	α = 1/2								α ∈ (0; 1)					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	9.49	0.00	8.03	0.02	13.88	0.00	19.57	0.00	0.29	0.59	1.30	0.25	1.76	0.42
BE	291.80	0.00	205.95	0.00	576.36	0.00	923.32	0.00	0.48	0.49	1.06	0.30	1.96	0.38
LU	275.29	0.00	2.1e04	0.00	1.1e03	0.00	3.5e08	0.00	0.99	0.32	0.35	0.55	16.18	0.00
UR[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	0.00
SZ	3.7e03	0.00	1.7e06	0.00	2.1e08	0.00	2.1e08	0.00	2.44	0.12	9.90	0.00	10.11	0.01
OW	324.70	0.00	435.46	0.00	390.97	0.00	558.43	0.00	0.82	0.37	0.34	0.56	1.01	0.60
NW	2.0e03	0.00	1.8e03	0.00	2.6e08	0.00	2.8e08	0.00	0.07	0.79	11.39	0.00	12.26	0.00
GL[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	0.00
ZG	51.52	0.00	159.36	0.00	5.0e04	0.00	5.6e04	0.00	3.50	0.06	5.04	0.02	5.04	0.08
FR	535.58	0.00	456.90	0.00	1.5e04	0.00	5.5e04	0.00	0.84	0.36	2.62	0.11	2.66	0.26
SO	713.98	0.00	1.2e03	0.00	2.7e03	0.00	9.9e04	0.00	2.05	0.15	0.80	0.37	2.35	0.31
BS[a]	.	.	.	.	.	.	.	.	.	.	.	.	.	0.00
BL	48.41	0.00	32.21	0.00	85.04	0.00	188.57	0.00	0.05	0.83	3.44	0.06	5.57	0.06
SH	0.05	0.82	4.36	0.11	0.52	0.77	5.84	0.12	4.04	0.04	0.22	0.64	5.83	0.05
AR	271.45	0.00	272.78	0.00	300.46	0.00	304.06	0.00	0.03	0.87	0.12	0.73	0.13	0.94
AI	79.74	0.00	3.4e06	0.00	1.1e04	0.00	7.9e07	0.00	1.04	0.31	2.58	0.11	5.11	0.08
SG	149.24	0.00	123.52	0.00	143.65	0.00	229.96	0.00	0.34	0.56	0.73	0.39	1.35	0.51
GR	394.05	0.00	657.78	0.00	3.0e03	0.00	3.0e03	0.00	1.07	0.30	1.67	0.20	1.67	0.43
AG	1.3e03	0.00	1.5e03	0.00	3.6e03	0.00	1.7e04	0.00	0.90	0.34	2.11	0.15	2.71	0.26
TG	61.52	0.00	298.28	0.00	171.00	0.00	334.44	0.00	2.61	0.11	2.16	0.14	3.29	0.19
TI	1.4e04	0.00	4.3e08	0.00	2.2e08	0.00	4.3e08	0.00	18.15	0.00	9.93	0.00	18.16	0.00
VD	678.04	0.00	4.2e03	0.00	2.7e03	0.00	4.3e03	0.00	2.76	0.10	1.63	0.20	4.02	0.13
VS	405.62	0.00	1.0e03	0.00	3.3e04	0.00	3.0e05	0.00	1.82	0.18	2.91	0.09	2.98	0.23
NE	79.17	0.00	2.4e08	0.00	4.5e08	0.00	4.8e08	0.00	10.41	0.00	18.84	0.00	20.21	0.00
GE	24.51	0.00	732.45	0.00	39.32	0.00	813.90	0.00	4.55	0.03	3.53	0.06	4.86	0.09
JU														

1979-2010

	α = 1/2								α ∈ (0; 1)					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	1.73	0.19	5.21	0.07	1.93	0.38	5.23	0.16	3.10	0.08	0.00	0.96	3.13	0.21
BE	12.67	0.00	13.04	0.00	16.28	0.00	21.16	0.00	0.11	0.74	0.95	0.33	1.73	0.42
LU	16.38	0.00	26.59	0.00	17.22	0.00	26.59	0.00	0.64	0.42	0.09	0.76	0.64	0.73
UR[a]	0.03	0.87	2.30	0.32	1.70	0.43	3.91	0.27	2.29	0.13	1.66	0.20	3.89	0.14
SZ	15.38	0.00	58.49	0.00	89.31	0.00	189.83	0.00	4.01	0.05	5.65	0.02	6.16	0.05
OW	17.84	0.00	35.72	0.00	27.43	0.00	37.16	0.00	1.29	0.26	0.71	0.40	1.30	0.52
NW	85.05	0.00	101.49	0.00	739.51	0.00	763.64	0.00	0.79	0.38	4.26	0.04	4.28	0.12
GL[a]	56.40	0.00	616.39	0.00	4.2e03	0.00	4.8e03	0.00	6.24	0.01	5.11	0.02	6.25	0.04
ZG	199.42	0.00	3.2e03	0.00	6.5e04	0.00	1.4e05	0.00	1.69	0.19	1.83	0.18	1.84	0.40
FR	575.36	0.00	2.3e03	0.00	7.4e03	0.00	7.9e03	0.00	0.53	0.47	1.11	0.29	1.20	0.55
SO	2.35	0.13	2.40	0.30	2.88	0.24	3.04	0.39	0.00	0.98	0.06	0.80	0.07	0.97
BS[a]	11.23	0.00	11.47	0.00	12.75	0.00	12.90	0.00	0.46	0.50	1.55	0.21	1.59	0.45
BL	35.37	0.00	37.06	0.00	57.11	0.00	65.28	0.00	0.09	0.76	0.13	0.72	0.95	0.62
SH	1.50	0.22	1.54	0.46	5.12	0.08	5.13	0.16	0.02	0.87	1.92	0.17	1.92	0.38
AR	7.90	0.00	9.63	0.01	9.37	0.01	10.75	0.01	0.04	0.85	0.06	0.81	0.08	0.96
AI	374.66	0.00	1.9e03	0.00	1.2e04	0.00	2.2e04	0.00	1.47	0.23	3.26	0.07	3.22	0.20
SG	33.13	0.00	151.39	0.00	36.20	0.00	153.08	0.00	1.90	0.17	0.46	0.50	2.02	0.36
GR	556.49	0.00	2.8e03	0.00	2.1e04	0.00	2.2e04	0.00	1.41	0.24	3.30	0.07	3.96	0.14
AG	9.43	0.00	13.29	0.00	24.67	0.00	69.48	0.00	1.43	0.23	3.39	0.07	5.90	0.05
TG	10.75	0.00	16.48	0.00	11.83	0.00	18.00	0.00	1.58	0.21	0.48	0.49	2.03	0.36
TI	19.29	0.00	22.60	0.00	37.04	0.00	39.87	0.00	0.28	0.60	1.01	0.32	1.10	0.58
VD	11.36	0.00	75.01	0.00	11.36	0.00	93.66	0.00	4.15	0.04	0.09	0.76	4.23	0.12
VS	30.32	0.00	299.63	0.00	296.72	0.00	328.33	0.00	1.40	0.24	2.02	0.16	2.01	0.37
NE	4.23	0.04	9.20	0.01	4.25	0.12	9.50	0.02	0.89	0.35	0.05	0.82	1.08	0.58
GE	2.83	0.09	3.14	0.21	5.34	0.07	5.34	0.15	0.01	0.90	0.45	0.50	0.52	0.77
JU	2.65	0.10	4.57	0.10	4.10	0.13	4.95	0.18	0.51	0.47	0.29	0.59	0.72	0.70

[a] For these cantons estimation was not possible due to the fact that for all years in the first sub-sample (1944–1978) the percent forecast errors are negative; i.e. for each year the outturn was higher than predicted values.

Table 15: Parameter estimates under linear loss and tests of symmetry: growth rate forecast errors

	1944-1978											
	k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.62	0.08	0.16	0.63	0.09	0.14	0.63	0.09	0.14	0.63	0.09	0.12
BE	0.59	0.08	0.30	0.60	0.09	0.26	0.59	0.09	0.28	0.60	0.09	0.26
LU	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
UR	0.53	0.09	0.73	0.54	0.09	0.65	0.54	0.09	0.69	0.54	0.09	0.65
SZ	0.53	0.09	0.73	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
OW	0.56	0.09	0.49	0.57	0.09	0.45	0.57	0.09	0.42	0.57	0.09	0.41
NW	0.44	0.09	0.49	0.44	0.09	0.46	0.43	0.09	0.45	0.43	0.09	0.45
GL	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
ZG	0.41	0.08	0.30	0.41	0.09	0.28	0.41	0.09	0.28	0.41	0.09	0.28
FR	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
SO	0.47	0.09	0.73	0.41	0.09	0.31	0.45	0.09	0.54	0.40	0.09	0.26
BS	0.56	0.09	0.49	0.60	0.09	0.26	0.61	0.09	0.21	0.61	0.09	0.21
BL	0.62	0.08	0.16	0.60	0.09	0.27	0.59	0.09	0.28	0.60	0.09	0.27
SH	0.39	0.09	0.21	0.42	0.09	0.35	0.41	0.09	0.28	0.42	0.09	0.35
AR	0.44	0.09	0.49	0.44	0.09	0.46	0.44	0.09	0.47	0.44	0.09	0.46
AI	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
SG	0.44	0.09	0.49	0.44	0.09	0.46	0.44	0.09	0.46	0.43	0.09	0.45
GR	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
AG	0.47	0.09	0.73	0.46	0.09	0.69	0.46	0.09	0.69	0.46	0.09	0.68
TG	0.56	0.09	0.49	0.57	0.09	0.45	0.57	0.09	0.42	0.57	0.09	0.41
TI	0.47	0.09	0.73	0.47	0.09	0.71	0.46	0.09	0.62	0.46	0.09	0.62
VD	0.47	0.09	0.71	0.46	0.09	0.70	0.44	0.09	0.54	0.46	0.09	0.66
VS	0.41	0.08	0.30	0.39	0.09	0.21	0.27	0.08	0.00	0.27	0.08	0.00
NE	0.59	0.08	0.30	0.64	0.09	0.11	0.64	0.08	0.11	0.64	0.08	0.10
GE	0.56	0.09	0.49	0.60	0.09	0.27	0.62	0.09	0.18	0.62	0.09	0.16
JU												

	1979-2010											
	k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.47	0.09	0.72	0.45	0.09	0.61	0.47	0.09	0.70	0.45	0.09	0.61
BE	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
LU	0.44	0.09	0.48	0.41	0.09	0.29	0.44	0.09	0.47	0.41	0.09	0.28
UR	0.59	0.09	0.28	0.62	0.09	0.17	0.65	0.08	0.08	0.65	0.08	0.07
SZ	0.53	0.09	0.72	0.53	0.09	0.70	0.53	0.09	0.72	0.53	0.09	0.69
OW	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
NW	0.59	0.09	0.28	0.61	0.09	0.19	0.61	0.09	0.21	0.62	0.09	0.16
GL	0.56	0.09	0.48	0.62	0.09	0.17	0.59	0.09	0.29	0.64	0.09	0.11
ZG	0.53	0.09	0.72	0.54	0.09	0.68	0.54	0.09	0.63	0.54	0.09	0.63
FR	0.38	0.09	0.14	0.36	0.08	0.09	0.37	0.09	0.14	0.35	0.08	0.08
SO	0.56	0.09	0.48	0.56	0.09	0.46	0.57	0.09	0.43	0.57	0.09	0.42
BS	0.41	0.09	0.28	0.40	0.09	0.26	0.39	0.09	0.20	0.55	0.09	0.58
BL	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
SH	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
AR	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
AI	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
SG	0.44	0.09	0.48	0.44	0.09	0.47	0.44	0.09	0.46	0.43	0.09	0.45
GR	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00	0.50	0.09	1.00
AG	0.56	0.09	0.48	0.56	0.09	0.46	0.57	0.09	0.43	0.57	0.09	0.43
TG	0.47	0.09	0.72	0.46	0.09	0.64	0.45	0.09	0.55	0.44	0.09	0.52
TI	0.47	0.09	0.72	0.46	0.09	0.65	0.47	0.09	0.72	0.46	0.09	0.61
VD	0.47	0.09	0.72	0.47	0.09	0.71	0.47	0.09	0.70	0.47	0.09	0.69
VS	0.41	0.09	0.28	0.39	0.09	0.19	0.36	0.08	0.10	0.36	0.08	0.10
NE	0.53	0.09	0.72	0.53	0.09	0.70	0.53	0.09	0.72	0.53	0.09	0.70
GE	0.53	0.09	0.72	0.53	0.09	0.72	0.54	0.09	0.66	0.54	0.09	0.66
JU	0.45	0.09	0.59	0.48	0.09	0.85	0.48	0.09	0.85	0.48	0.09	0.84

Table 16: Rationality test under linear loss: growth rate forecast errors

	1944-1978													
	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	1.99	0.16	2.50	0.29	2.23	0.33	3.21	0.36	0.28	0.60	0.07	0.79	0.82	0.66
BE	1.09	0.30	1.79	0.41	1.23	0.54	1.79	0.62	0.54	0.46	0.05	0.82	0.54	0.76
LU	0.00	1.00	7.83	0.02	4.08	0.13	7.99	0.05	7.83	0.01	4.08	0.04	7.99	0.02
UR	0.12	0.73	3.71	0.16	2.01	0.37	3.75	0.29	3.51	0.06	1.85	0.17	3.54	0.17
SZ	0.12	0.73	0.63	0.73	0.20	0.91	0.66	0.88	0.63	0.43	0.20	0.66	0.66	0.72
OW	0.48	0.49	1.38	0.50	2.60	0.27	2.94	0.40	0.82	0.37	1.94	0.16	2.25	0.32
NW	0.48	0.49	1.08	0.58	1.30	0.52	1.42	0.70	0.53	0.47	0.74	0.39	0.85	0.65
GL	0.00	1.00	1.87	0.39	0.98	0.61	1.95	0.58	1.87	0.17	0.98	0.32	1.95	0.38
ZG	1.09	0.30	1.24	0.54	1.17	0.56	1.25	0.74	0.06	0.81	0.01	0.94	0.07	0.97
FR	0.00	1.00	3.55	0.17	0.26	0.88	3.71	0.29	3.55	0.06	0.26	0.61	3.71	0.16
SO	0.12	0.73	11.41	0.00	7.01	0.03	12.17	0.01	10.37	0.00	6.64	0.01	10.89	0.00
BS	0.48	0.49	2.04	0.36	3.59	0.17	3.76	0.29	0.75	0.39	2.04	0.15	2.18	0.34
BL	1.99	0.16	1.51	0.47	1.18	0.55	1.55	0.67	0.30	0.58	0.01	0.92	0.33	0.85
SH	1.55	0.21	1.22	0.54	1.17	0.56	1.36	0.71	0.36	0.55	0.00	0.99	0.48	0.79
AR	0.48	0.49	0.94	0.63	0.73	0.69	0.96	0.81	0.40	0.53	0.21	0.65	0.42	0.81
AI	0.00	1.00	0.26	0.88	0.22	0.90	0.30	0.96	0.26	0.61	0.22	0.64	0.30	0.86
SG	0.48	0.49	1.14	0.57	1.10	0.58	1.47	0.69	0.59	0.44	0.56	0.45	0.90	0.64
GR	0.00	1.00	0.02	0.99	0.05	0.97	0.17	0.98	0.02	0.90	0.05	0.82	0.17	0.92
AG	0.12	0.73	1.88	0.39	2.02	0.36	2.57	0.46	1.72	0.19	1.86	0.17	2.39	0.30
TG	0.48	0.49	1.58	0.45	2.36	0.31	2.70	0.44	1.00	0.32	1.72	0.19	2.03	0.36
TI	0.12	0.73	0.83	0.66	4.90	0.09	4.90	0.18	0.69	0.41	4.65	0.03	4.65	0.10
VD	0.13	0.71	0.16	0.93	1.49	0.48	2.11	0.55	0.01	0.92	1.12	0.29	1.92	0.38
VS	1.09	0.30	3.87	0.14	18.13	0.00	18.47	0.00	2.27	0.13	9.49	0.00	9.57	0.01
NE	1.09	0.30	3.75	0.15	4.09	0.13	4.24	0.24	1.22	0.27	1.47	0.23	1.58	0.45
GE	0.48	0.49	1.46	0.48	4.75	0.09	5.47	0.14	0.25	0.62	2.96	0.09	3.51	0.17
JU														

	1979-2010													
	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	0.13	0.72	5.29	0.07	1.52	0.47	5.33	0.15	5.03	0.02	1.37	0.24	5.06	0.08
BE	0.00	1.00	2.39	0.30	0.41	0.81	3.14	0.37	2.39	0.12	0.41	0.52	3.14	0.21
LU	0.51	0.48	6.39	0.04	0.88	0.65	6.43	0.09	5.25	0.02	0.34	0.56	5.28	0.07
UR	1.17	0.28	5.26	0.07	9.02	0.01	9.70	0.02	3.35	0.07	5.91	0.02	6.30	0.04
SZ	0.13	0.72	1.44	0.49	0.45	0.80	1.78	0.62	1.29	0.26	0.32	0.57	1.62	0.44
OW	0.00	1.00	1.14	0.57	1.37	0.50	1.80	0.62	1.14	0.29	1.37	0.24	1.80	0.41
NW	1.17	0.28	4.35	0.11	3.86	0.15	5.60	0.13	2.65	0.10	2.26	0.13	3.61	0.16
GL	0.51	0.48	9.41	0.01	6.31	0.04	11.06	0.01	7.53	0.01	5.18	0.02	8.55	0.01
ZG	0.13	0.72	2.25	0.32	4.30	0.12	4.37	0.22	2.08	0.15	4.07	0.04	4.14	0.13
FR	2.13	0.14	4.85	0.09	2.38	0.30	5.46	0.14	2.00	0.16	0.19	0.66	2.42	0.30
SO	0.51	0.48	0.94	0.63	2.28	0.32	2.35	0.50	0.40	0.53	1.64	0.20	1.71	0.43
BS	1.17	0.28	1.73	0.42	3.97	0.14	2.94	0.40	0.48	0.49	2.35	0.13	4.33	0.11
BL	0.00	1.00	0.00	1.00	0.07	0.96	0.16	0.98	0.00	1.00	0.07	0.79	0.16	0.92
SH	0.00	1.00	0.20	0.91	0.23	0.89	0.59	0.90	0.20	0.66	0.23	0.63	0.59	0.74
AR	0.00	1.00	0.33	0.85	0.55	0.76	0.76	0.86	0.33	0.56	0.55	0.46	0.76	0.68
AI	0.00	1.00	0.61	0.74	0.41	0.82	0.62	0.89	0.61	0.44	0.41	0.52	0.62	0.73
SG	0.51	0.48	0.66	0.72	1.07	0.59	1.45	0.69	0.14	0.71	0.53	0.47	0.88	0.64
GR	0.00	1.00	0.72	0.70	0.50	0.78	0.83	0.84	0.72	0.40	0.50	0.48	0.83	0.66
AG	0.51	0.48	1.14	0.57	2.09	0.35	2.25	0.52	0.59	0.44	1.47	0.23	1.62	0.44
TG	0.13	0.72	4.10	0.13	6.98	0.03	7.64	0.05	3.88	0.05	6.62	0.01	7.22	0.03
TI	0.13	0.72	3.59	0.17	0.33	0.85	4.95	0.18	3.39	0.07	0.20	0.66	4.70	0.10
VD	0.13	0.72	1.08	0.58	1.39	0.50	1.81	0.61	0.94	0.33	1.24	0.27	1.65	0.44
VS	1.17	0.28	4.47	0.11	7.77	0.02	8.02	0.05	2.74	0.10	5.13	0.02	5.30	0.07
NE	0.13	0.72	1.26	0.53	0.16	0.92	1.31	0.73	1.11	0.29	0.04	0.85	1.16	0.56
GE	0.13	0.72	0.27	0.87	3.05	0.22	3.08	0.38	0.14	0.71	2.86	0.09	2.89	0.24
JU	0.29	0.59	0.05	0.98	0.64	0.73	0.96	0.81	0.01	0.91	0.60	0.44	0.92	0.63

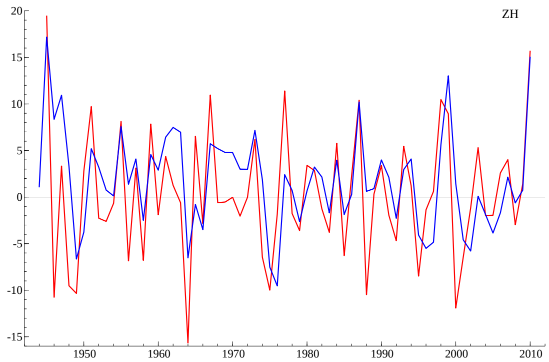
Table 17: Parameter estimates under quadratic loss and tests of symmetry: growth rate forecast errors

	1944-1978												1979-2010											
	k=1			k=2			k=3			k=4			k=1			k=2			k=3			k=4		
	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p	α	s.e.	p
ZH	0.50	0.11	0.98	0.52	0.11	0.83	0.52	0.11	0.86	0.51	0.11	0.93	0.45	0.11	0.64	0.31	0.10	0.05	0.43	0.11	0.54	0.30	0.10	0.04
BE	0.55	0.10	0.61	0.51	0.10	0.89	0.52	0.10	0.86	0.51	0.10	0.89	0.56	0.11	0.57	0.57	0.11	0.55	0.55	0.11	0.63	0.55	0.11	0.63
LU	0.55	0.11	0.67	0.66	0.10	0.12	0.55	0.11	0.66	0.66	0.10	0.10	0.50	0.11	0.97	0.49	0.11	0.91	0.51	0.11	0.95	0.49	0.11	0.92
UR	0.49	0.12	0.91	0.59	0.12	0.41	0.56	0.12	0.59	0.60	0.12	0.38	0.54	0.10	0.72	0.55	0.10	0.65	0.55	0.10	0.65	0.55	0.10	0.63
SZ	0.51	0.11	0.93	0.45	0.11	0.64	0.48	0.11	0.83	0.44	0.11	0.62	0.50	0.13	0.99	0.50	0.13	0.98	0.50	0.13	0.98	0.51	0.13	0.91
OW	0.50	0.11	0.99	0.52	0.11	0.84	0.53	0.11	0.78	0.53	0.11	0.81	0.47	0.11	0.80	0.48	0.11	0.84	0.48	0.11	0.88	0.49	0.11	0.92
NW	0.49	0.11	0.90	0.51	0.11	0.96	0.53	0.11	0.81	0.52	0.11	0.87	0.53	0.14	0.83	0.84	0.10	0.00	0.67	0.13	0.19	0.85	0.09	0.00
GL	0.51	0.10	0.94	0.47	0.10	0.76	0.46	0.10	0.70	0.47	0.10	0.76	0.54	0.11	0.73	0.56	0.11	0.61	0.55	0.11	0.65	0.56	0.11	0.58
ZG	0.50	0.12	0.97	0.51	0.12	0.96	0.51	0.12	0.95	0.52	0.12	0.89	0.52	0.11	0.87	0.51	0.11	0.90	0.50	0.11	0.97	0.52	0.11	0.87
FR	0.56	0.10	0.57	0.55	0.11	0.63	0.56	0.11	0.61	0.59	0.11	0.39	0.47	0.11	0.82	0.45	0.11	0.66	0.47	0.11	0.77	0.47	0.11	0.77
SO	0.51	0.11	0.90	0.27	0.09	0.01	0.39	0.10	0.28	0.29	0.09	0.02	0.47	0.13	0.79	0.49	0.13	0.92	0.42	0.12	0.51	0.44	0.12	0.61
BS	0.51	0.11	0.92	0.53	0.11	0.80	0.52	0.11	0.85	0.52	0.11	0.83	0.44	0.12	0.60	0.38	0.11	0.31	0.55	0.12	0.68	0.36	0.11	0.20
BL	0.55	0.12	0.66	0.62	0.12	0.34	0.57	0.12	0.56	0.60	0.12	0.42	0.46	0.12	0.75	0.45	0.12	0.70	0.45	0.11	0.69	0.46	0.11	0.70
SH	0.50	0.11	0.98	0.51	0.12	0.91	0.51	0.12	0.95	0.49	0.12	0.96	0.49	0.12	0.92	0.49	0.12	0.93	0.54	0.11	0.71	0.56	0.11	0.61
AR	0.51	0.11	0.91	0.50	0.11	0.98	0.51	0.11	0.96	0.49	0.11	0.96	0.49	0.11	0.93	0.47	0.11	0.77	0.49	0.11	0.93	0.47	0.11	0.77
AI	0.46	0.12	0.73	0.46	0.12	0.74	0.44	0.12	0.65	0.45	0.12	0.71	0.50	0.11	0.97	0.49	0.11	0.96	0.50	0.11	0.99	0.50	0.11	0.96
SG	0.54	0.11	0.71	0.53	0.11	0.75	0.53	0.11	0.79	0.53	0.11	0.75	0.49	0.10	0.90	0.48	0.10	0.87	0.55	0.10	0.63	0.49	0.10	0.90
GR	0.53	0.12	0.81	0.44	0.11	0.56	0.42	0.11	0.46	0.42	0.11	0.47	0.49	0.11	0.93	0.50	0.11	0.98	0.50	0.11	1.00	0.50	0.11	0.99
AG	0.52	0.10	0.82	0.53	0.11	0.81	0.51	0.11	0.92	0.51	0.11	0.91	0.50	0.11	0.99	0.51	0.11	0.92	0.52	0.11	0.86	0.51	0.11	0.90
TG	0.55	0.12	0.70	0.52	0.11	0.86	0.56	0.11	0.57	0.55	0.11	0.63	0.44	0.10	0.55	0.44	0.10	0.56	0.29	0.09	0.02	0.23	0.09	0.00
TI	0.52	0.11	0.84	0.52	0.11	0.89	0.50	0.11	0.98	0.50	0.11	0.97	0.48	0.11	0.87	0.48	0.11	0.84	0.47	0.11	0.81	0.59	0.11	0.44
VD	0.62	0.12	0.34	0.60	0.12	0.39	0.56	0.13	0.64	0.60	0.12	0.38	0.43	0.12	0.54	0.43	0.12	0.55	0.33	0.11	0.12	0.34	0.11	0.13
VS	0.56	0.11	0.58	0.55	0.12	0.69	0.44	0.12	0.57	0.44	0.12	0.57	0.44	0.13	0.67	0.28	0.11	0.05	0.27	0.10	0.02	0.25	0.10	0.01
NE	0.52	0.12	0.84	0.60	0.12	0.38	0.60	0.12	0.39	0.61	0.12	0.37	0.50	0.12	0.98	0.45	0.11	0.69	0.48	0.12	0.84	0.46	0.11	0.75
GE	0.54	0.12	0.77	0.56	0.13	0.64	0.55	0.13	0.69	0.56	0.13	0.63	0.49	0.11	0.90	0.49	0.11	0.94	0.56	0.11	0.59	0.59	0.11	0.38
JU													0.47	0.11	0.78	0.49	0.11	0.92	0.50	0.11	0.97	0.44	0.11	0.60

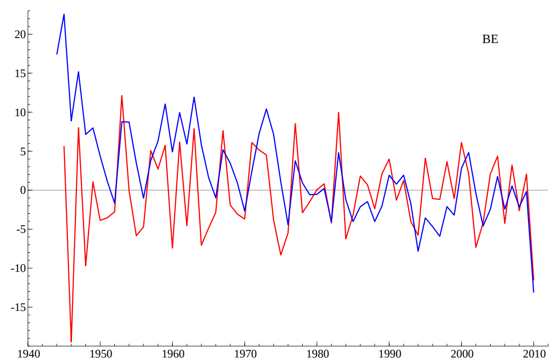
Table 18: Rationality test under quadratic loss: growth rate forecast errors

	1944-1978													
	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	0.00	0.98	0.05	0.98	0.60	0.74	1.25	0.74	0.00	0.98	0.56	0.45	1.24	0.54
BE	0.26	0.61	0.23	0.89	0.13	0.94	0.36	0.95	0.21	0.65	0.10	0.75	0.35	0.84
LU	0.18	0.67	10.72	0.00	2.61	0.27	10.97	0.01	8.30	0.00	2.41	0.12	8.33	0.02
UR	0.01	0.91	5.21	0.07	3.29	0.19	5.55	0.14	4.55	0.03	3.00	0.08	4.78	0.09
SZ	0.01	0.93	3.98	0.14	0.32	0.85	4.02	0.26	3.77	0.05	0.28	0.60	3.77	0.15
OW	0.00	0.99	0.13	0.94	1.01	0.60	1.03	0.79	0.09	0.76	0.94	0.33	0.97	0.62
NW	0.02	0.90	0.65	0.72	3.07	0.22	3.34	0.34	0.65	0.42	3.02	0.08	3.32	0.19
GL	0.01	0.94	4.43	0.11	2.34	0.31	4.44	0.22	4.34	0.04	2.20	0.14	4.34	0.11
ZG	0.00	0.97	0.46	0.80	0.08	0.96	0.53	0.91	0.45	0.50	0.08	0.78	0.51	0.77
FR	0.32	0.57	6.57	0.04	0.54	0.77	7.73	0.05	6.33	0.01	0.27	0.60	7.00	0.03
SO	0.02	0.90	12.09	0.00	4.57	0.10	11.81	0.01	5.79	0.02	3.39	0.07	6.72	0.03
BS	0.01	0.92	0.07	0.96	1.35	0.51	1.37	0.71	0.01	0.92	1.31	0.25	1.33	0.51
BL	0.19	0.66	4.56	0.10	1.55	0.46	4.55	0.21	3.64	0.06	1.21	0.27	3.91	0.14
SH	0.00	0.98	0.69	0.71	0.02	0.99	1.60	0.66	0.67	0.41	0.01	0.92	1.59	0.45
AR	0.01	0.91	0.86	0.65	0.46	0.79	2.54	0.47	0.86	0.35	0.46	0.50	2.54	0.28
AI	0.12	0.73	0.28	0.87	0.45	0.80	0.60	0.90	0.17	0.68	0.25	0.62	0.46	0.79
SG	0.14	0.71	0.16	0.92	0.08	0.96	0.16	0.98	0.06	0.81	0.01	0.93	0.06	0.97
GR	0.06	0.81	1.01	0.60	1.37	0.50	1.40	0.71	0.68	0.41	0.82	0.36	0.88	0.65
AG	0.05	0.82	0.42	0.81	0.91	0.64	1.05	0.79	0.36	0.55	0.90	0.34	1.03	0.60
TG	0.15	0.70	0.72	0.70	1.45	0.48	1.95	0.58	0.69	0.41	1.14	0.29	1.72	0.42
TI	0.04	0.84	0.45	0.80	2.11	0.35	2.70	0.44	0.43	0.51	2.11	0.15	2.70	0.26
VD	0.92	0.34	1.32	0.52	0.23	0.89	1.39	0.71	0.58	0.45	0.01	0.93	0.61	0.74
VS	0.30	0.58	1.88	0.39	5.58	0.06	5.59	0.13	1.72	0.19	5.26	0.02	5.27	0.07
NE	0.04	0.84	2.85	0.24	2.98	0.23	3.09	0.38	2.09	0.15	2.23	0.14	2.28	0.32
GE	0.09	0.77	0.64	0.73	0.79	0.67	3.89	0.27	0.42	0.52	0.63	0.43	3.66	0.16
JU														

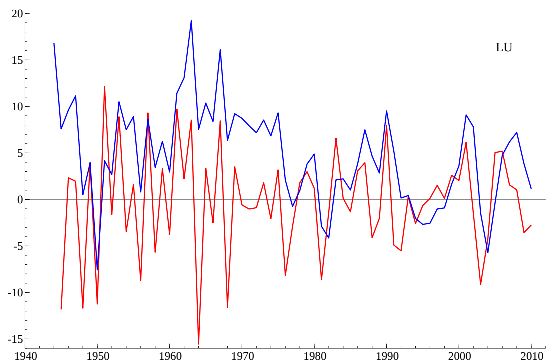
	1979-2010													
	$\alpha = 1/2$								$\alpha \in (0;1)$					
	k=1		k=2		k=3		k=4		k=2		k=3		k=4	
	J	p	J	p	J	p	J	p	J	p	J	p	J	p
ZH	0.22	0.64	10.09	0.01	3.69	0.16	10.75	0.01	6.22	0.01	3.32	0.07	6.60	0.04
BE	0.32	0.57	1.03	0.60	1.04	0.60	2.51	0.47	0.67	0.41	0.81	0.37	2.27	0.32
LU	0.00	0.97	5.56	0.06	0.03	0.99	5.56	0.13	5.54	0.02	0.02	0.88	5.55	0.06
UR	0.13	0.72	3.04	0.22	4.62	0.10	4.81	0.19	2.83	0.09	4.42	0.04	4.58	0.10
SZ	0.00	0.99	0.00	1.00	0.06	0.97	0.13	0.99	0.00	0.96	0.06	0.80	0.12	0.94
OW	0.06	0.80	2.51	0.29	2.18	0.34	3.34	0.34	2.47	0.12	2.16	0.14	3.33	0.19
NW	0.05	0.83	17.26	0.00	5.13	0.08	19.67	0.00	4.32	0.04	3.46	0.06	4.31	0.12
GL	0.12	0.73	5.65	0.06	5.09	0.08	6.28	0.10	5.40	0.02	4.88	0.03	5.99	0.05
ZG	0.03	0.87	4.64	0.10	1.98	0.37	4.64	0.20	4.63	0.03	1.98	0.16	4.62	0.10
FR	0.05	0.82	1.88	0.39	0.17	0.92	2.34	0.50	1.69	0.19	0.09	0.77	2.26	0.32
SO	0.07	0.79	1.80	0.41	3.08	0.21	3.55	0.31	1.79	0.18	2.64	0.10	3.29	0.19
BS	0.28	0.60	2.93	0.23	2.10	0.35	3.68	0.30	1.89	0.17	3.03	0.08	2.04	0.36
BL	0.10	0.75	0.24	0.89	0.19	0.91	0.24	0.97	0.09	0.76	0.03	0.87	0.09	0.95
SH	0.01	0.92	0.02	0.99	3.09	0.21	4.05	0.26	0.01	0.91	2.95	0.09	3.79	0.15
AR	0.01	0.93	2.05	0.36	0.01	1.00	2.04	0.56	1.96	0.16	0.00	0.99	1.96	0.37
AI	0.00	0.97	0.03	0.98	0.43	0.81	0.60	0.90	0.03	0.86	0.43	0.51	0.60	0.74
SG	0.02	0.90	0.44	0.80	0.27	0.87	0.76	0.86	0.41	0.52	0.59	0.44	0.74	0.69
GR	0.01	0.93	0.35	0.84	0.36	0.83	0.46	0.93	0.34	0.56	0.36	0.55	0.46	0.80
AG	0.00	0.99	0.74	0.69	3.71	0.16	3.89	0.27	0.73	0.39	3.68	0.06	3.87	0.14
TG	0.35	0.55	3.67	0.16	13.54	0.00	19.52	0.00	3.32	0.07	8.28	0.00	9.58	0.01
TI	0.03	0.87	4.87	0.09	0.25	0.88	6.90	0.08	4.83	0.03	0.19	0.66	6.30	0.04
VD	0.37	0.54	0.42	0.81	6.06	0.05	5.94	0.11	0.07	0.79	3.60	0.06	3.64	0.16
VS	0.18	0.67	6.90	0.03	7.98	0.02	9.40	0.02	2.96	0.09	2.72	0.10	3.01	0.22
NE	0.00	0.98	1.24	0.54	1.39	0.50	1.49	0.68	1.09	0.30	1.35	0.25	1.39	0.50
GE	0.01	0.90	0.15	0.93	4.49	0.11	6.49	0.09	0.14	0.70	4.20	0.04	5.74	0.06
JU	0.08	0.78	0.12	0.94	1.68	0.43	4.29	0.23	0.11	0.73	1.68	0.20	4.02	0.13



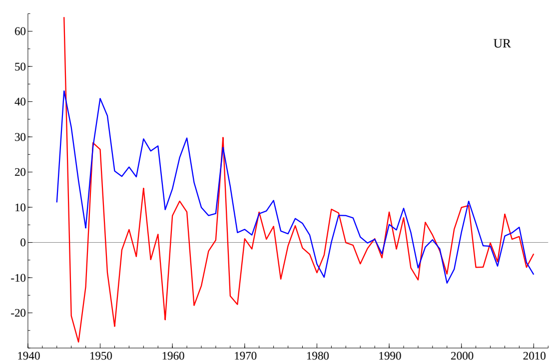
(a) Zurich



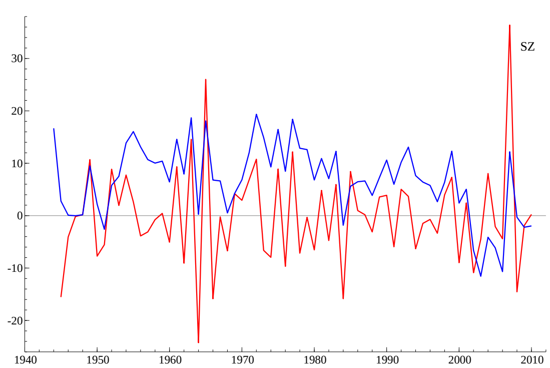
(b) Bern



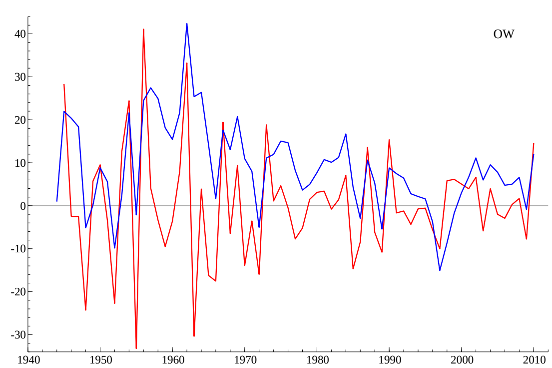
(c) Luzern



(d) Uri

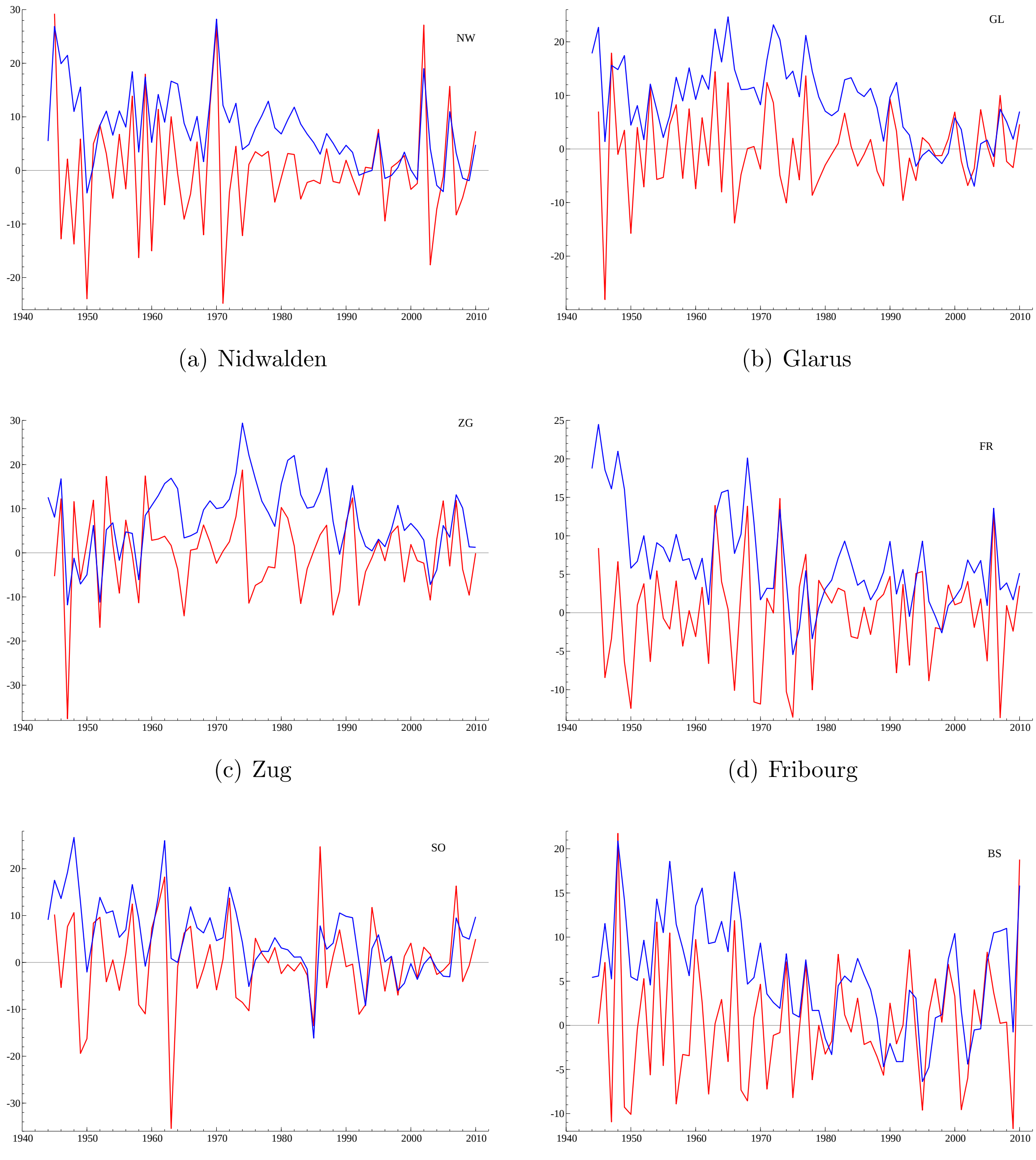


(e) Schwyz



(f) Obwalden

Figure 2: Tax revenue forecast errors: percent (blue line) and growth rate (red line)

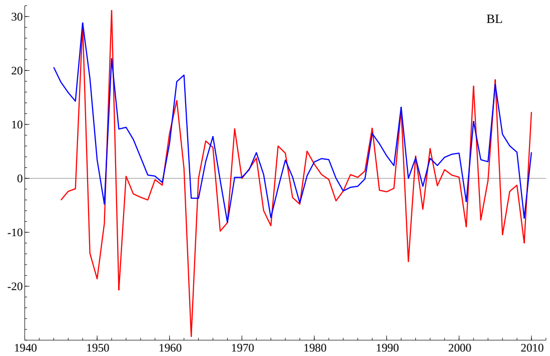


(a) Nidwalden (b) Glarus

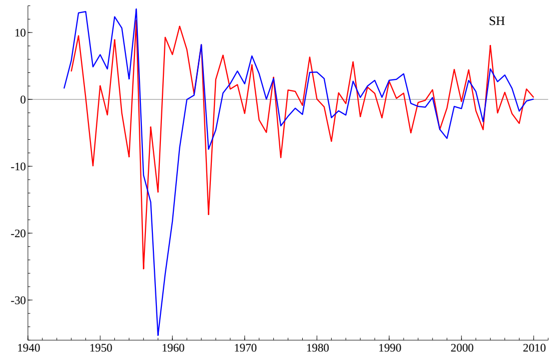
(c) Zug (d) Fribourg

(e) Soloturn (f) Basel-Stadt

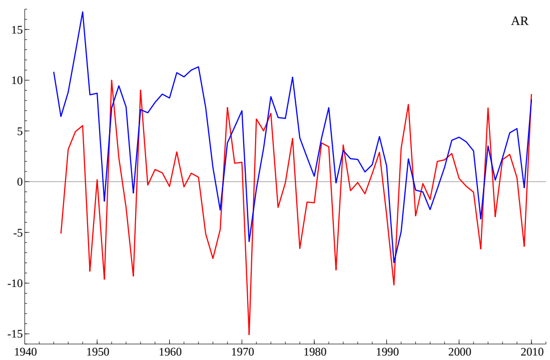
Figure 3: Tax revenue forecast errors: percent (blue line) and growth rate (red line)



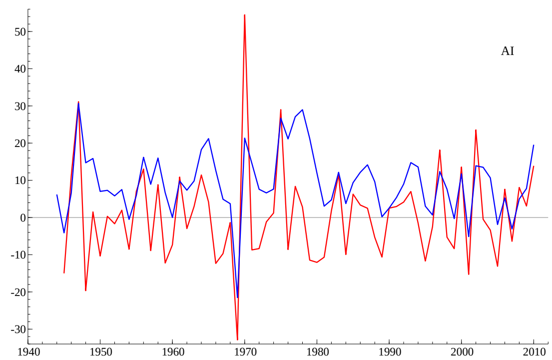
(a) Basel-Landschaft



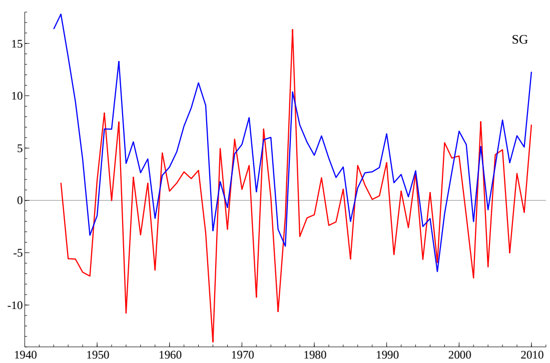
(b) Schaffhausen



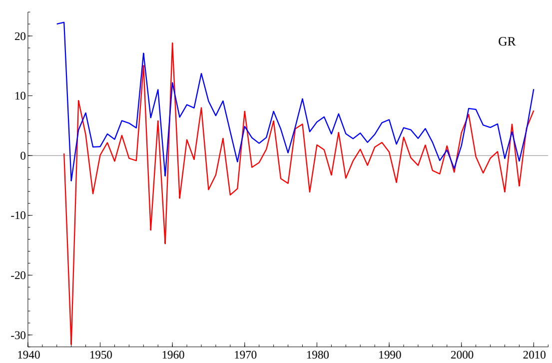
(c) Appenzell Ausserrhoden



(d) Appenzell Innerrhoden

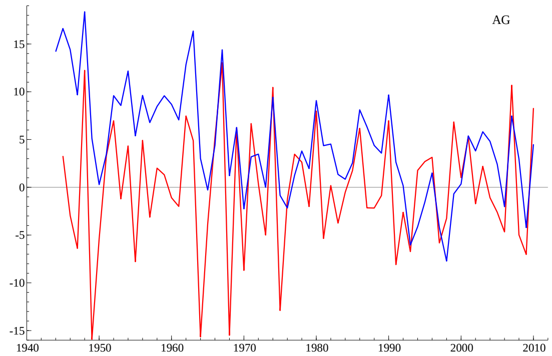


(e) St. Gallen

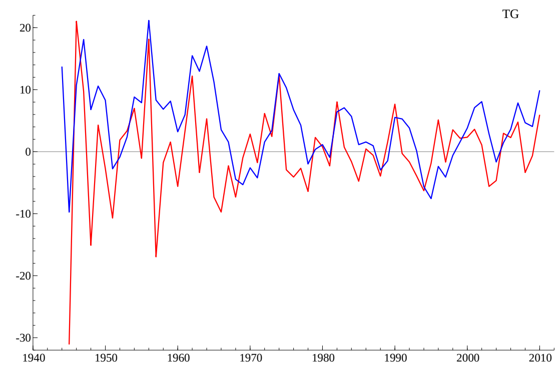


(f) Graubünden

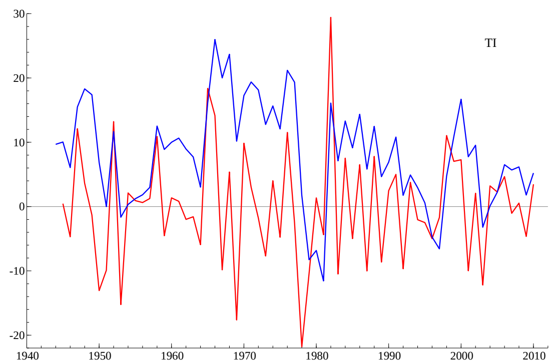
Figure 4: Tax revenue forecast errors: percent (blue line) and growth rate (red line)



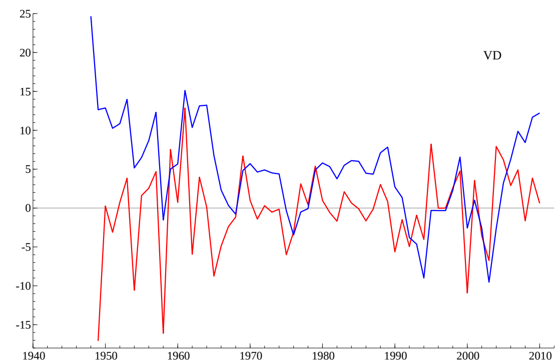
(a) Aargau



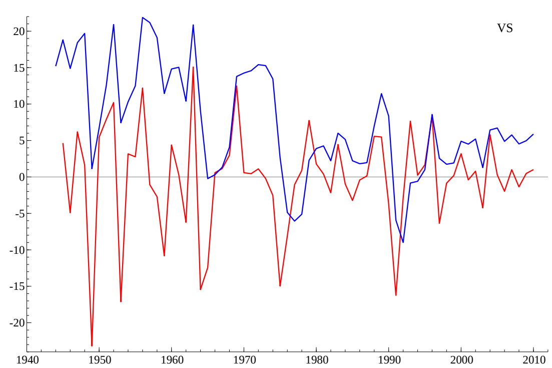
(b) Thurgau



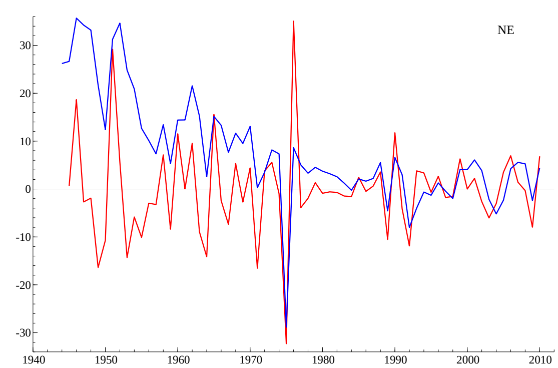
(c) Ticino



(d) Vaud

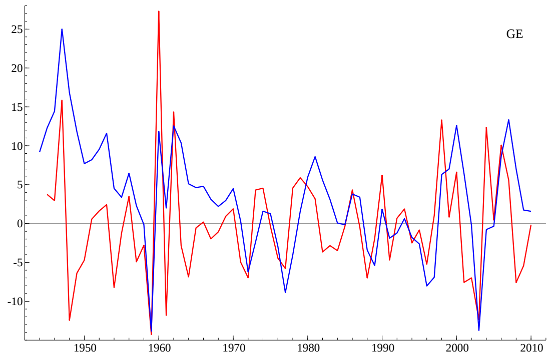


(e) Valais

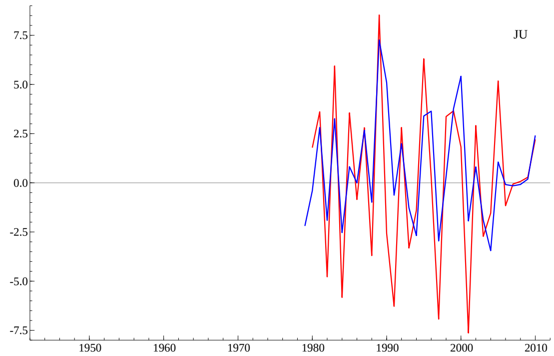


(f) Neuchâtel

Figure 5: Tax revenue forecast errors: percent (blue line) and growth rate (red line)



(a) Genève



(b) Jura

Figure 6: Tax revenue forecast errors: percent (blue line) and growth rate (red line)

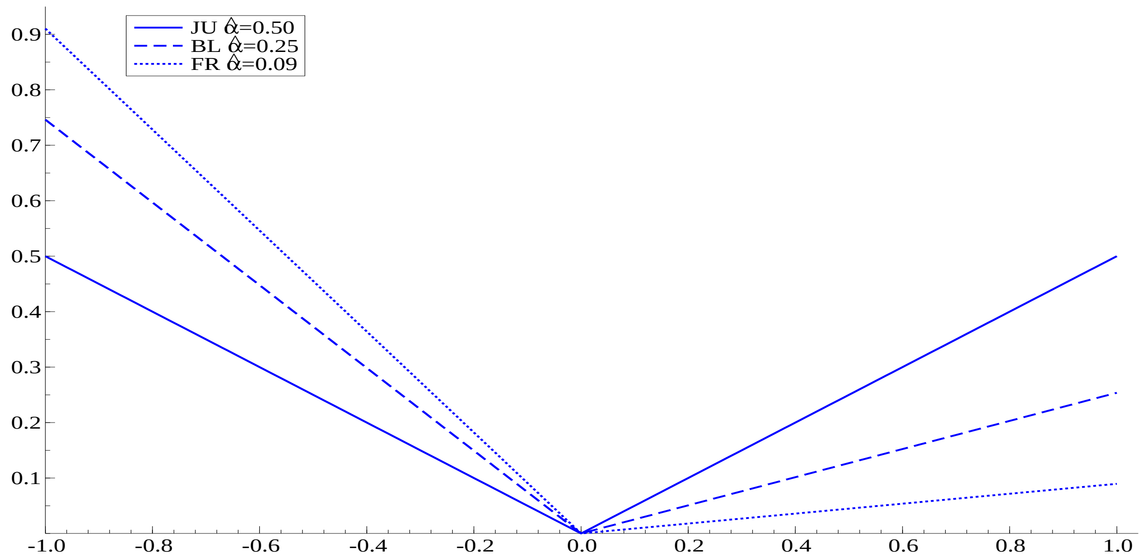


Figure 7: Percent forecast errors: examples of linear loss functions, $k = 1$

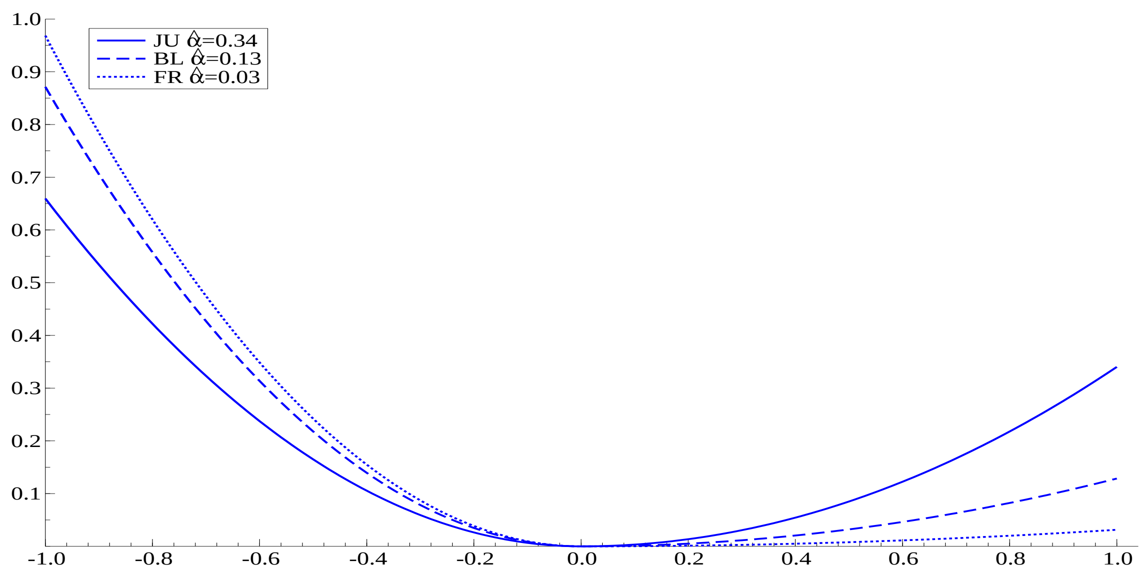


Figure 8: Percent forecast errors: examples of quadratic loss functions, $k = 1$

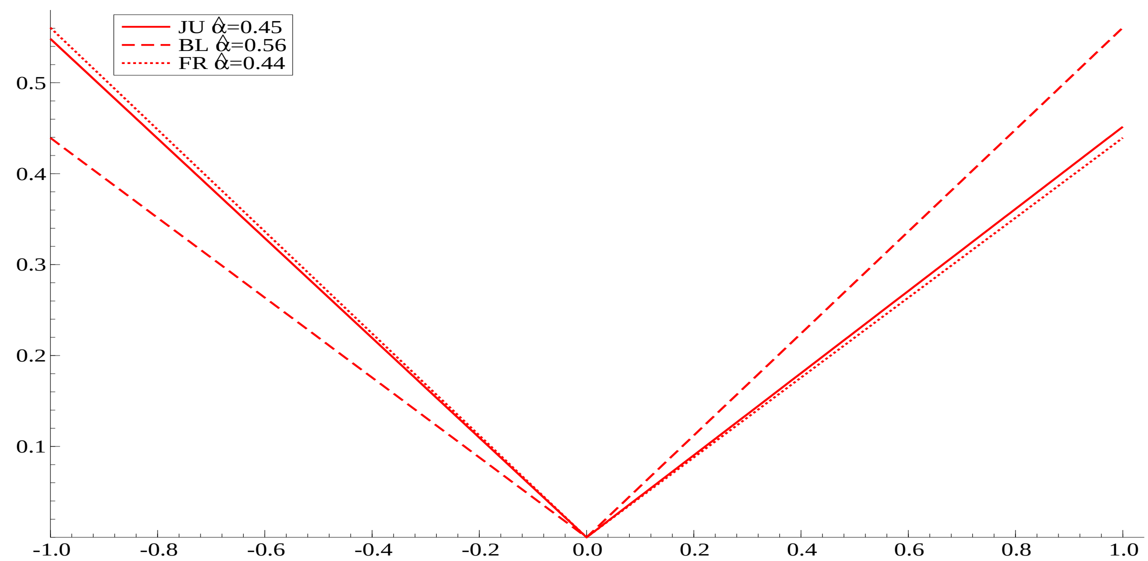


Figure 9: Growth rate forecast errors: examples of linear loss functions, $k = 1$

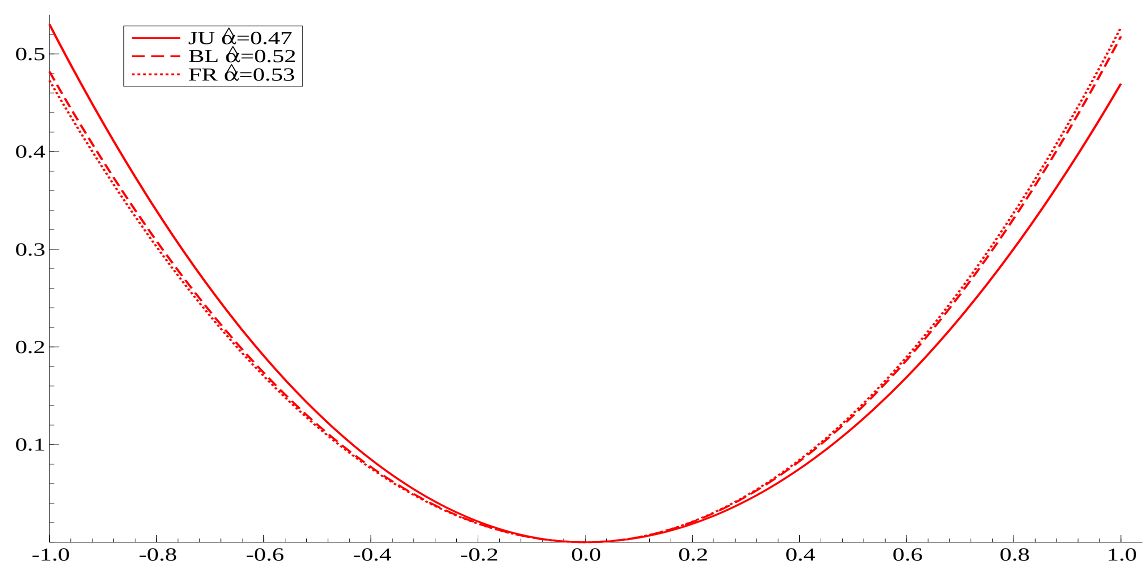


Figure 10: Growth rate forecast errors: examples of quadratic loss functions, $k = 1$

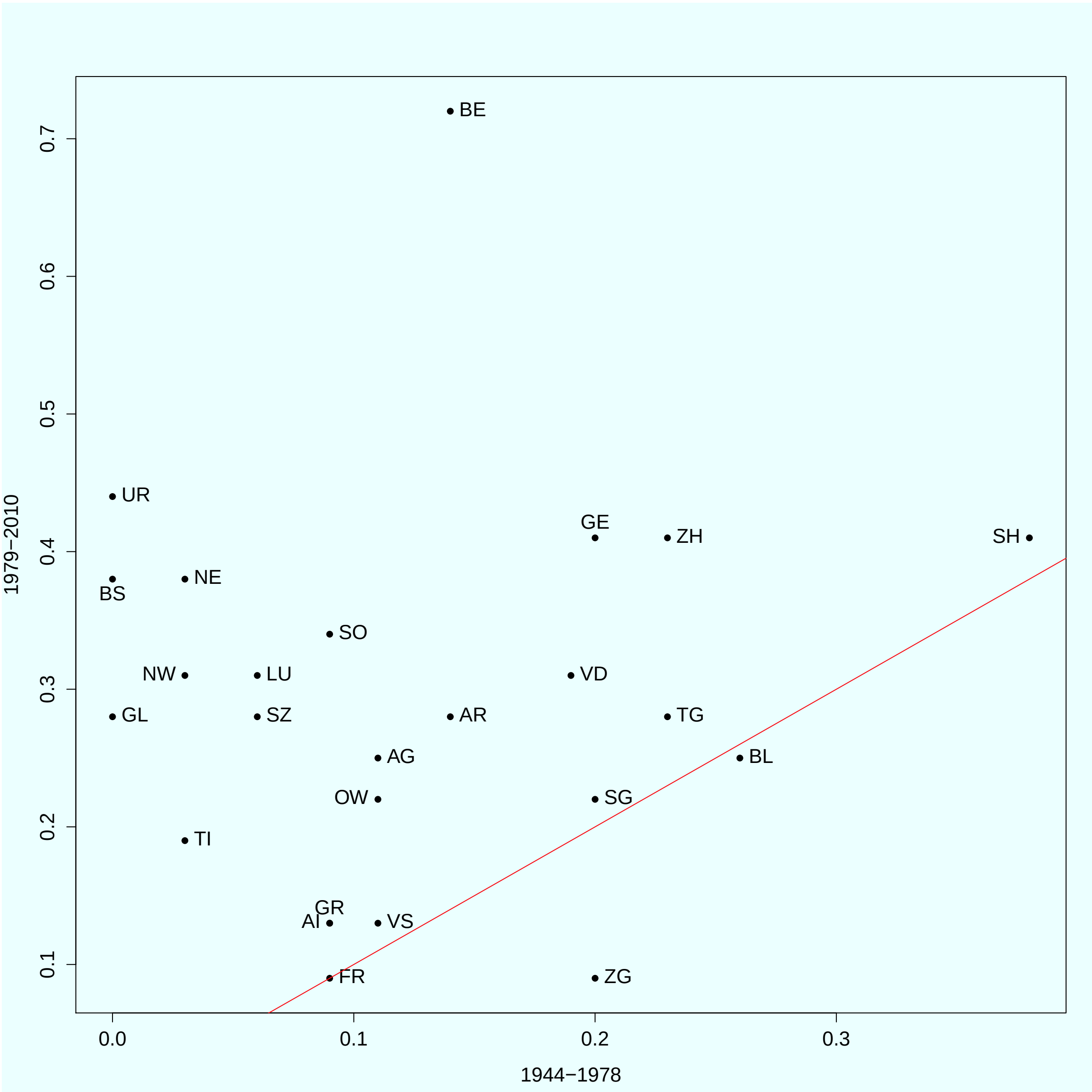


Figure 11: Percent forecast error: Cross-plot of estimates of α ($k = 1, p = 1$) reported in Table 11, x-axis (1944–1978), y-axis (1979–2010). The straight line is a 45-degree line.

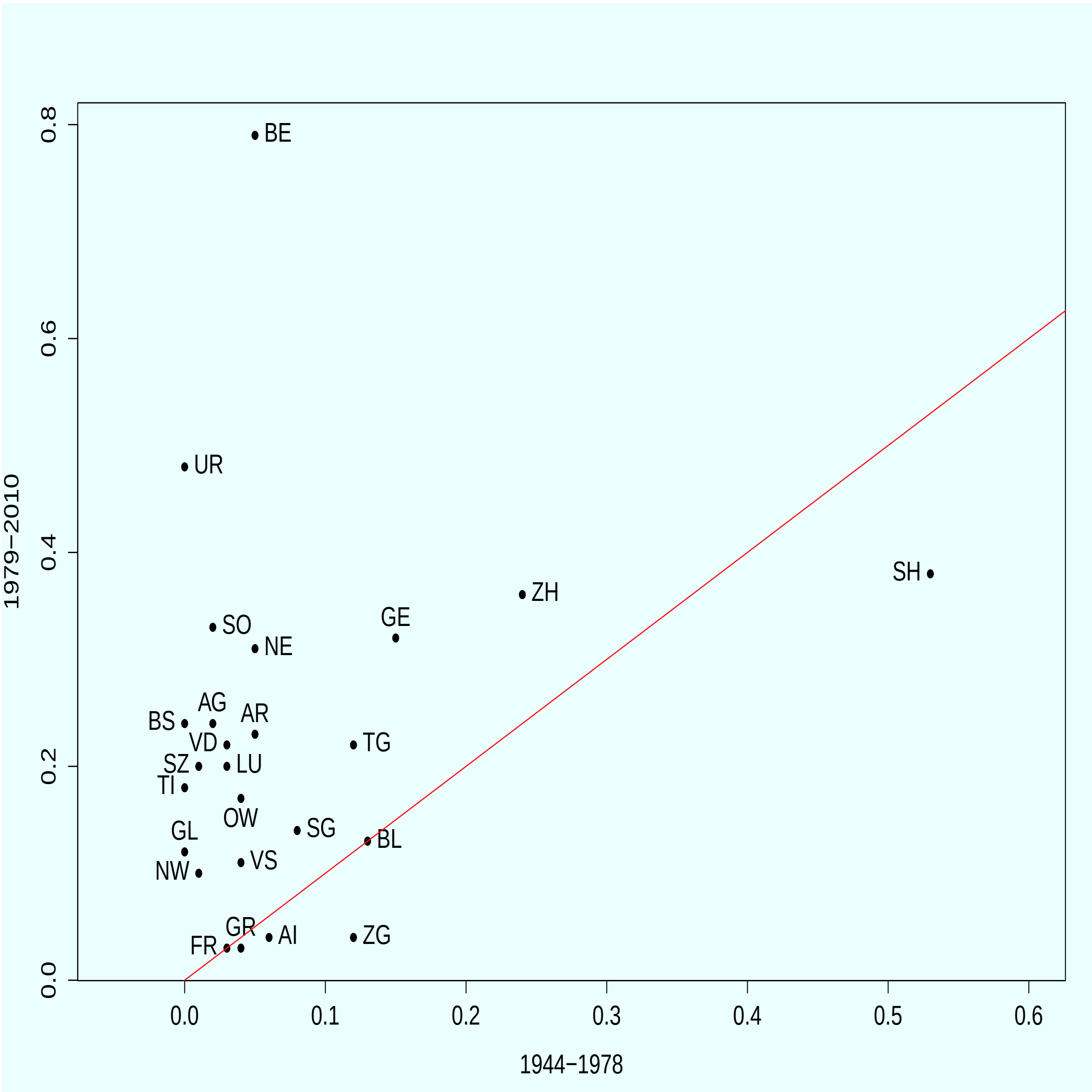


Figure 12: Percent forecast error: Cross-plot of estimates of α ($k = 1, p = 2$) reported in Table 13, x-axis (1944–1978), y-axis (1979–2010). The straight line is a 45-degree line.

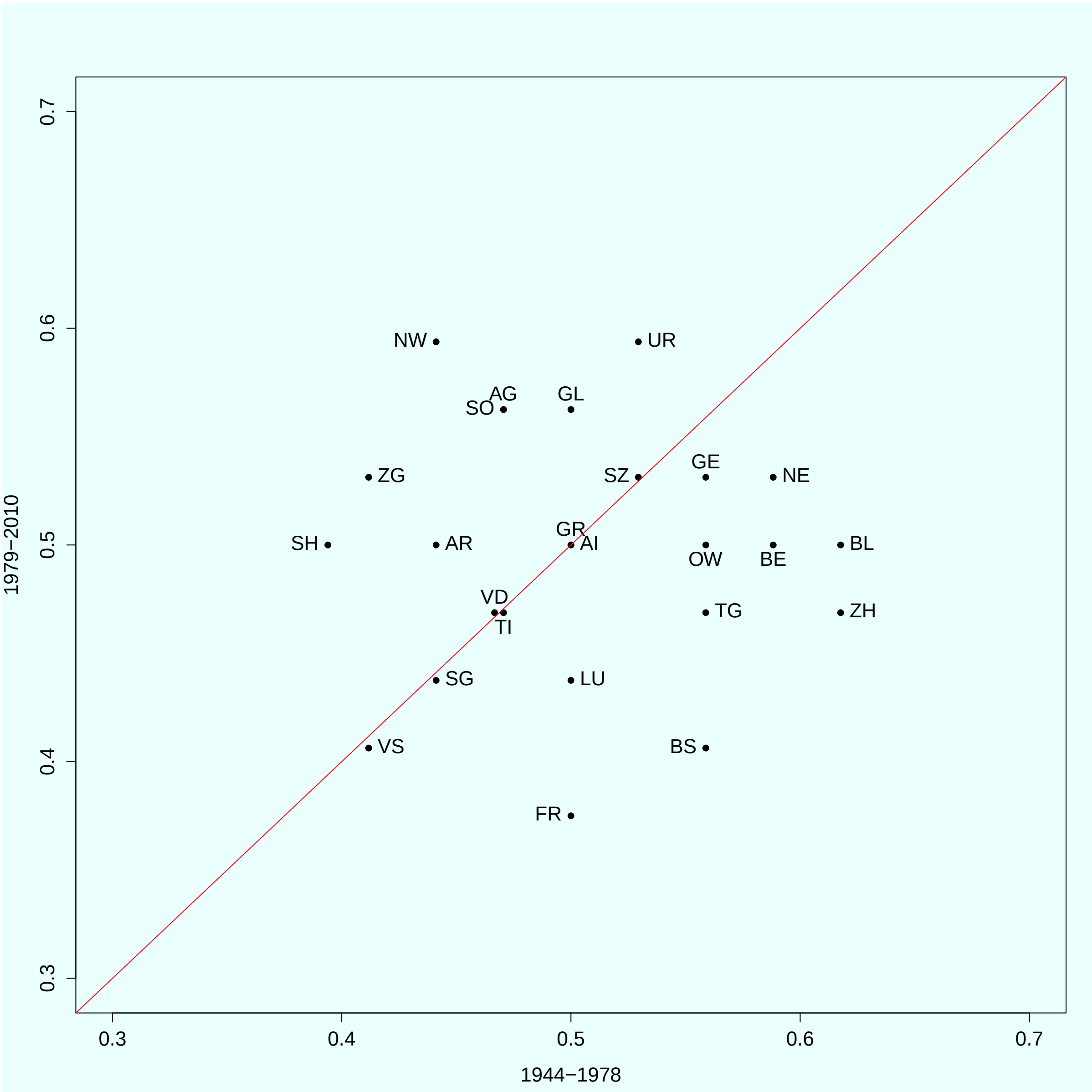


Figure 13: Growth rate forecast error: Cross-plot of estimates of α ($k = 1, p = 1$) reported in Table 15, x-axis (1944–1978), y-axis (1979–2010). The straight line is a 45-degree line.

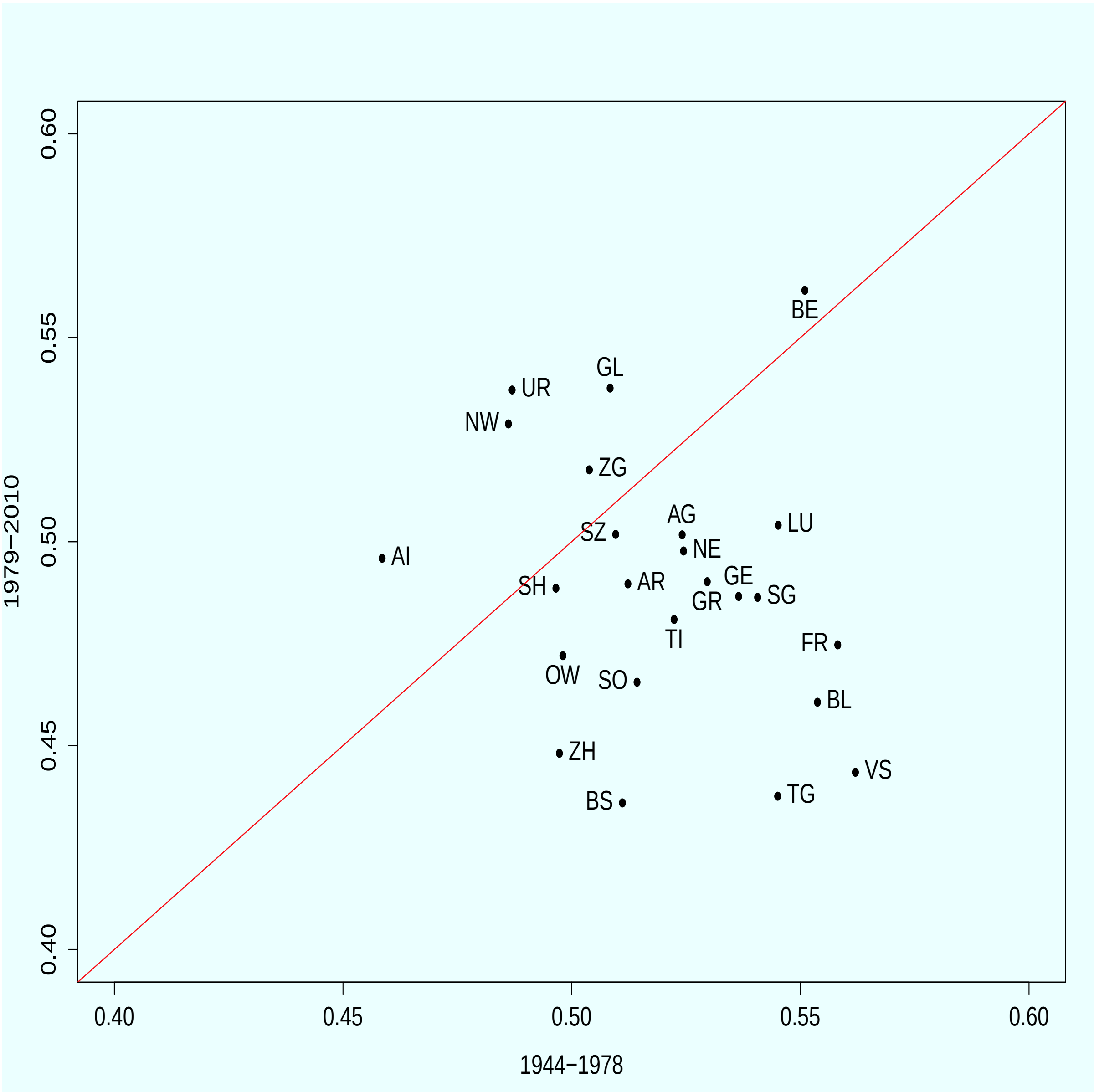


Figure 14: Growth rate forecast error: Cross-plot of estimates of α ($k = 1, p = 2$) reported in Table 17, x-axis (1944–1978), y-axis (1979–2010). The straight line is a 45-degree line.