



**Barcelona
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Centro Nacional de Supercomputación



EXCELENCIA
SEVERO
OCHOA

The Weather Roulette: assessing the economic value of seasonal wind speed predictions

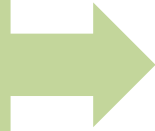
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USERS NEED

Wind industry currently uses **climatology** for resource assessments



CLIMATE SERVICE

Semi-operational prototype that provides wind speed seasonal predictions

<http://project-ukko.net>

EUPORIAS 

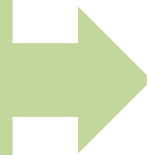


How do we engage wind industry users to consider using seasonal predictions besides climatology?

Demonstrating the **VALUE** of probabilistic predictions in economic terms 

METHODOLOGY

We use the **Weather roulette** framework to show how climate predictions outperform the climatology in skillful areas



LET'S PLAY!

It has been designed as a game that you can play in the interactive screen



- User needs & seasonal pred.
- Weather Roulette information


Introduction

Weather Roulette framework is based on Hagedorn & Smith 2009.

Decision makers are not necessarily familiar with statistical techniques used for the calculation of skill scores in climate predictions, whereas economic and financial knowledge is widespread in the corporate world.

Weather roulette translates skill scores into commonplace concepts as interest ratios or return of investment.

METEOROLOGICAL APPLICATIONS
Meteorol. Appl. **16**: 143–155 (2009)
Published online 23 October 2008 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/met.92

 **RMetS**
Royal Meteorological Society

Communicating the value of probabilistic forecasts with weather roulette

Renate Hagedorn^{a*} and Leonard A. Smith^b
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^b *Centre for the Analysis of Time Series (CATS), London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK*

ABSTRACT: In times of ever increasing financial constraints on public weather services it is of growing importance to communicate the value of their forecasts and products. While many diagnostic tools exist to evaluate forecast systems, intuitive diagnostics for communicating the skill of probabilistic forecasts are few. When the goal is communication with a non-expert audience it can be helpful to compare performance in more everyday terms than 'bits of information'. Ideally, of course, the method of presentation will be directly related to specific skill scores with known strengths and weaknesses. This paper introduces Weather Roulette, a conceptual framework for evaluating probabilistic predictions where skill is quantified using an *effective daily interest rate*; it is straightforward to deploy, comes with a simple storyline and importantly is comprehensible and plausible for a non-expert audience. Two variants of Weather Roulette are presented, one of which directly reflects proper local skill scores. Weather Roulette contrasts the performance of two forecasting systems, one of which may be climatology. Several examples of its application to ECMWF forecasts are discussed illustrating this new tool as useful addition to the suite of available probabilistic scoring metrics. Copyright © 2008 Royal Meteorological Society

KEY WORDS diagnostic; forecast evaluation; value; score; communication; probability forecast; proper

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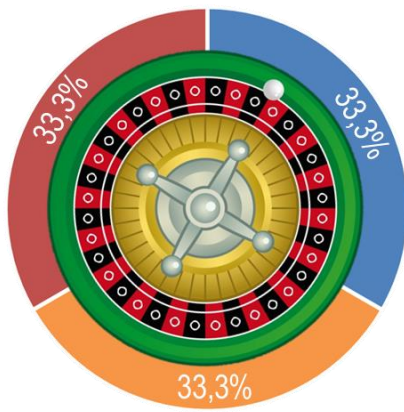


To assess the value of probabilistic prediction for wind energy users, seasonal wind speed predictions **play against climatology**.

Climatology assumes a **fixed probability** to each category while climate predictions adjust the category probabilities of the 'climatology' forecast.

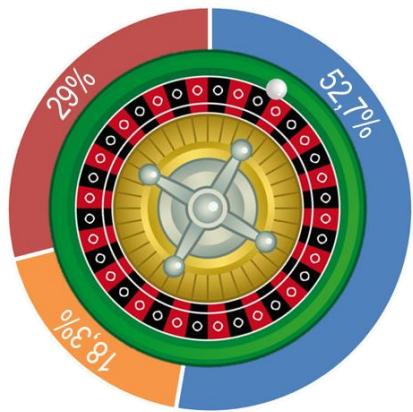
Introduction

- User needs & seasonal pred.
- Weather Roulette information



Climatology

Expected wind speed:



**RESILIENCE
seasonal predictions**

- Above average
- Average
- Below average

In the game, the user bets proportionally to the probabilities estimated in the seasonal forecast (e.g. 52% of 10€ to below average winds = 5.2€ invested in the category)

The amount invested in the observed category is multiplied by 3 (i.e. the inverse of the climatology probability)

If the observed category had a larger probability in the forecast than in climatology, then the user earns money (e.g. $5.2€ \times 3 = 15.6€$). Otherwise, the user loses money.





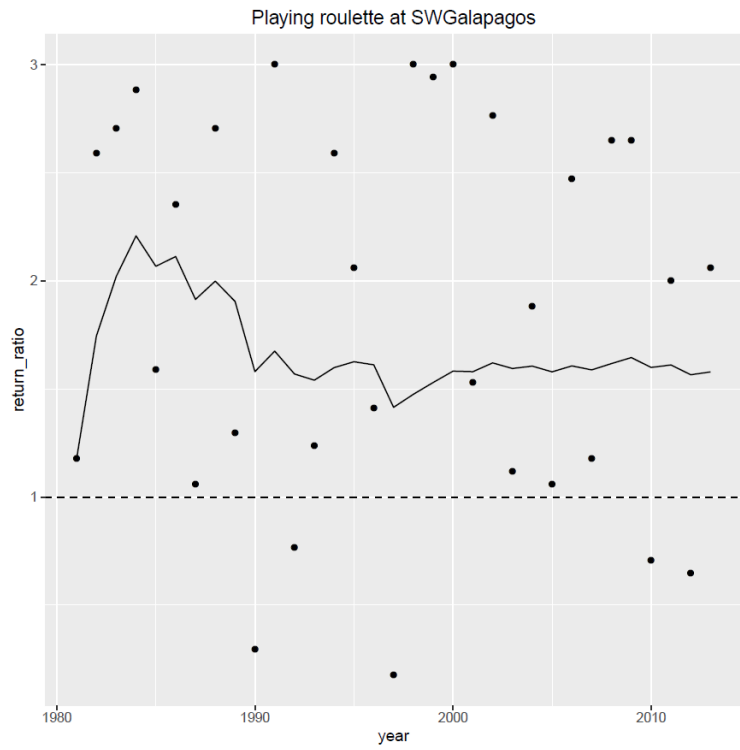
- Initial investment of 10€
- Everything earned is reinverted

- User needs & seasonal pred.
- Weather Roulette information

- 33 runs (from 1981 to 2013)
- Always in Winter period (Dec-Jan-Feb)

- In each game the skill of the seasonal predictions is provided as RPSS (Ranked Probability Skill Score)

- The dots are the performance of the forecast in each run (individual return ratios)



- After a sufficient number of runs we calculate the geometric average of return ratios (the line)
- That can be indicated as interest rate too



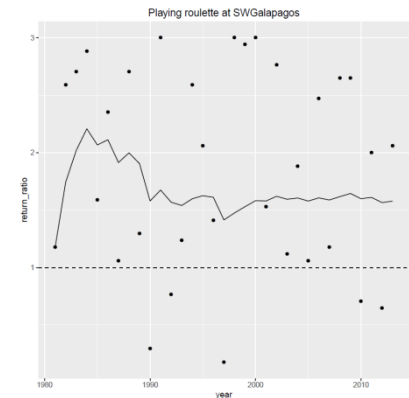
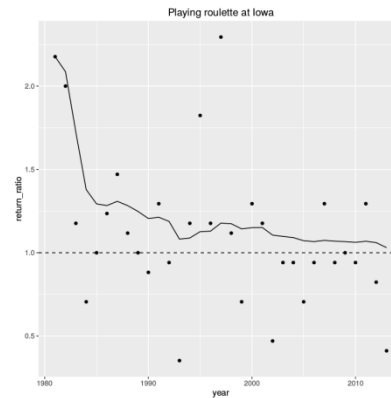
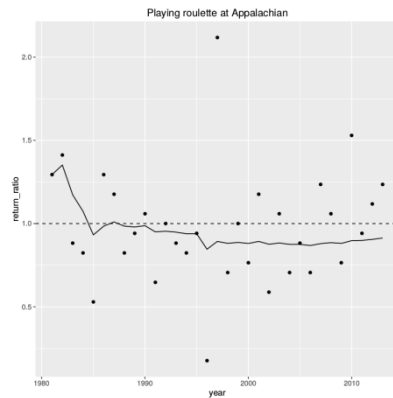
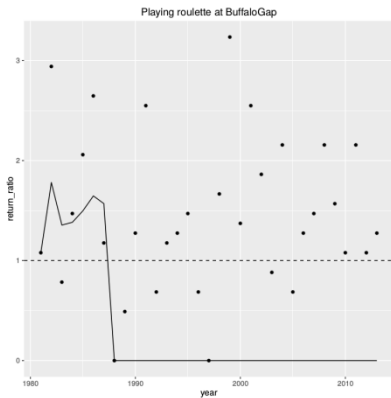
User needs & seasonal pred.

Weather Roulette information

- With the return ratio and the amount invested the total amount earned can be calculated

- Below 1 (dashed line) climatology is better

- Over 1 seasonal predictions are better



Let's play!

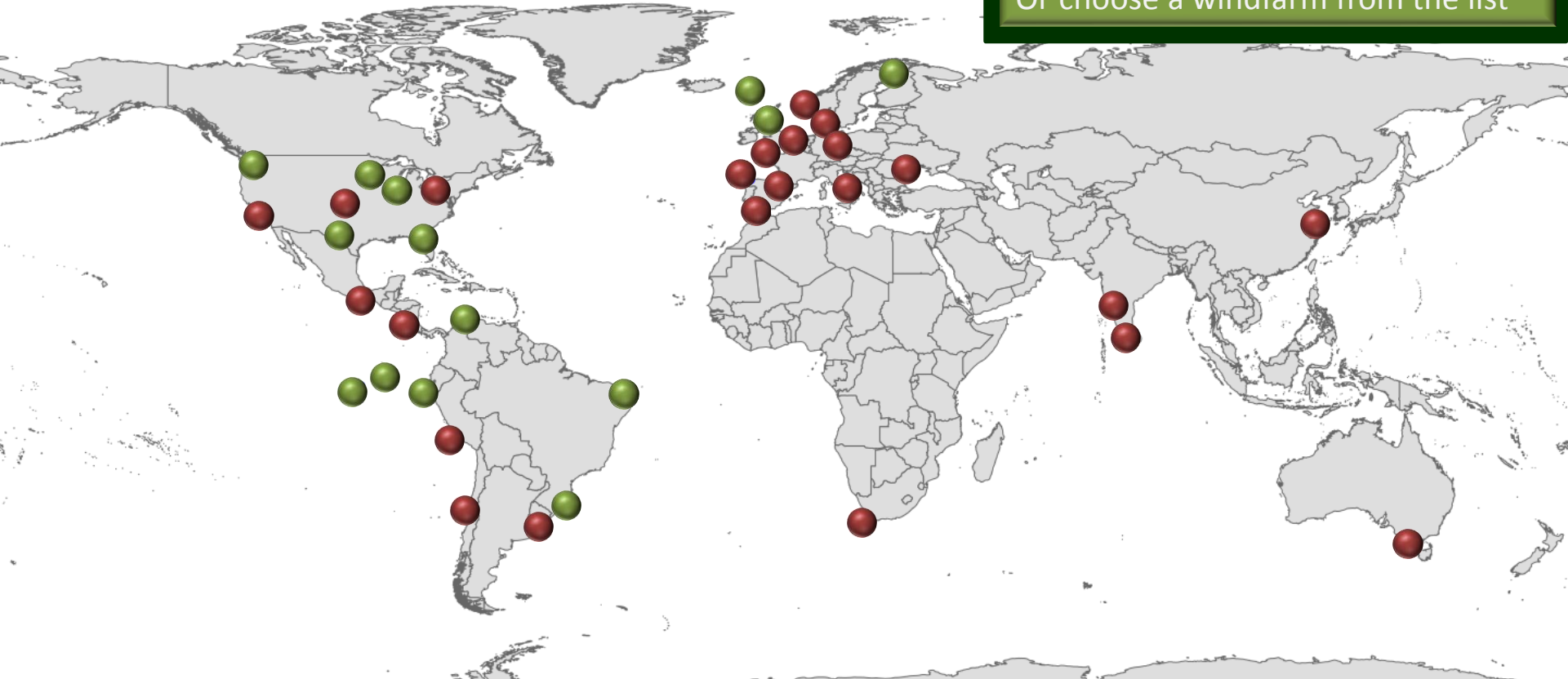


Let's Play!

- Wind farms in areas with Skill scores >0
- Wind farms in areas with Skill scores ≤ 0

Click in a wind farm in the map

Or choose a windfarm from the list



Have you played enough?

What if we play in a portfolio of 6 wind farms?

After all, large companies own many wind farms...



Windfarm	RPSS	Windfarm	RPSS
SWGalapagos	0,55	Guanacaste	0,00
Guajira	0,35	Shangai	0,00
Talara	0,29	CapeTown	-0,01
Orlando	0,23	Fantanele	-0,01
BuffaloGap	0,22	Uruguay	-0,01
Indiana	0,18	Stavanger	-0,02
RioGrandeNorte	0,13	Campania	-0,03
Galapagos	0,12	HornRevs	-0,03
Faeroe	0,08	Bretagne	-0,04
Marcona	0,08	Ebro	-0,05
ShepherdFlats	0,06	Magdeburg	-0,05
Oklahoma	0,06	Melbourne	-0,06
Iowa	0,03	Karnataka	-0,06
Coquimbo	0,03	Tarifa	-0,06
Edinburg	0,02	Appalachian	-0,07
Oslo	0,02	Lugo	-0,08
RioGrandeSur	0,01	LaVentosa	-0,09
		TamilNadu	-0,10
		Belgium	-0,10
		TehachapiPass	-0,12

Let's Play!

Back to the map

See all results in a table

Wind farms in areas with Skill scores >0

Wind farms in areas with Skill scores ≤0

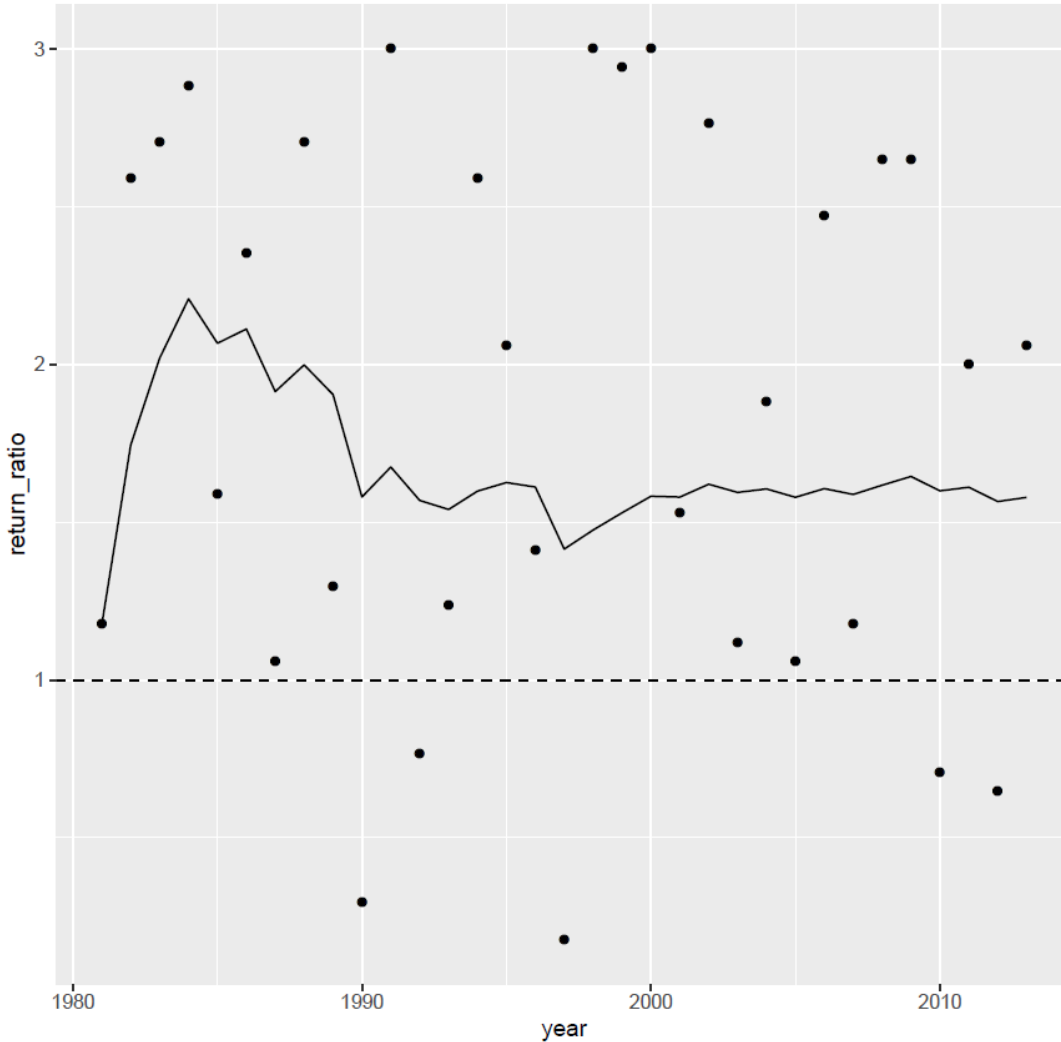


Let's Play!

Back to the map

See all results in a table

Playing roulette at SWGalapagos



Skill score (RPSS) = 0.55

Return ratio = 1.578

Interest rate = 57.8%

From 10€ inverted,
34 772 654€ returned after 33 runs



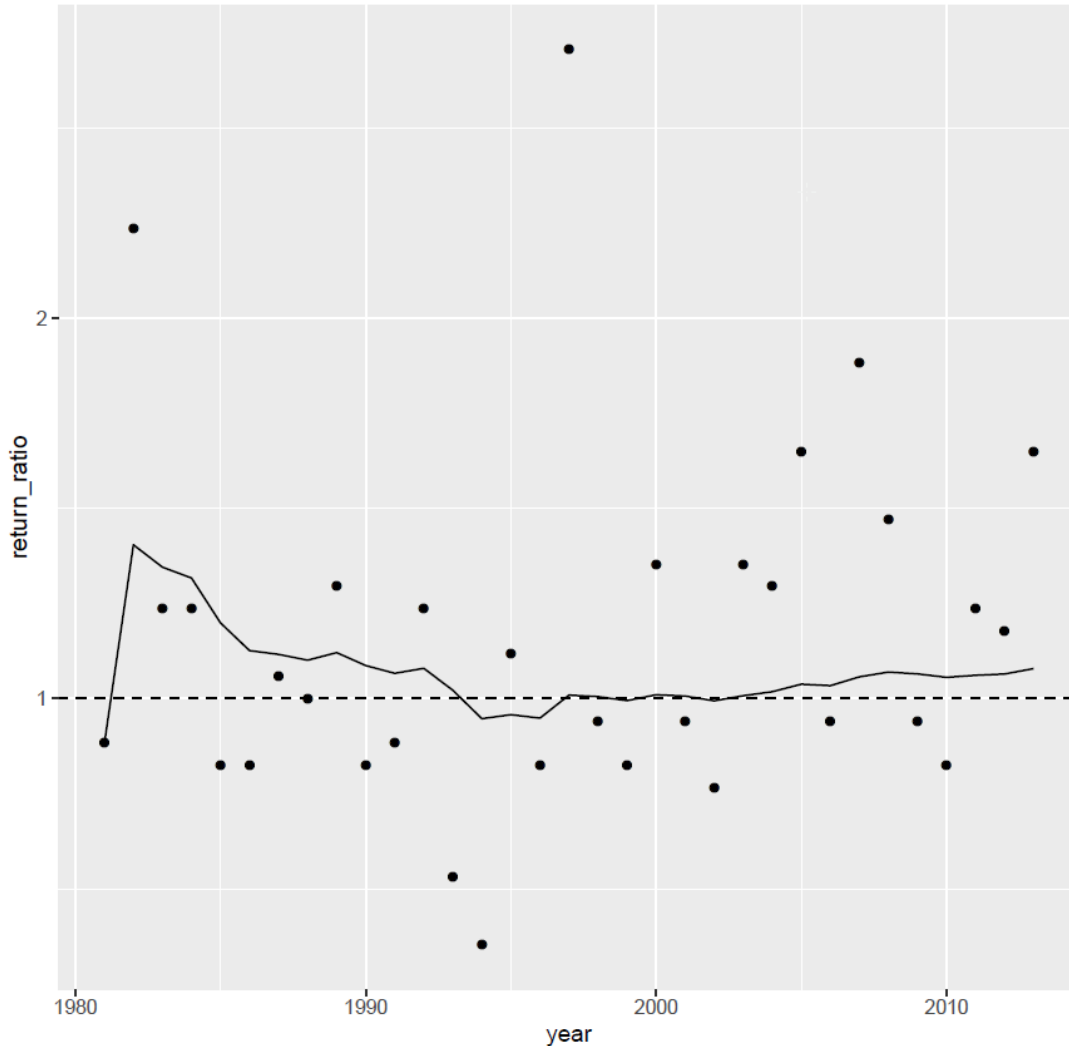


Let's Play!

Back to the map

See all results in a table

Playing roulette at Galapagos



Skill score (RPSS) = 0.12

Return ratio = 1.079

Interest rate = 7.9%

From 10€ inverted,
123€ returned after 33 runs



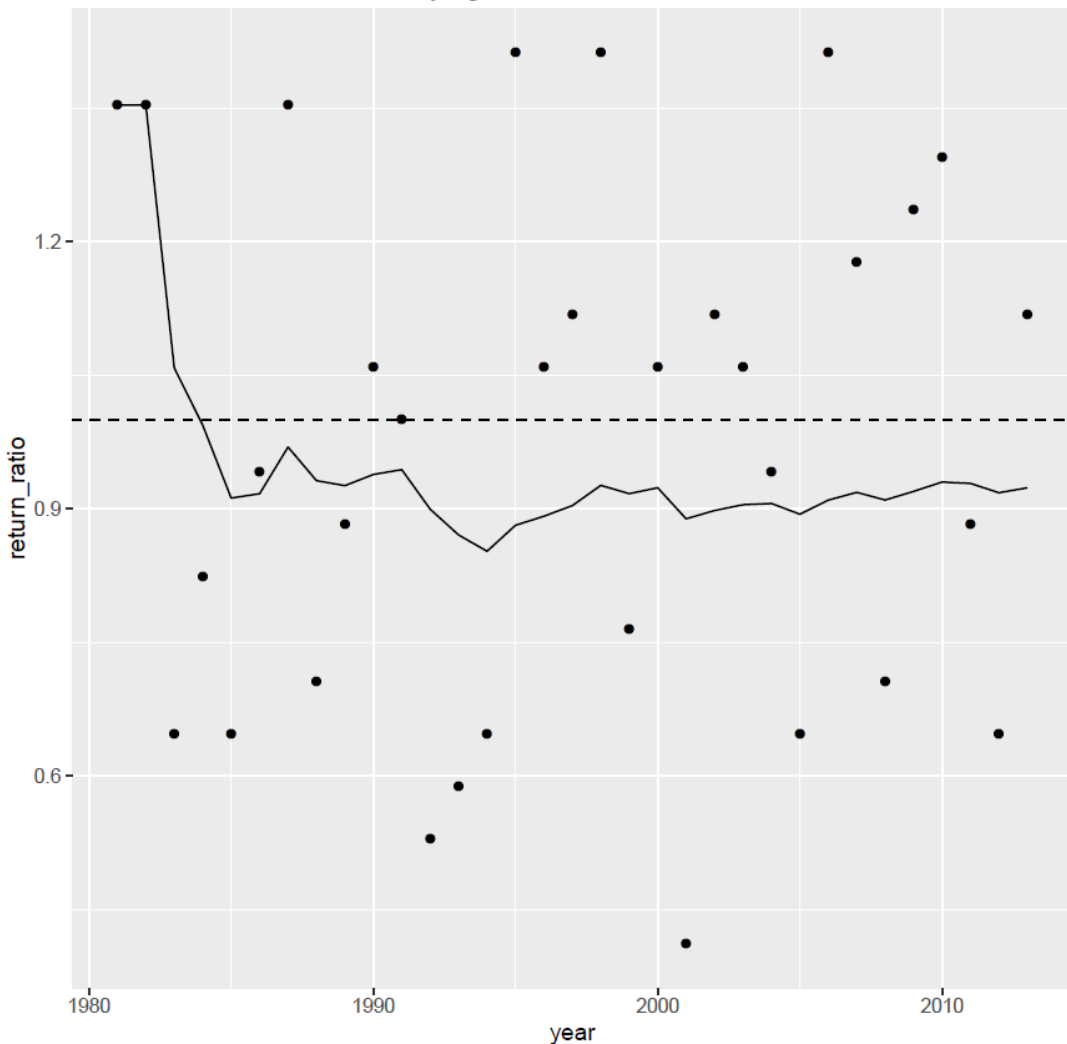


Let's Play!

Back to the map

See all results in a table

Playing roulette at LaVentosa



Skill score (RPSS) = -0.09

Return ratio = 0.924

Interest rate = -7.6%

From 10€ inverted,
70 cents returned after 33 runs



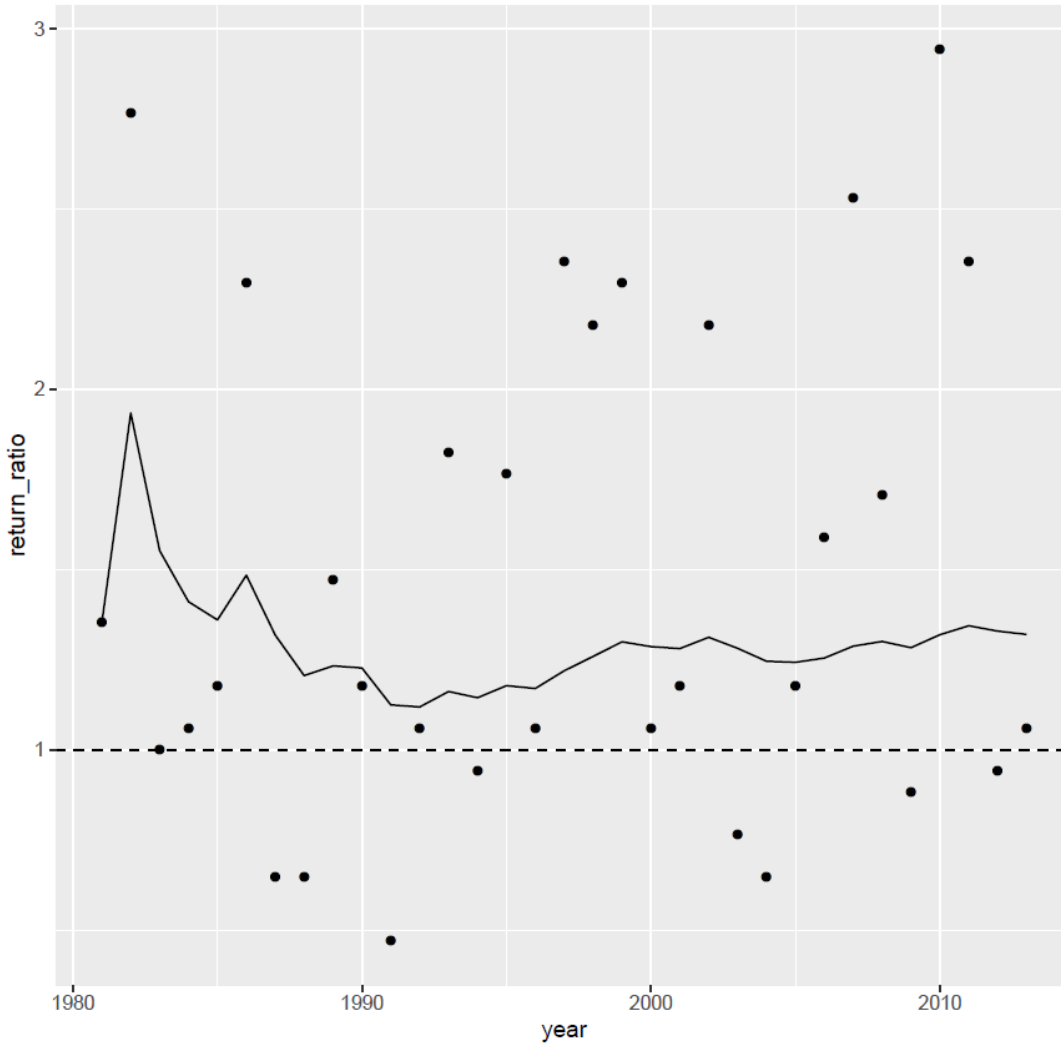


Let's Play!

Back to the map

See all results in a table

Playing roulette at Guajira



Skill score (RPSS) = 0.35

Return ratio = 1.32

Interest rate = 32%

From 10€ inverted,
95 667€ returned after 33 runs





Let's Play!

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See all results in a table

Skill score (RPSS) = 0.29

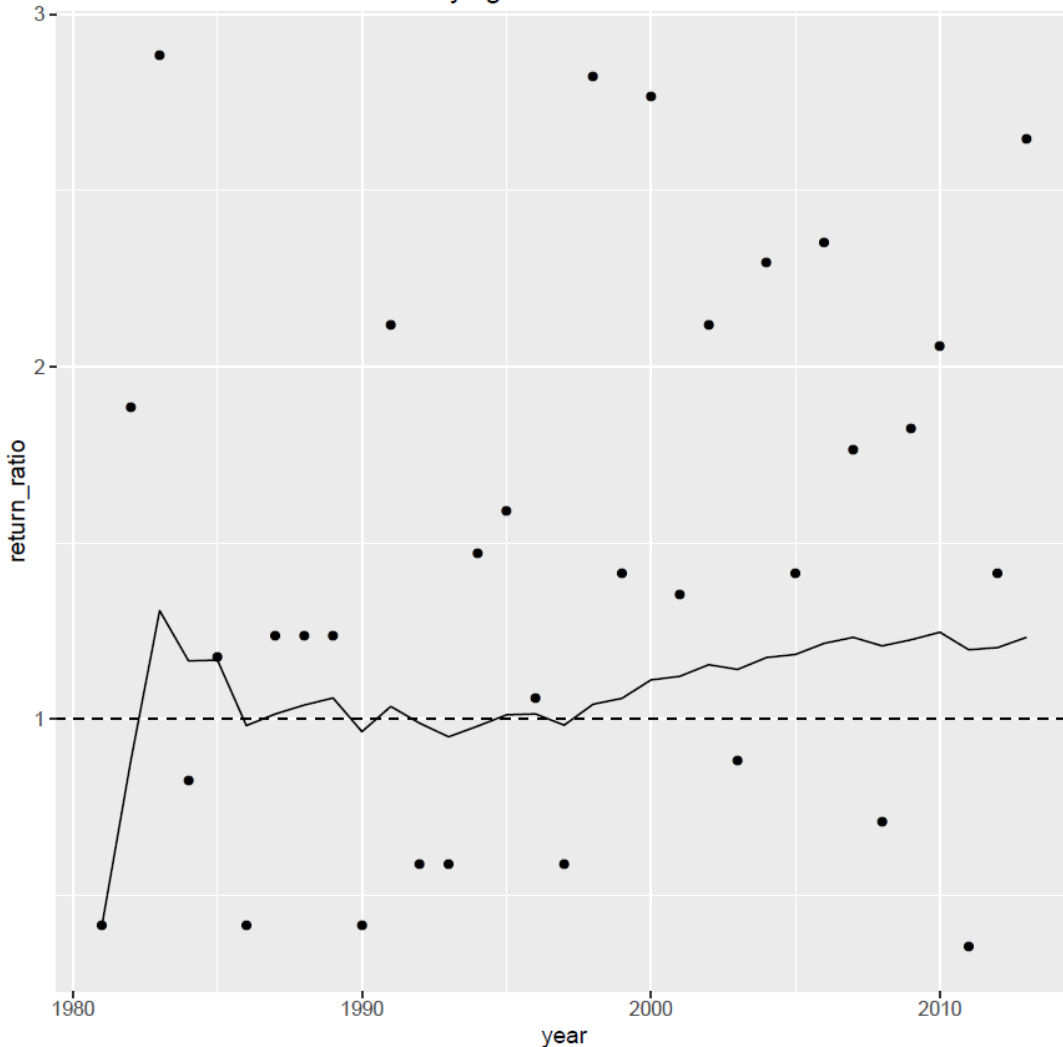
Return ratio = 1.232

Interest rate = 23.2%

From 10€ inverted,
9 657€ returned after 33 runs



Playing roulette at Talara



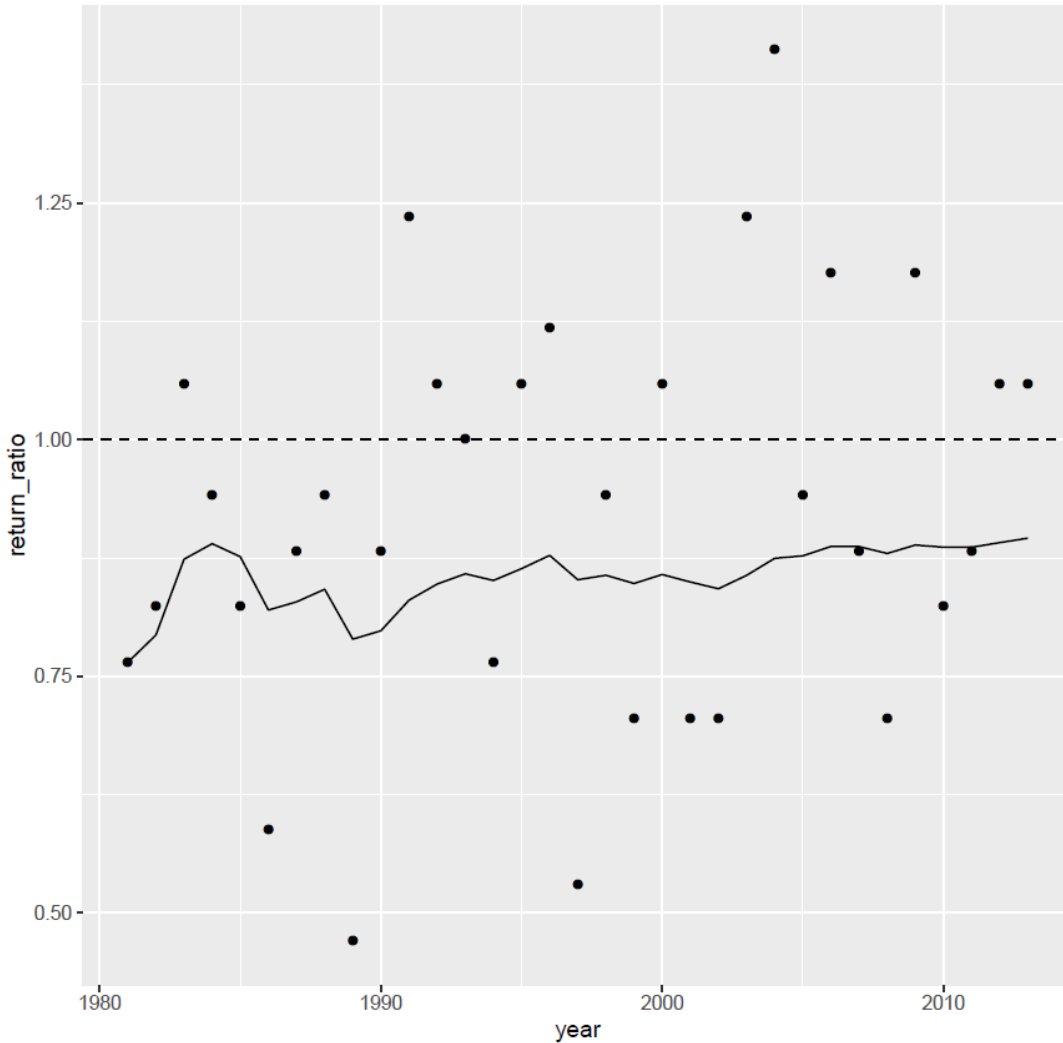


Let's Play!

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See all results in a table

Playing roulette at Marcona



Skill score (RPSS) = 0.08

Return ratio = 1.024

Interest rate = 2.4%

From 10€ inverted,
22€ returned after 33 runs



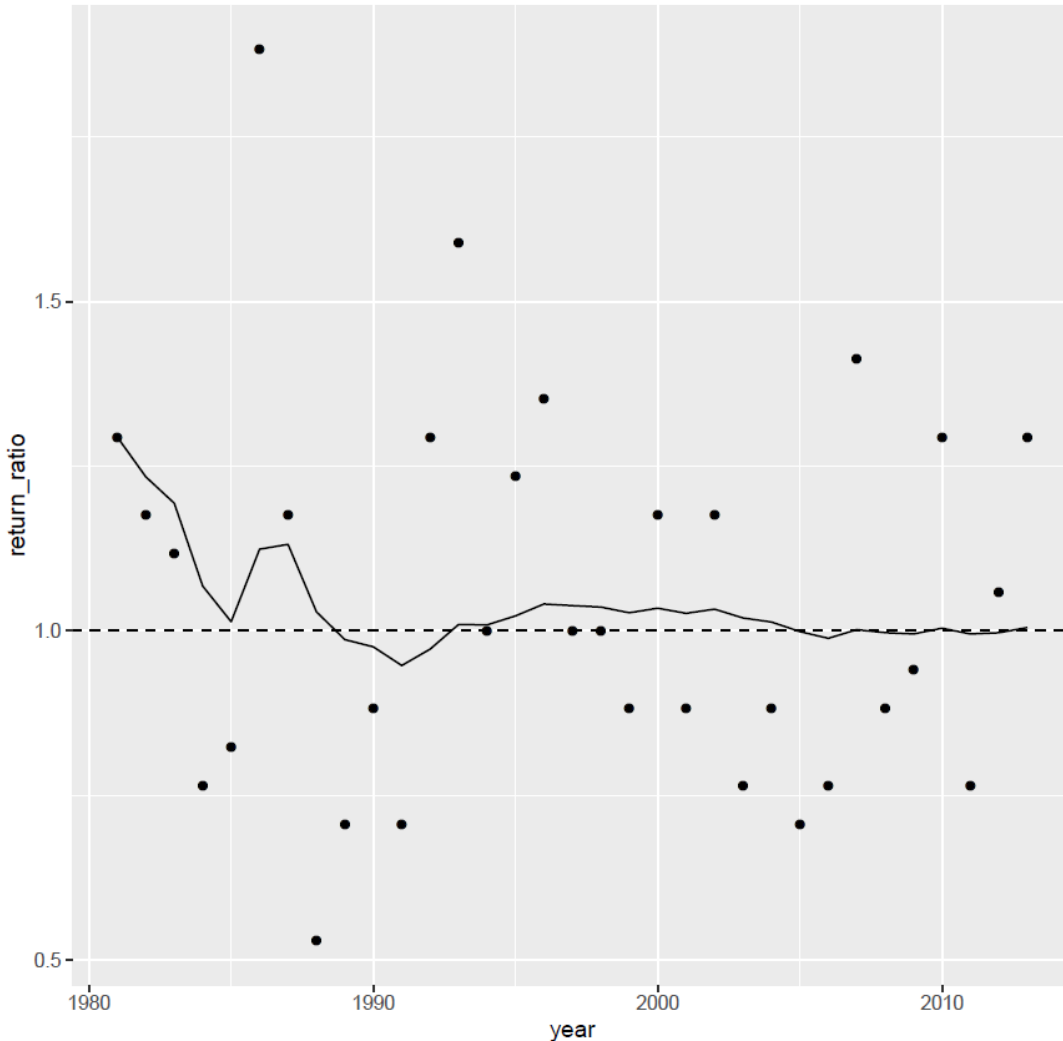


Let's Play!

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See all results in a table

Playing roulette at Guanacaste



Skill score (RPSS) = 0

Return ratio = 1.005

Interest rate = 0.5%

From 10€ inverted,
11.8€ returned after 33 runs



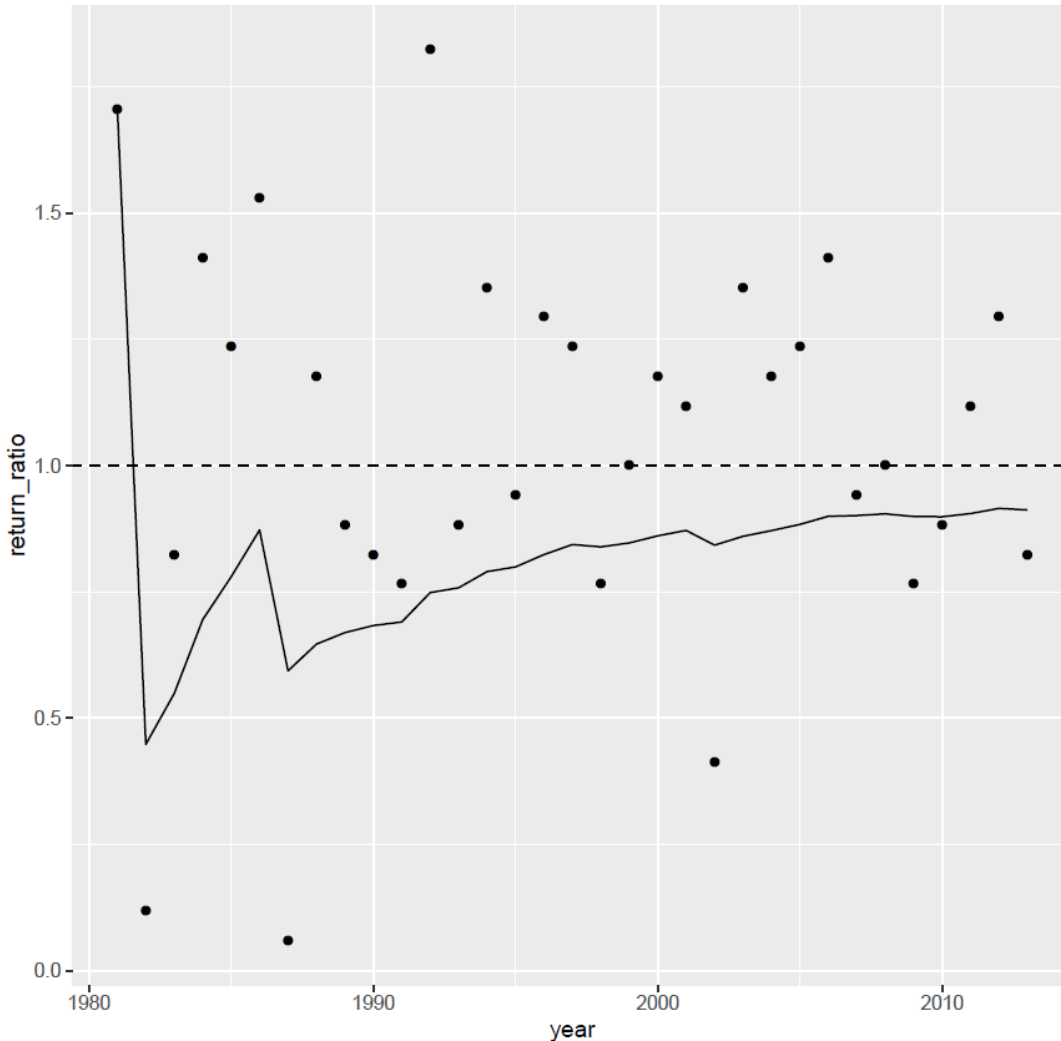


Let's Play!

Back to the map

See all results in a table

Playing roulette at RioGrandeSur



Skill score (RPSS) = 0.01

Return ratio = 0.912

Interest rate = -8.8%

From 10€ inverted,
50 cent returned after 33 runs



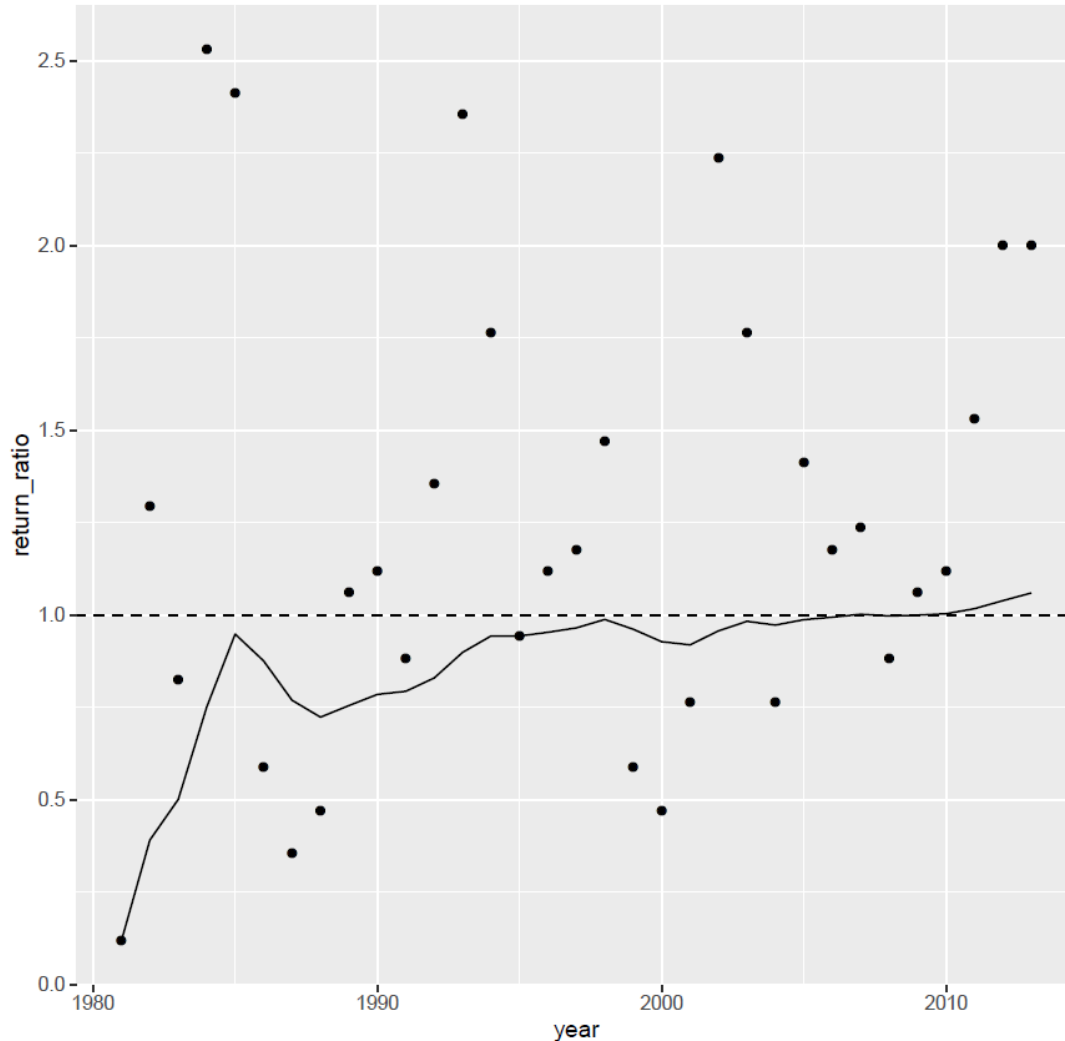


Let's Play!

Back to the map

See all results in a table

Playing roulette at RioGrandeNorte



Skill score (RPSS) = 0.13

Return ratio = 1.059

Interest rate = 5.9%

From 10€ inverted,
66.8€ returned after 33 runs



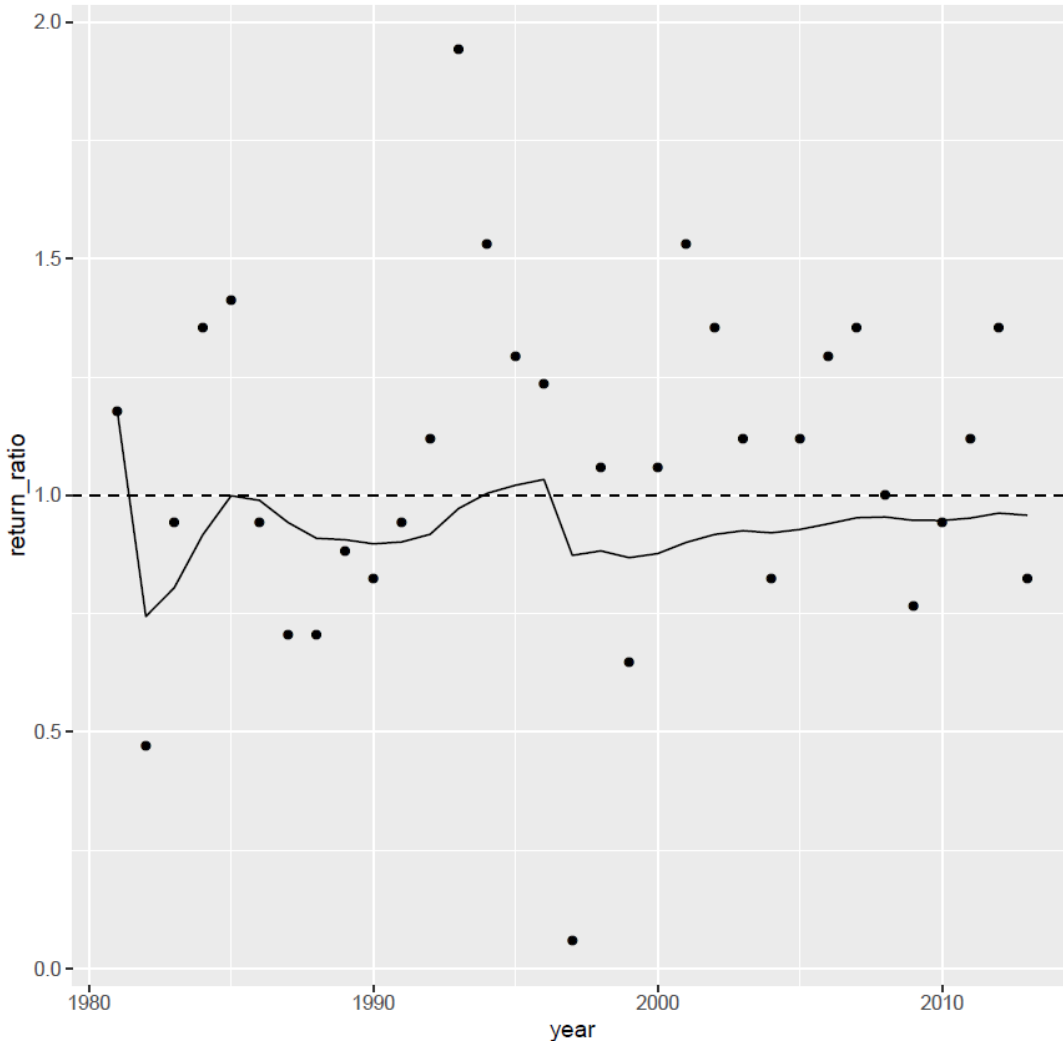


Let's Play!

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See all results in a table

Playing roulette at Coquimbo



Skill score (RPSS) = 0.03

Return ratio = 0.958

Interest rate = -4.2%

From 10€ inverted,
2.4€ returned after 33 runs



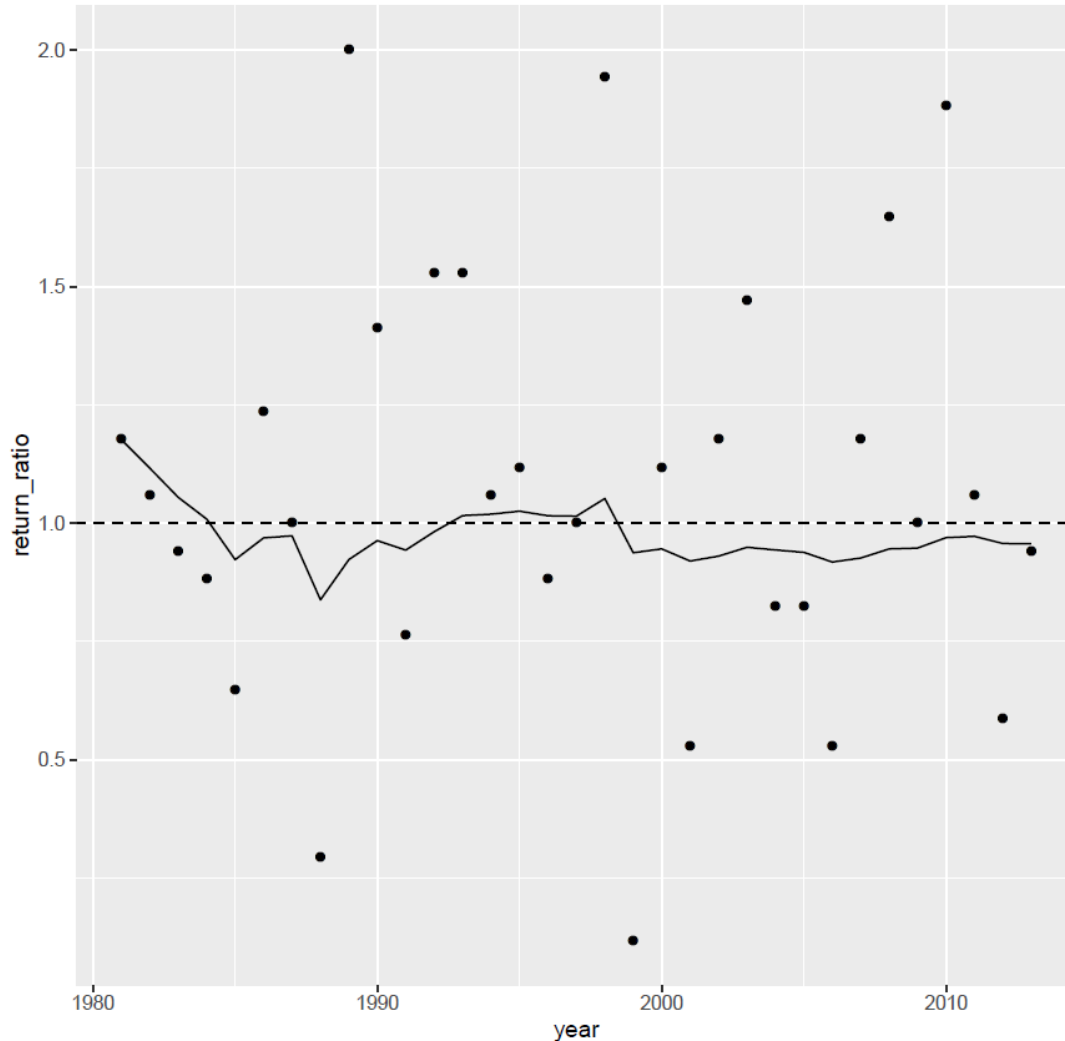


Let's Play!

Back to the map

See all results in a table

Playing roulette at Uruguay



Skill score (RPSS) = -0.01

Return ratio = 0.956

Interest rate = -4.4%

From 10€ inverted,
2.3€ returned after 33 runs



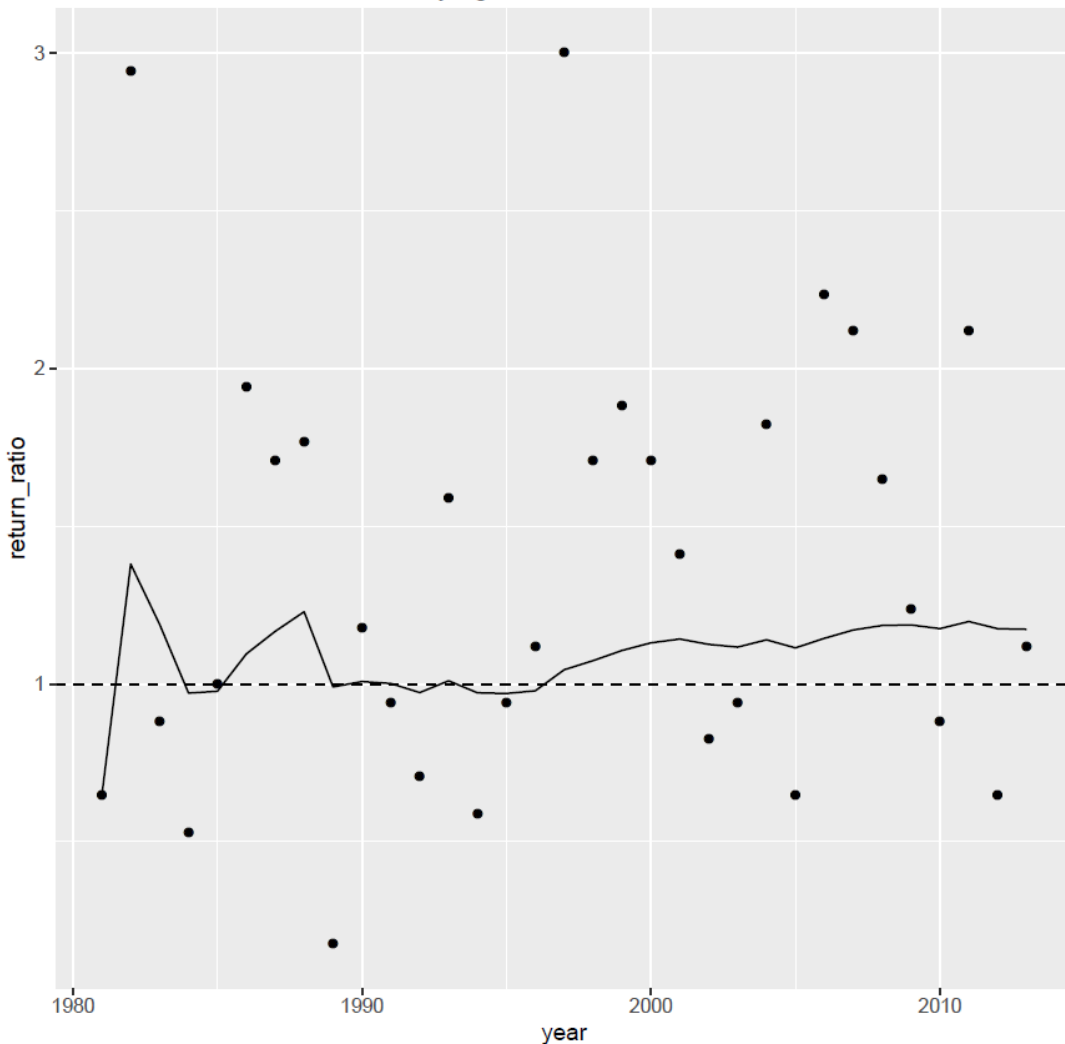


Let's Play!

Back to the map

See all results in a table

Playing roulette at Orlando



Skill score (RPSS) = 0.23

Return ratio = 1.173

Interest rate = 17.3%

From 10€ inverted,
1944€ returned after 33 runs



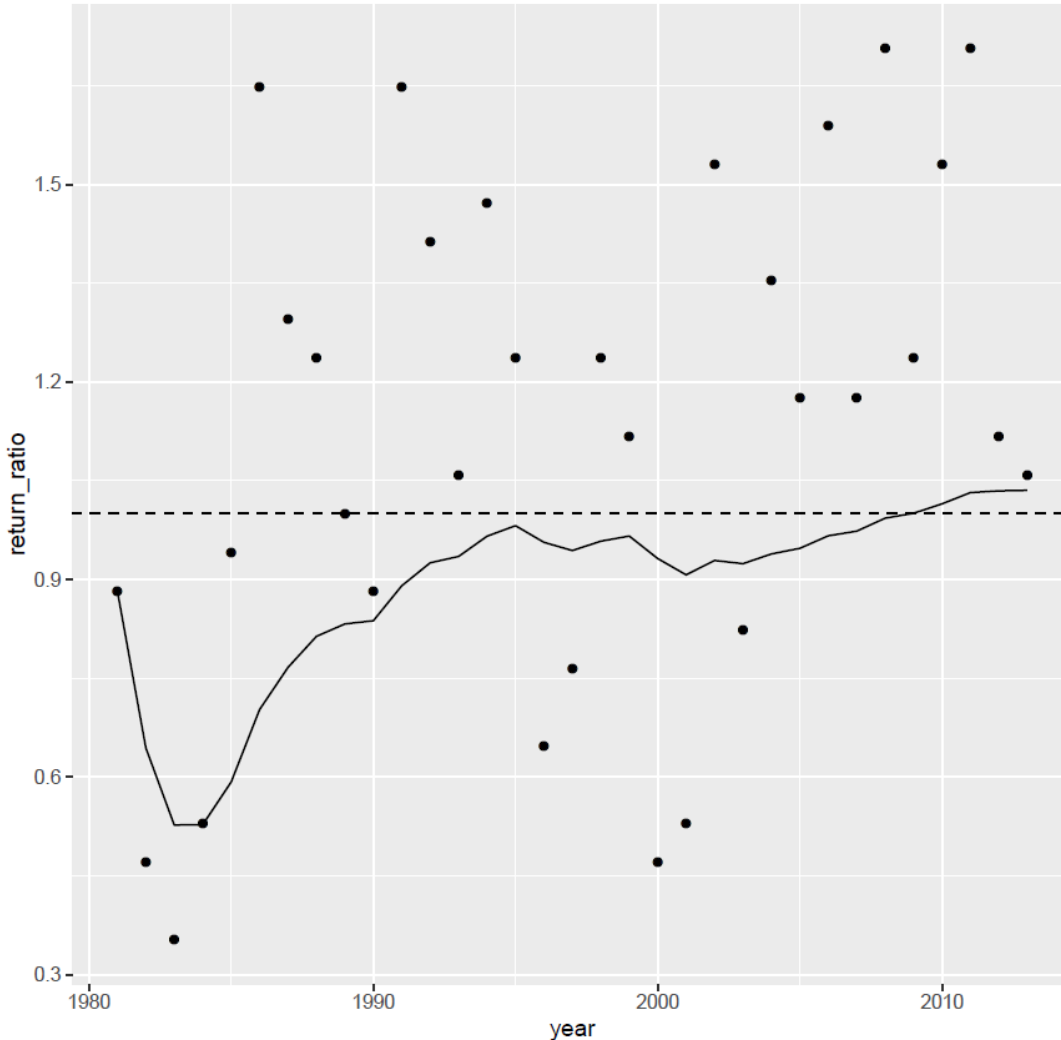


Let's Play!

Back to the map

See all results in a table

Playing roulette at ShepherdFlats



Skill score (RPSS) = 0.06

Return ratio = 1.035

Interest rate = 3.5%

From 10€ inverted,
31.5€ returned after 33 runs



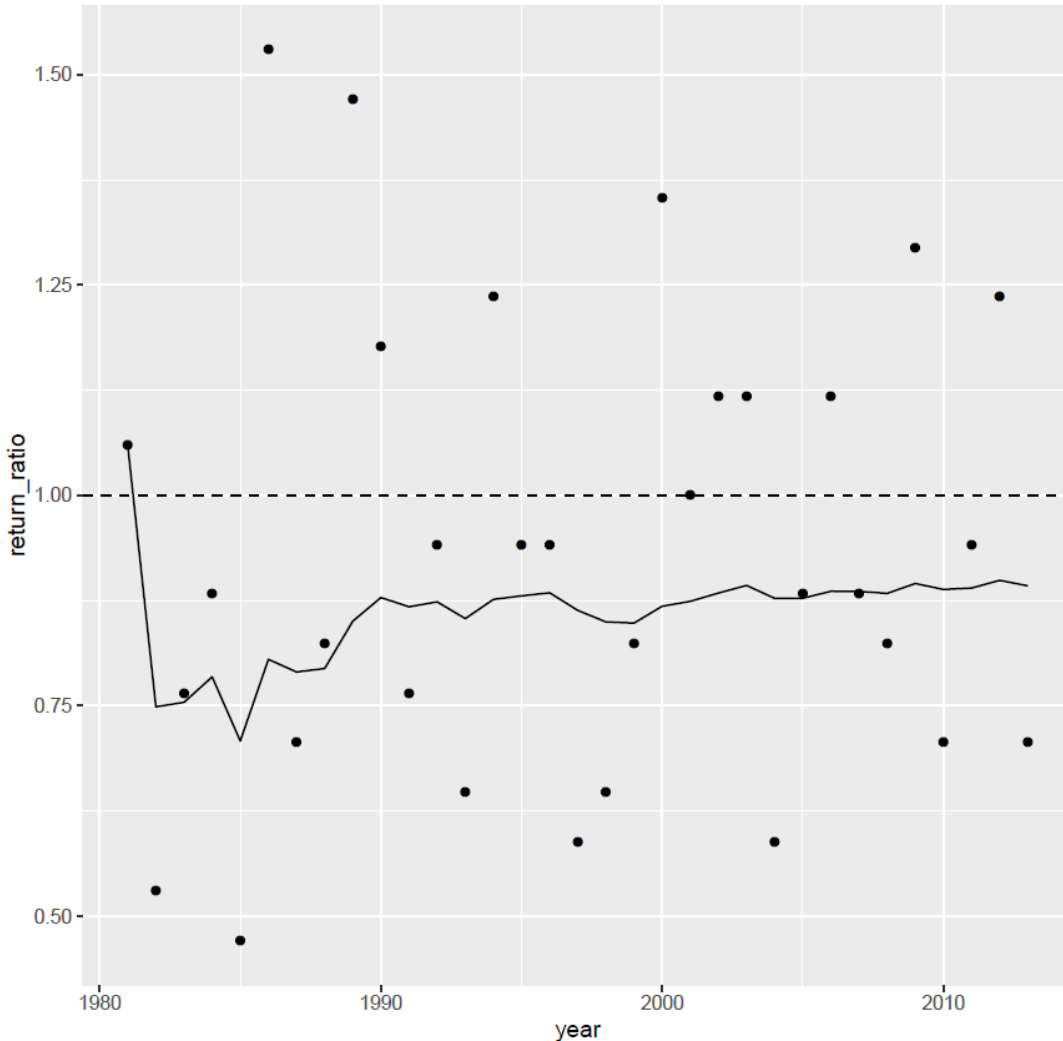


Let's Play!

Back to the map

See all results in a table

Playing roulette at TehachapiPass



Skill score (RPSS) = -0.12

Return ratio = 0.892

Interest rate = -10.8%

From 10€ inverted,
20 cents returned after 33 runs



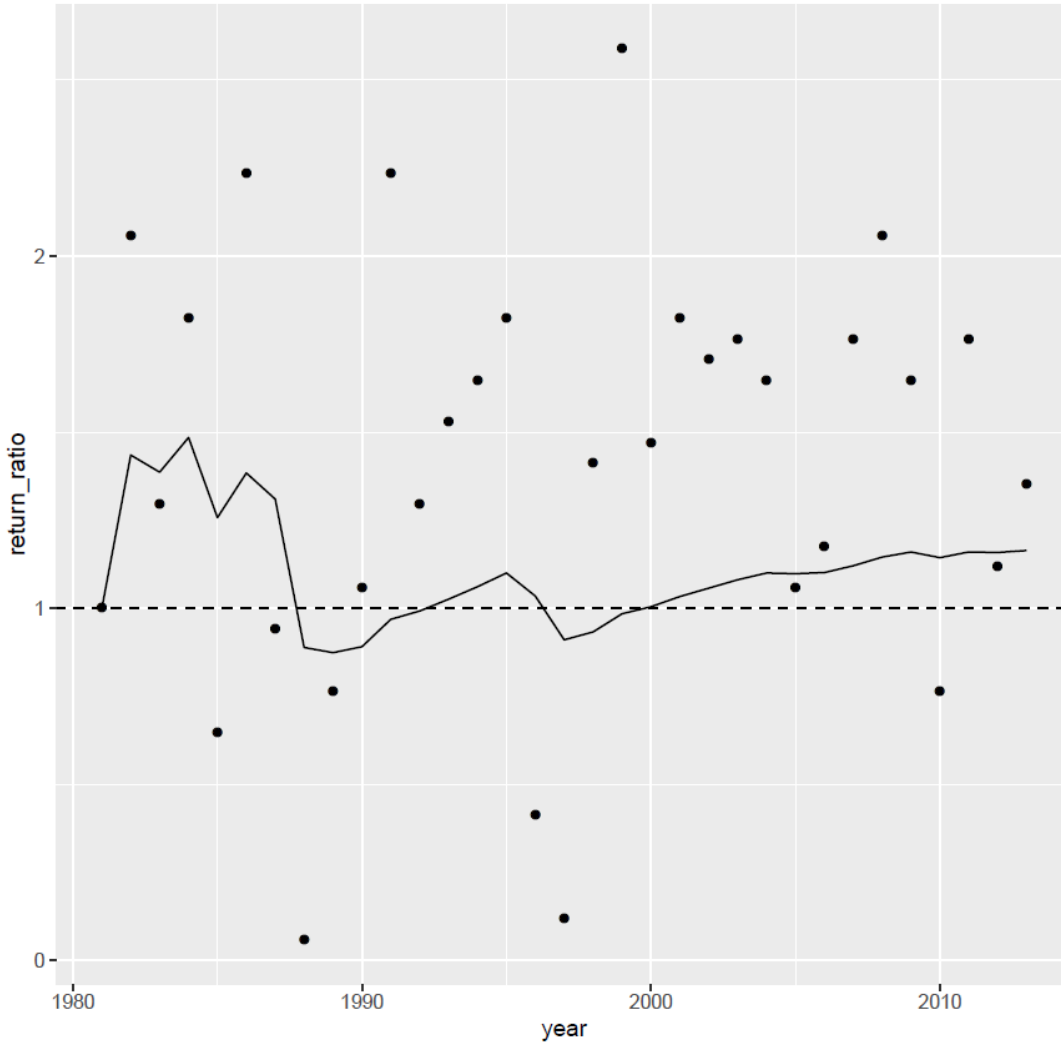


Let's Play!

Back to the map

See all results in a table

Playing roulette at BuffaloGap



Skill score (RPSS) = 0.22

Return ratio = 1.164

Interest rate = 16.4%

From 10€ inverted,
1499 € returned after 33 runs



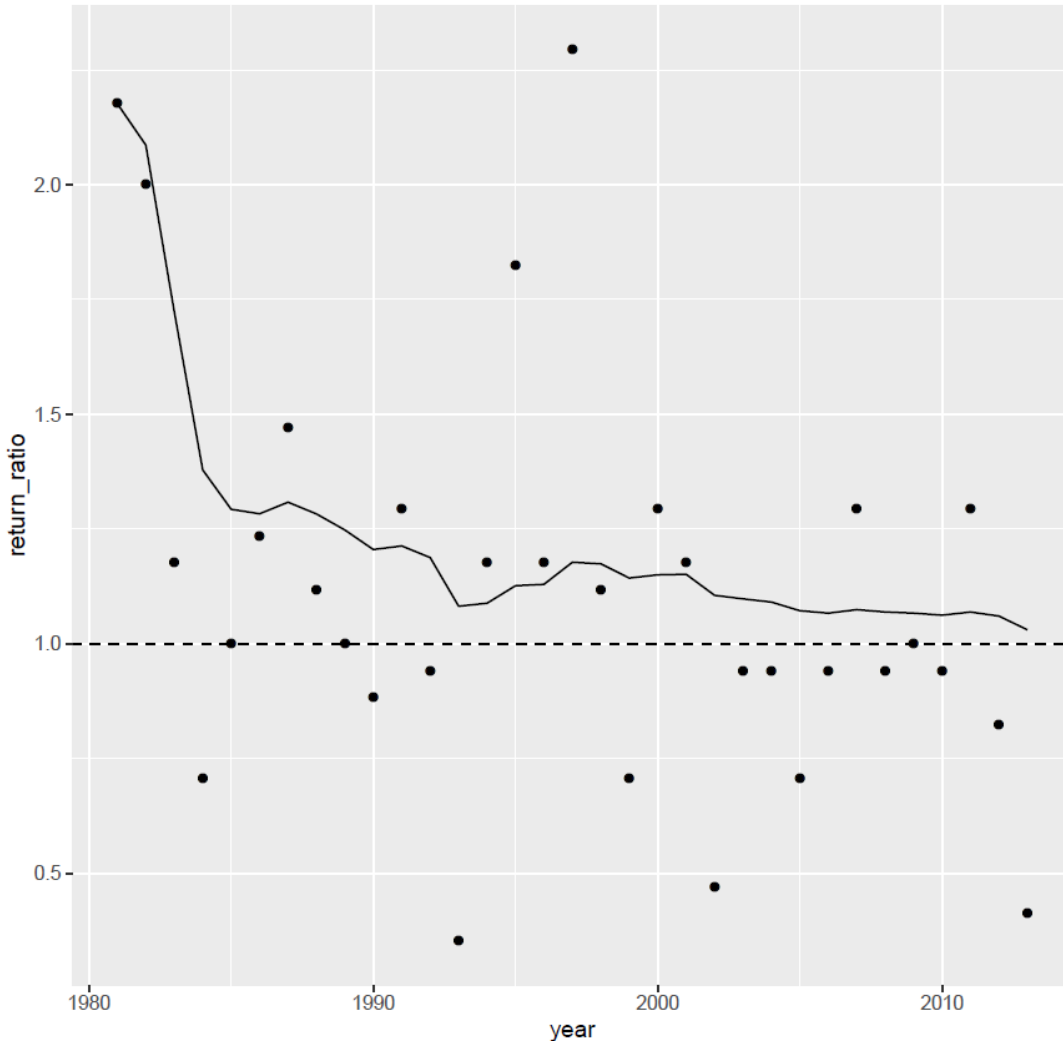


Let's Play!

Back to the map

See all results in a table

Playing roulette at Iowa



Skill score (RPSS) = 0.03

Return ratio = 1.031

Interest rate = 3.1%

From 10€ inverted,
27€ returned after 33 runs



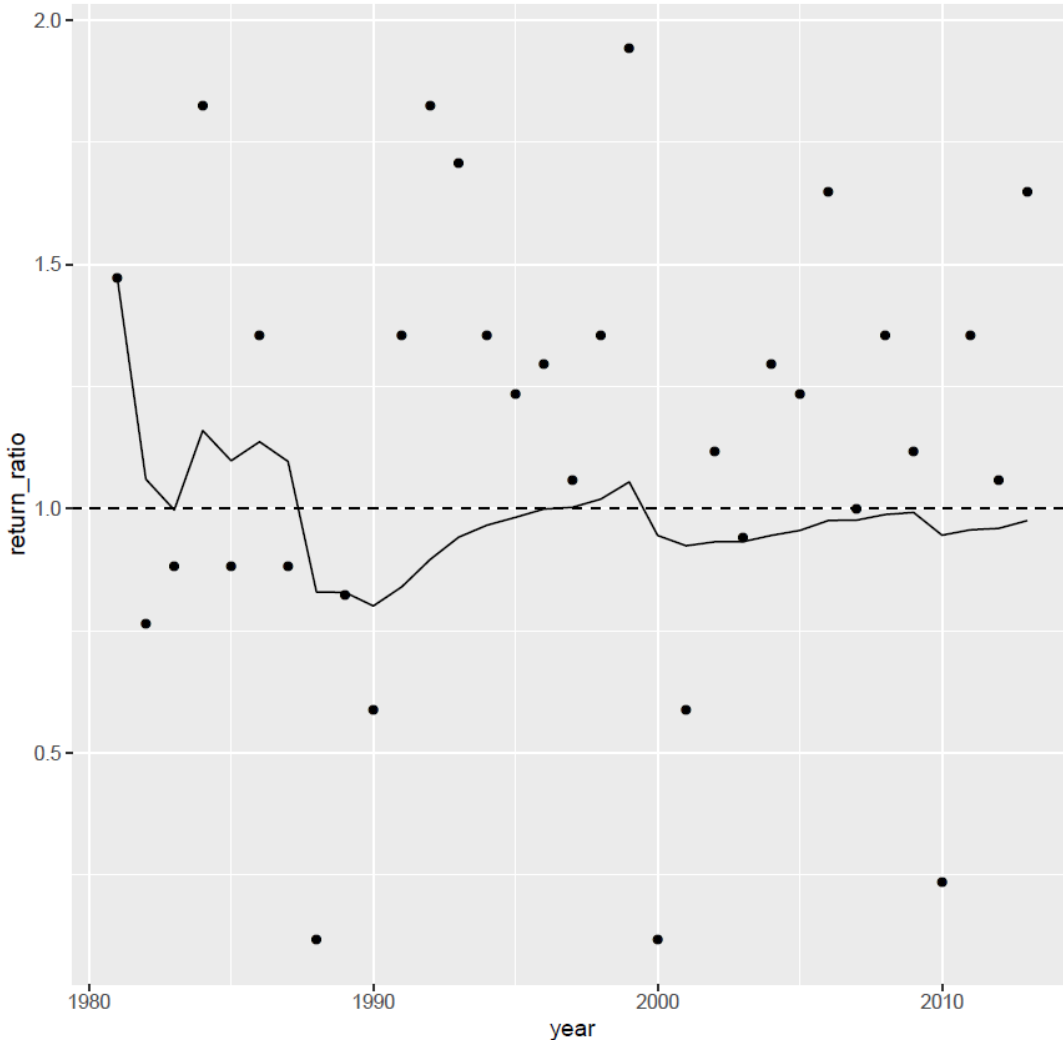


Let's Play!

Back to the map

See all results in a table

Playing roulette at Oklahoma



Skill score (RPSS) = 0.06

Return ratio = 0.976

Interest rate = -2.4%

From 10€ inverted,
4.4€ returned after 33 runs





Let's Play!

Back to the map

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Skill score (RPSS) = -0.07

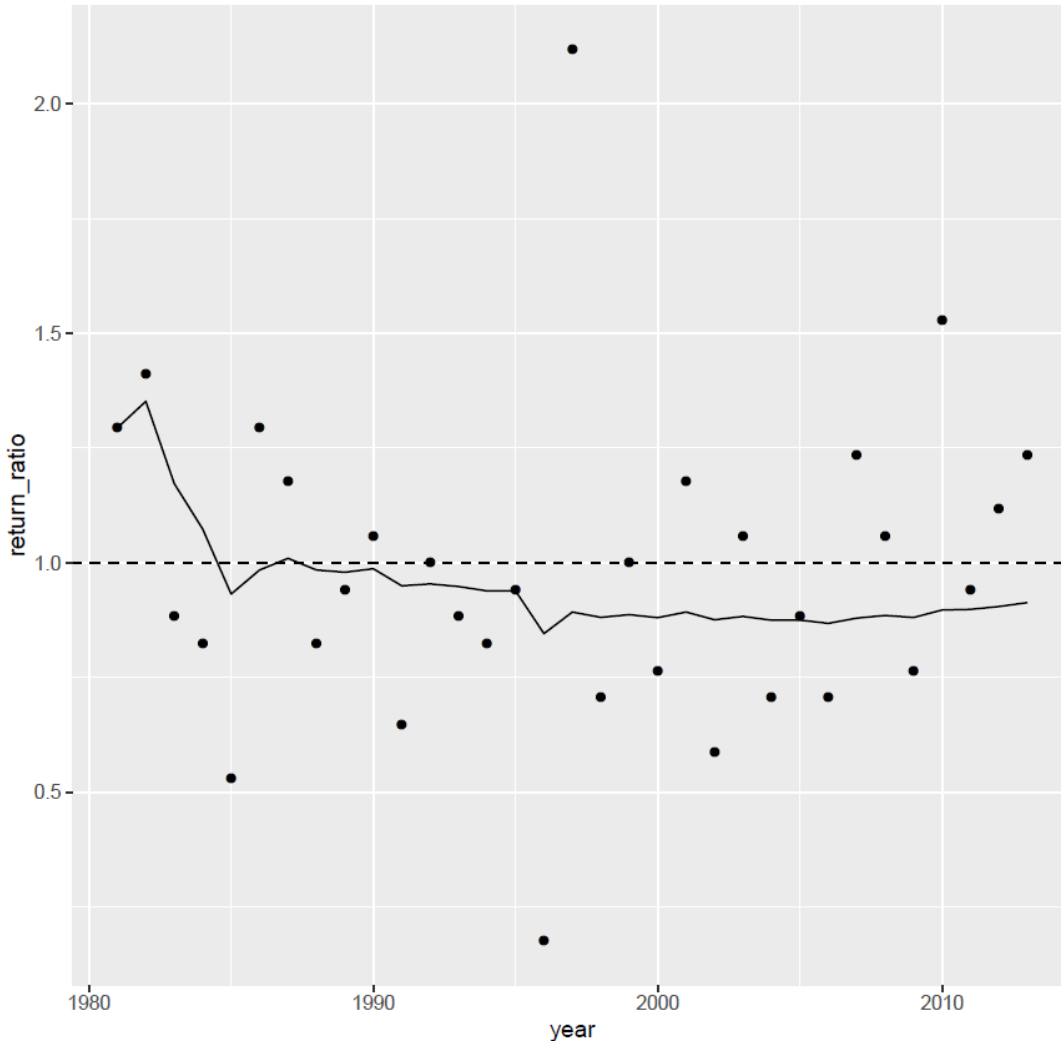
Return ratio = 0.913

Interest rate = -8.7%

From 10€ inverted,
50 cents returned after 33 runs



Playing roulette at Appalachian



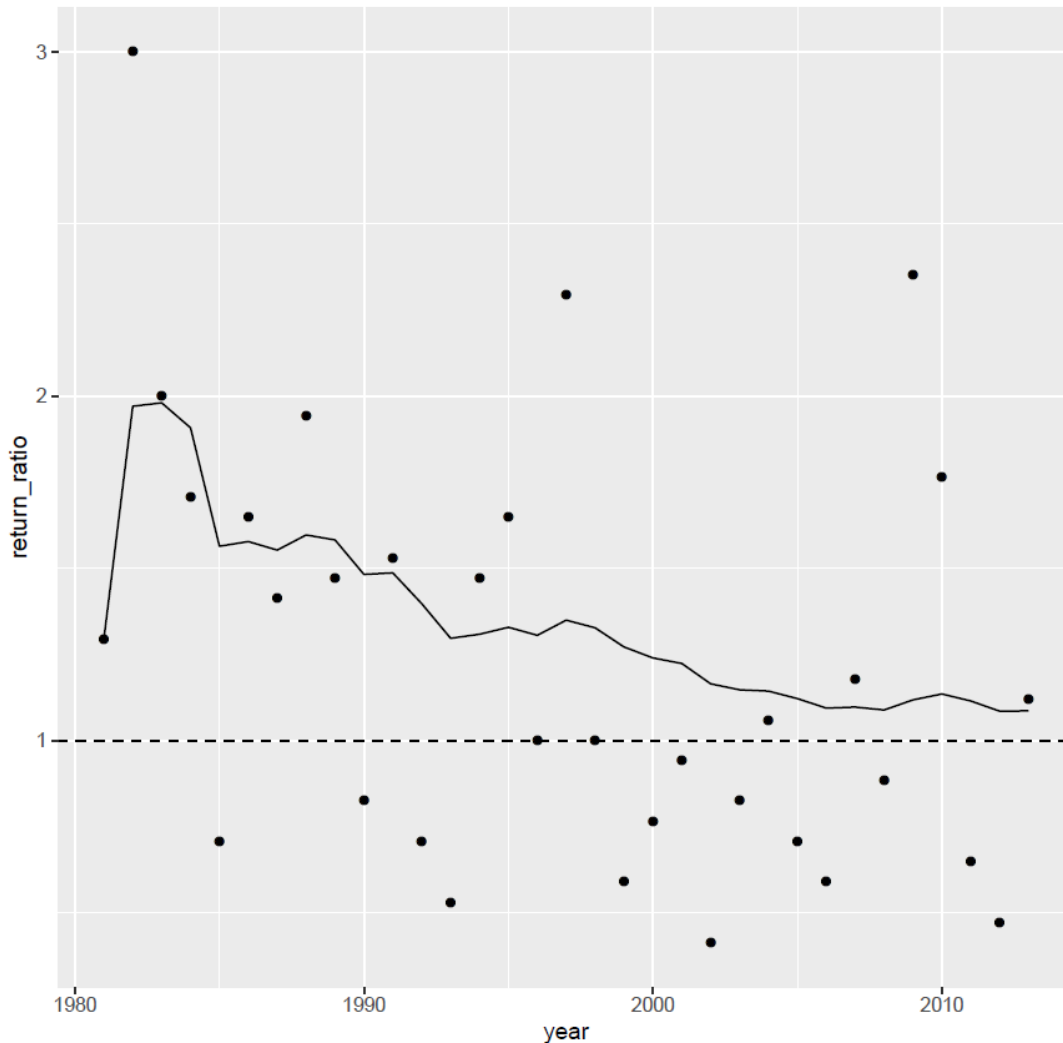


Let's Play!

Back to the map

See all results in a table

Playing roulette at Indiana



Skill score (RPSS) = 0.18

Return ratio = 1.086

Interest rate = 8.6%

From 10€ inverted,
150€ returned after 33 runs



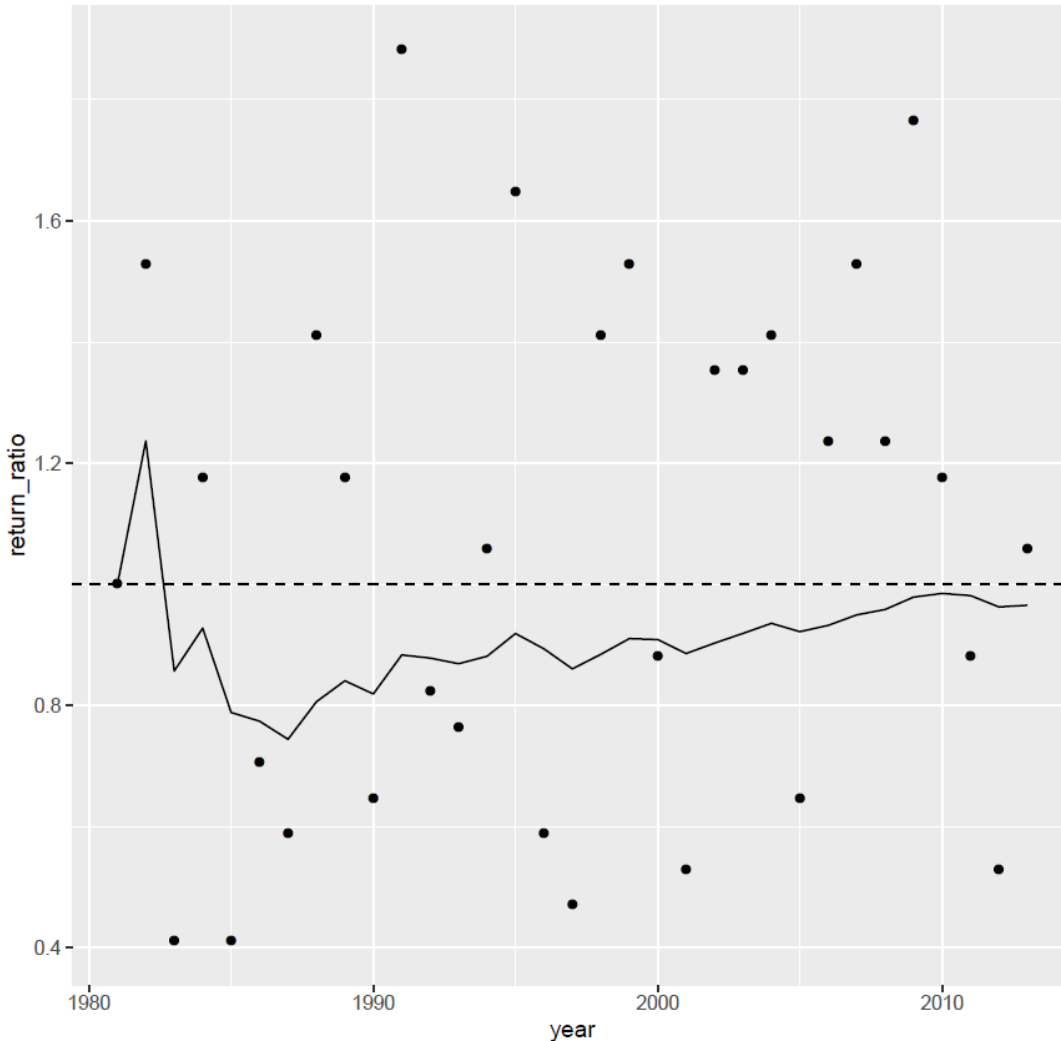


Let's Play!

Back to the map

See all results in a table

Playing roulette at Fantanele



Skill score (RPSS) = -0.01

Return ratio = 0.966

Interest rate = -3.4%

From 10€ inverted,
3.1€ returned after 33 runs



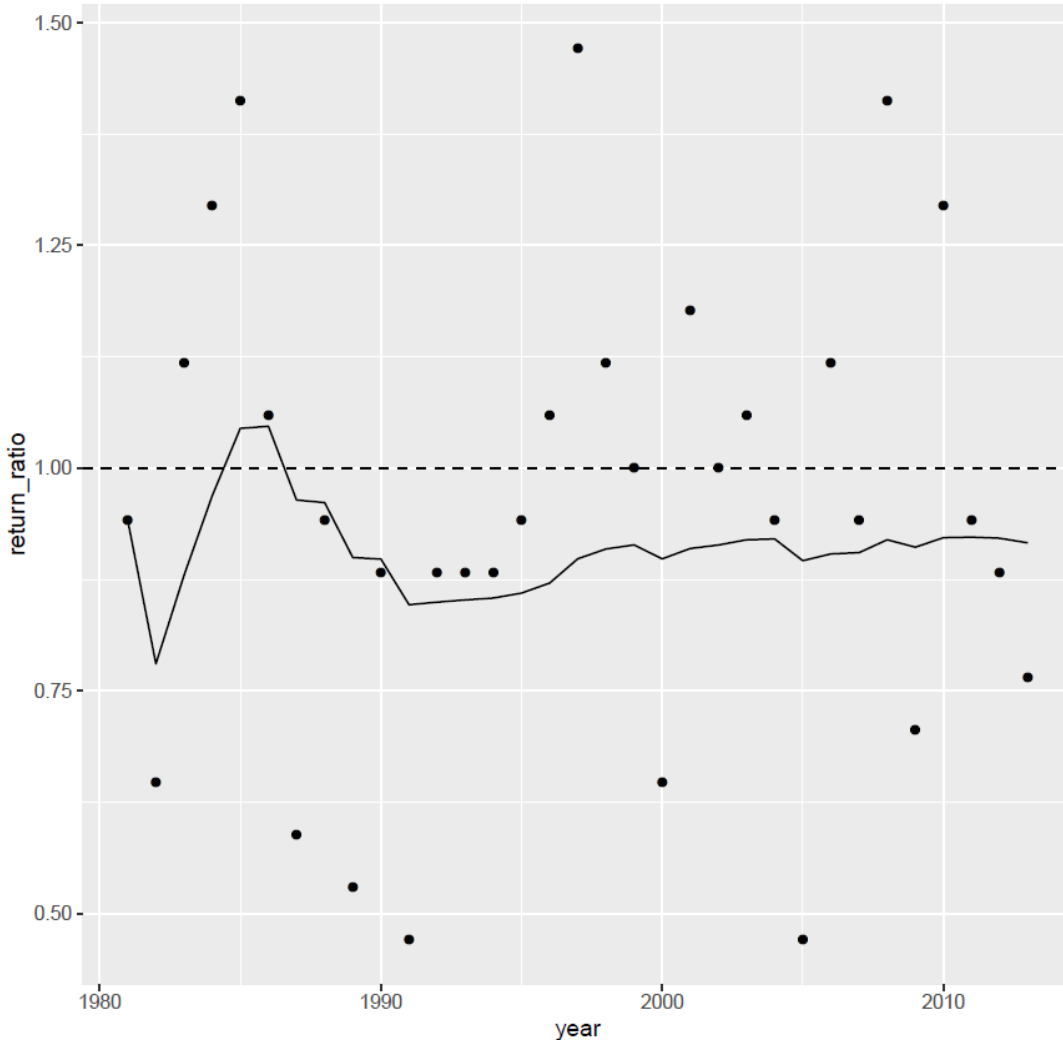


Let's Play!

Back to the map

See all results in a table

Playing roulette at Lugo



Skill score (RPSS) = -0.08

Return ratio = 0.916

Interest rate = -8.4%

From 10€ inverted,
60cent returned after 33 runs





Let's Play!

Back to the map

See all results in a table

Skill score (RPSS) = -0.06

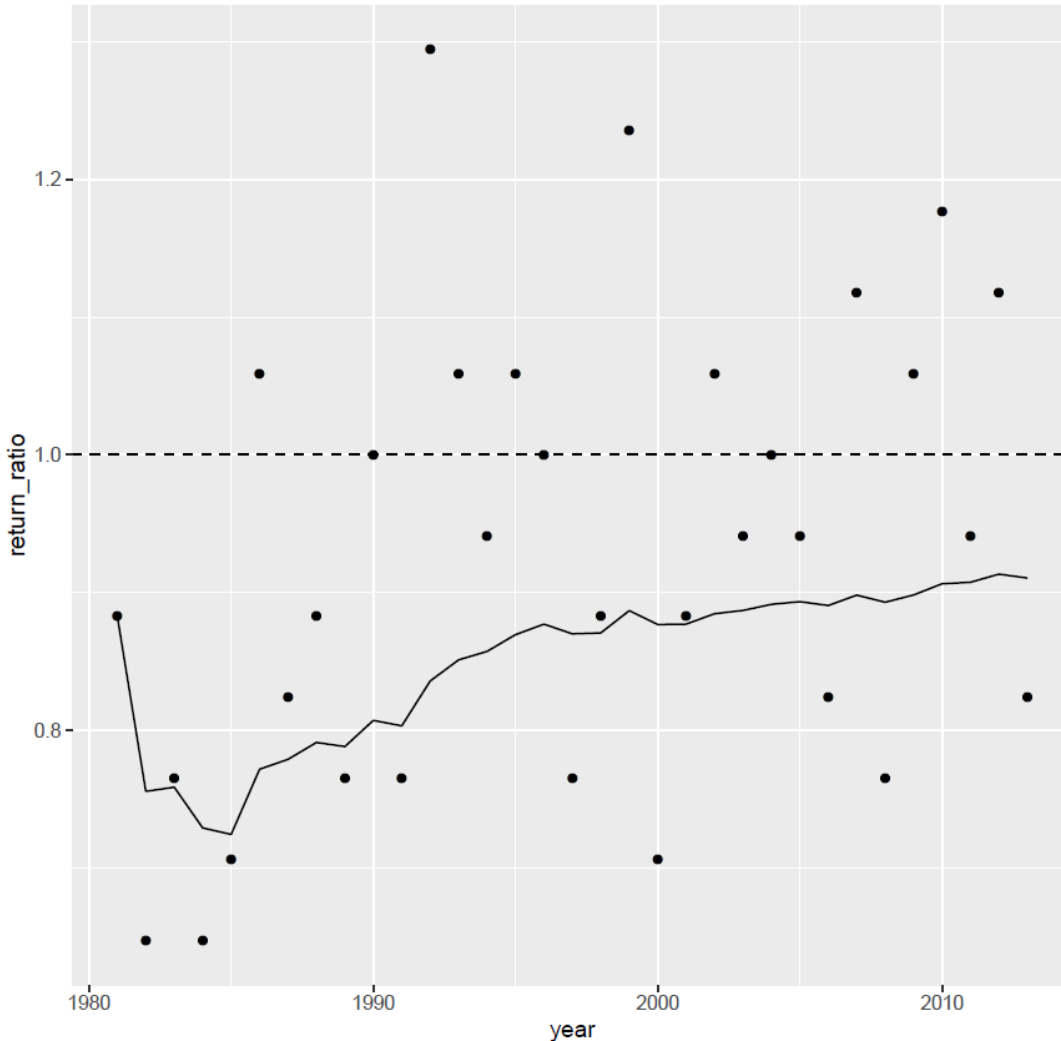
Return ratio = 0.910

Interest rate = -9%

From 10€ inverted,
50 cent returned after 33 runs



Playing roulette at Tarifa



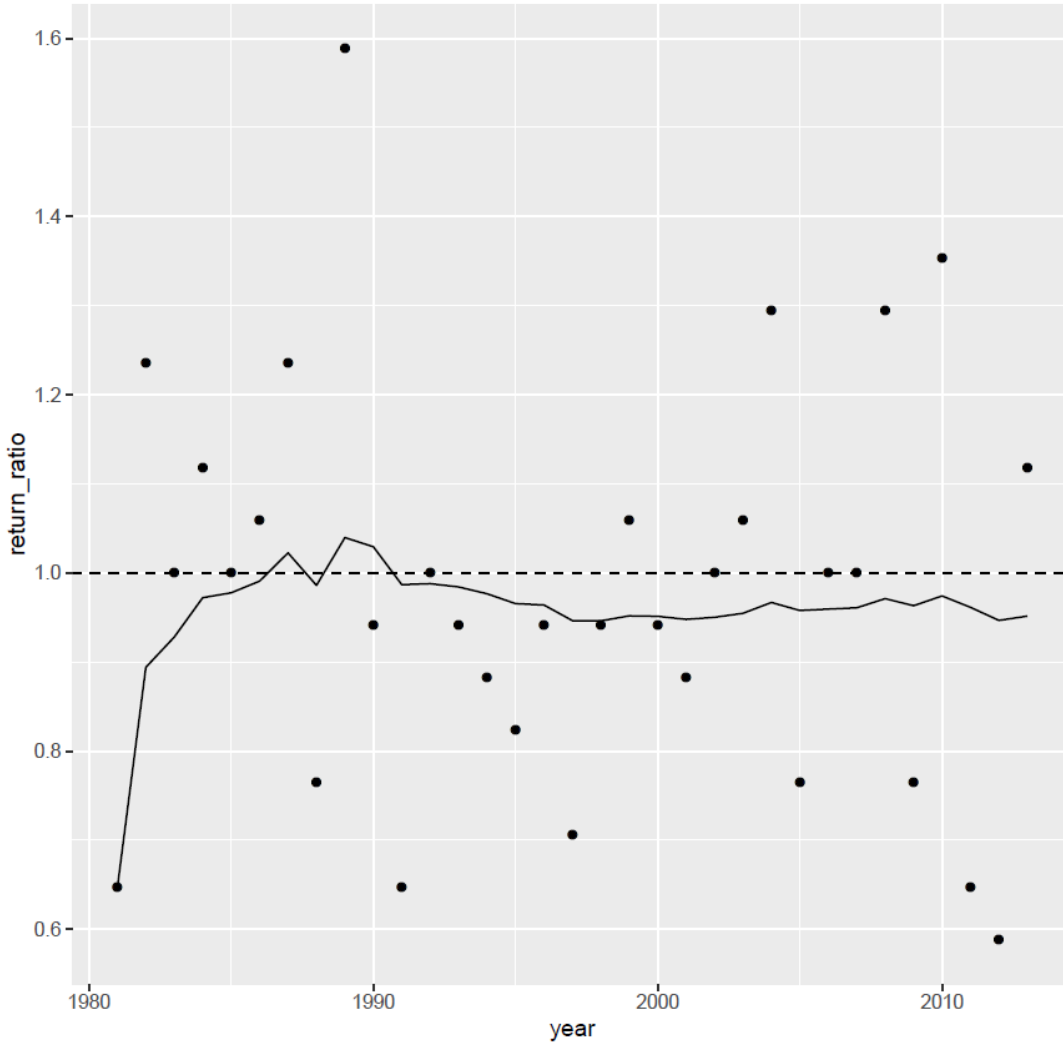


Let's Play!

Back to the map

See all results in a table

Playing roulette at Ebro



Skill score (RPSS) = -0.05

Return ratio = 0.952

Interest rate = -4.8%

From 10€ inverted,
1.9€ returned after 33 runs



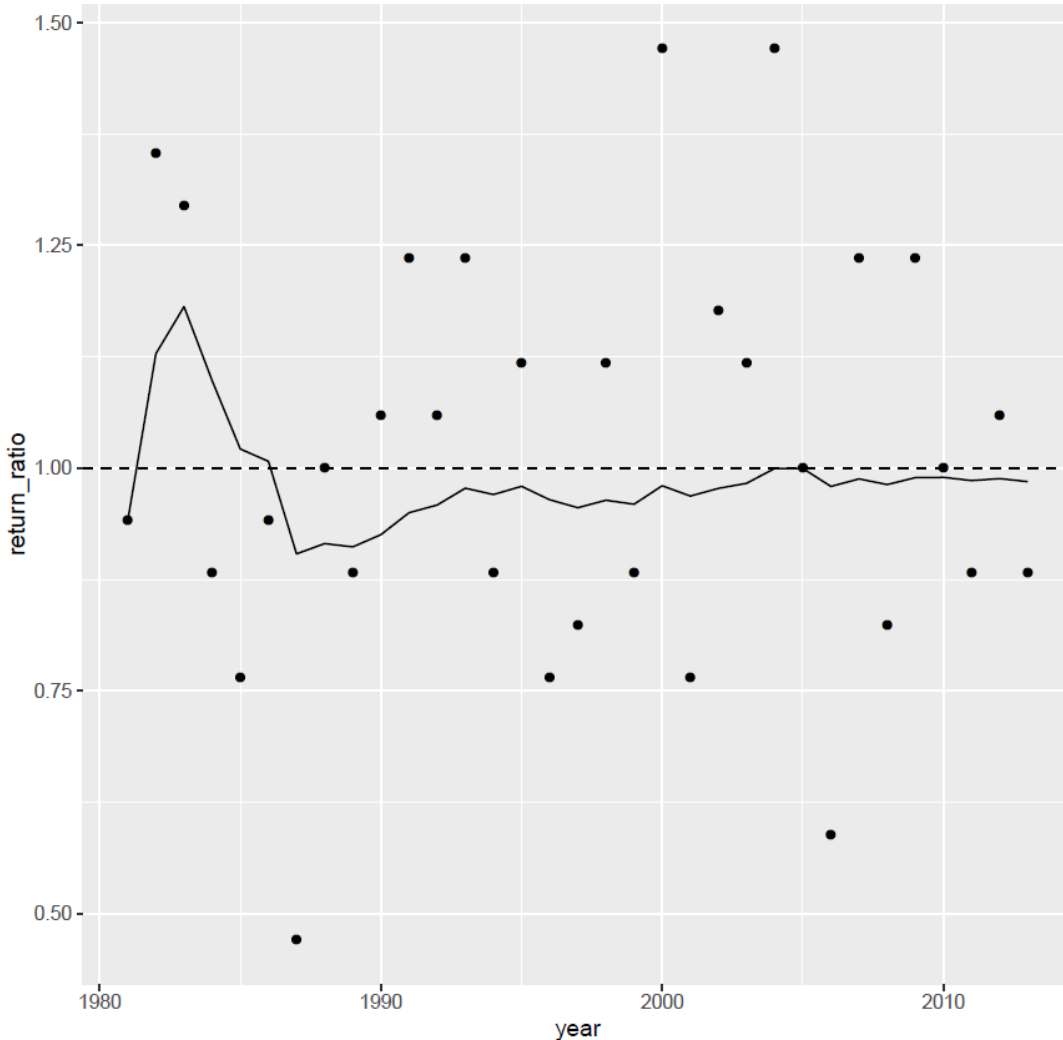


Let's Play!

Back to the map

See all results in a table

Playing roulette at Campania



Skill score (RPSS) = -0.03

Return ratio = 0.985

Interest rate = -1.5%

From 10€ inverted,
6€ returned after 33 runs



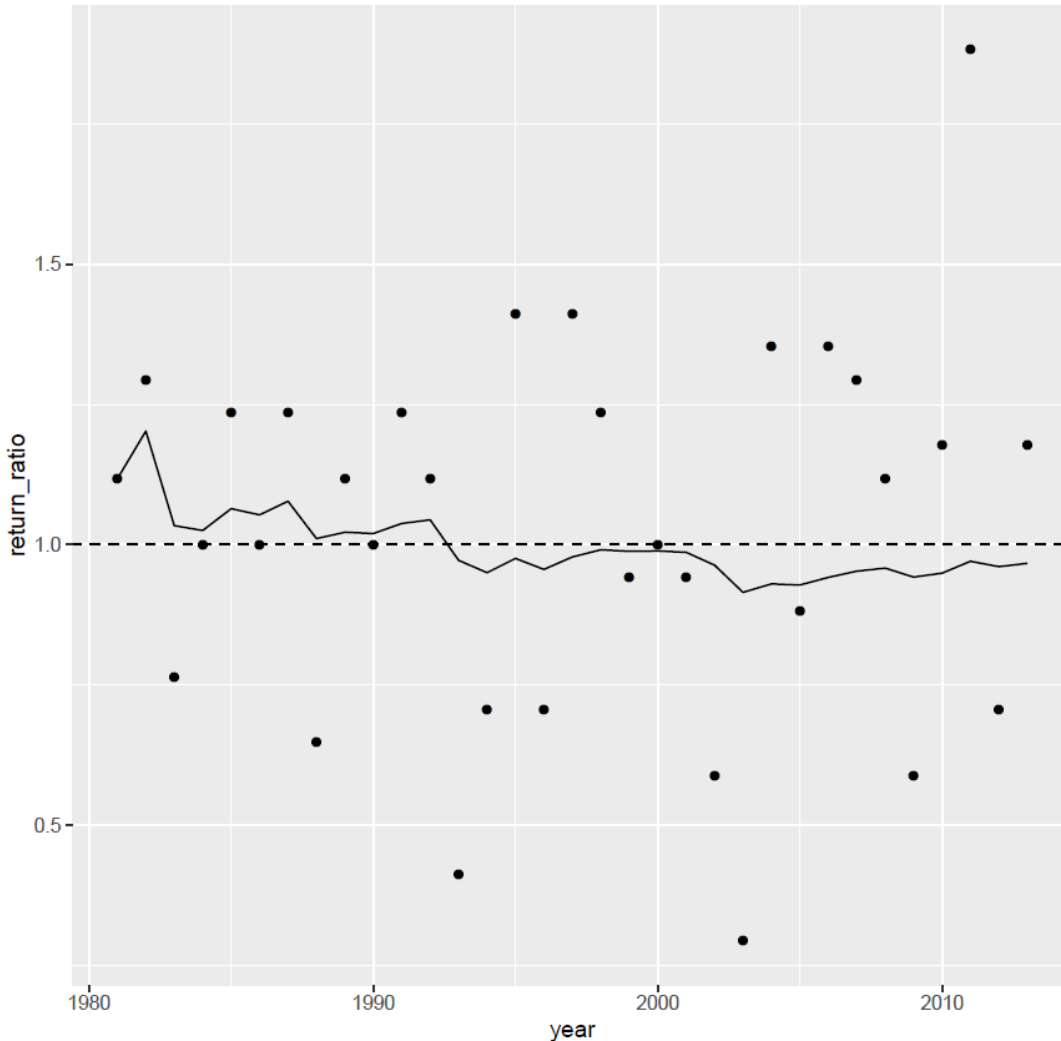


Let's Play!

Back to the map

See all results in a table

Playing roulette at Stavanger



Skill score (RPSS) = -0.02
Return ratio = 0.967
Interest rate = -3.3%

From 10€ inverted,
3.3€ returned after 33 runs



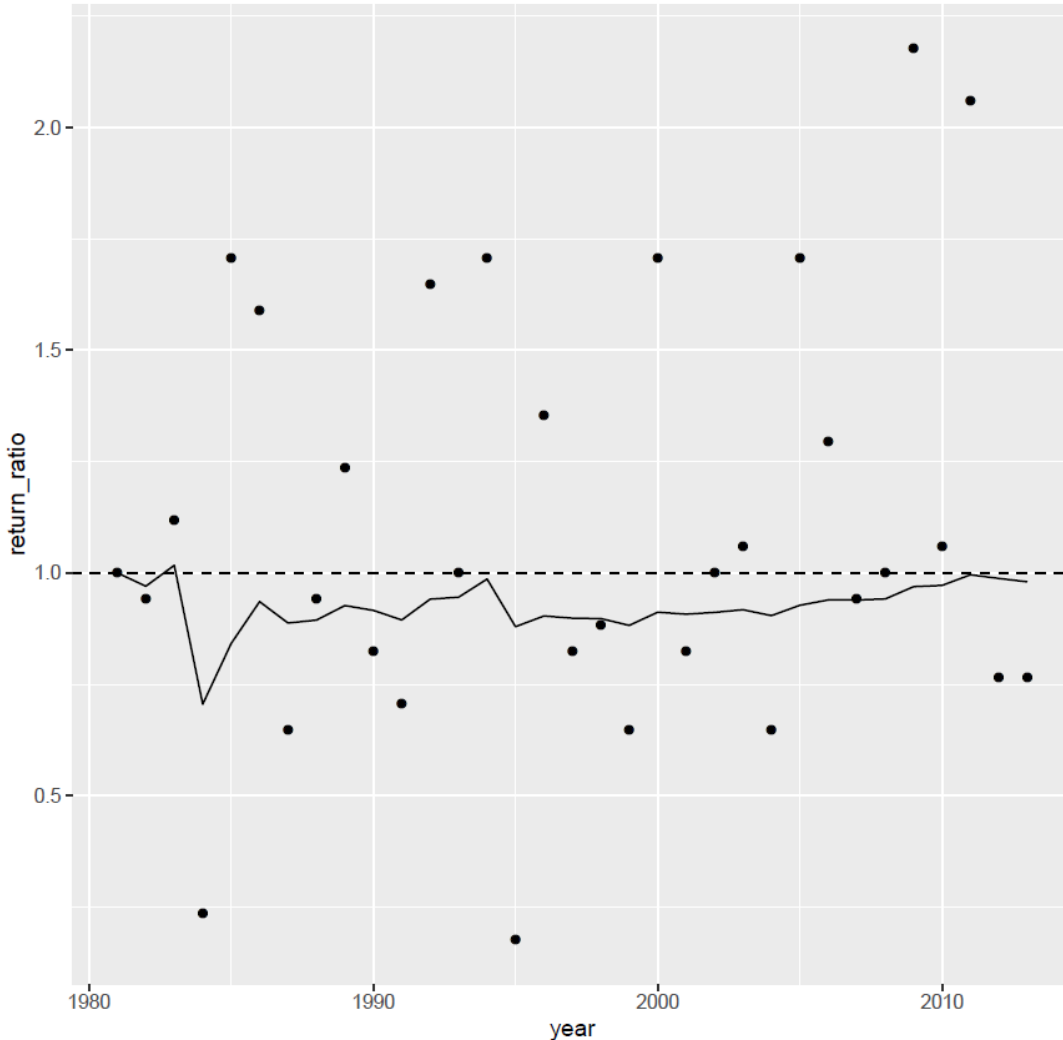


Let's Play!

Back to the map

See all results in a table

Playing roulette at Oslo



Skill score (RPSS) = 0.02

Return ratio = 0.98

Interest rate = -2%

From 10€ inverted,
5.1€ returned after 33 runs



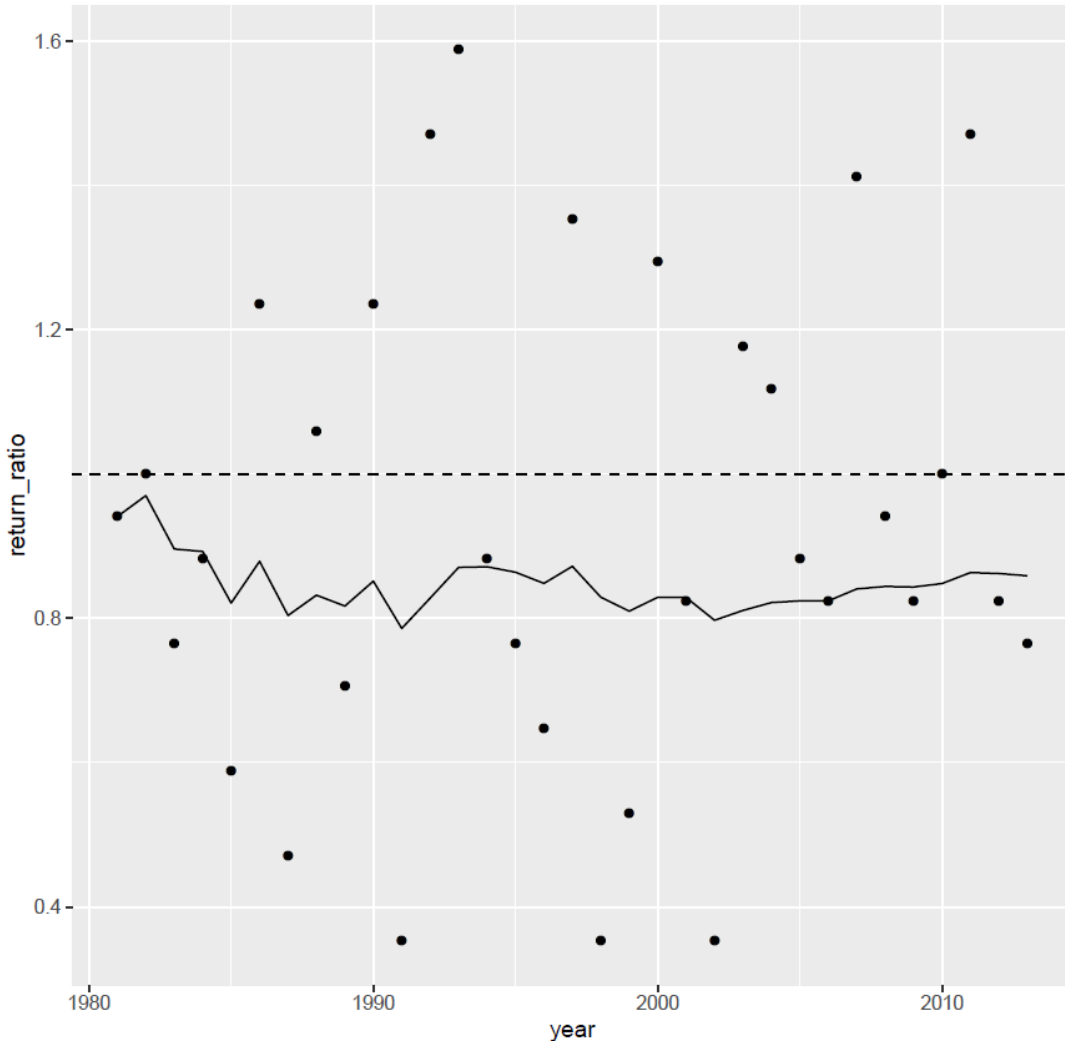


Let's Play!

Back to the map

See all results in a table

Playing roulette at Belgium



Skill score (RPSS) = -0.10

Return ratio = 0.859

Interest rate = -14.1%

From 10€ inverted,
10 cent returned after 33 runs



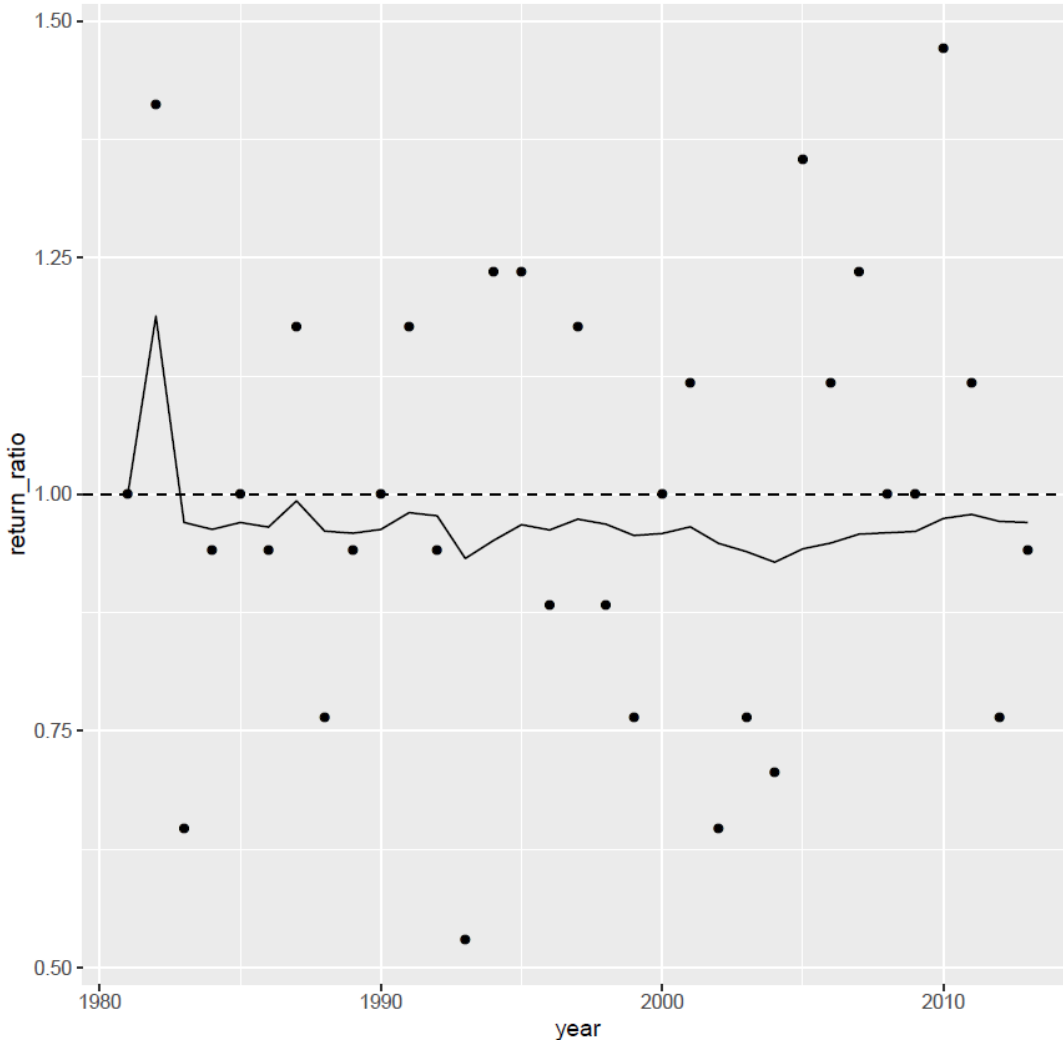


Let's Play!

Back to the map

See all results in a table

Playing roulette at HornRevs



Skill score (RPSS) = -0.03
Return ratio = 0.970
Interest rate = -3%

From 10€ inverted,
3.7€ returned after 33 runs



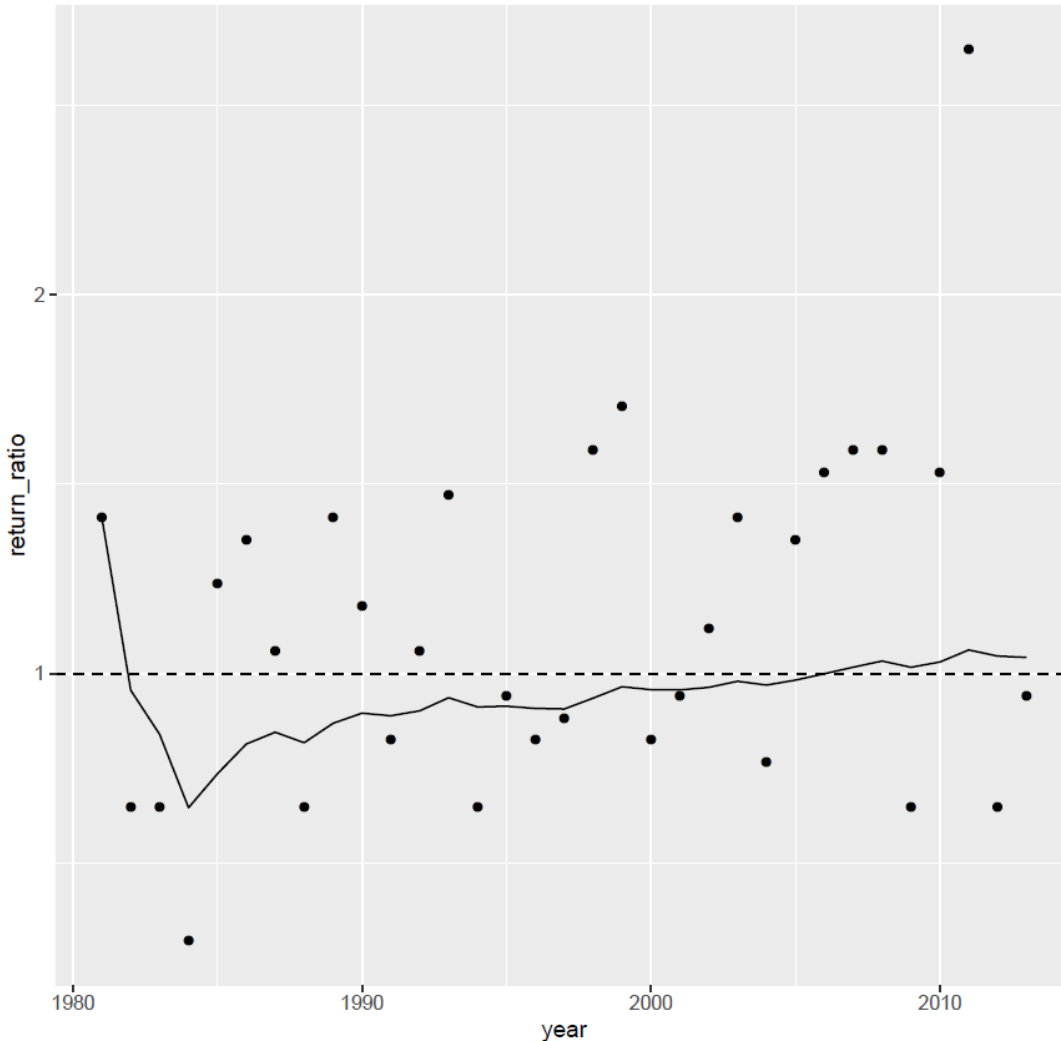


Let's Play!

Back to the map

See all results in a table

Playing roulette at Faeroe



Skill score (RPSS) = 0.08

Return ratio = 1.043

Interest rate = 4.3%

From 10€ inverted,
39.6€ returned after 33 runs



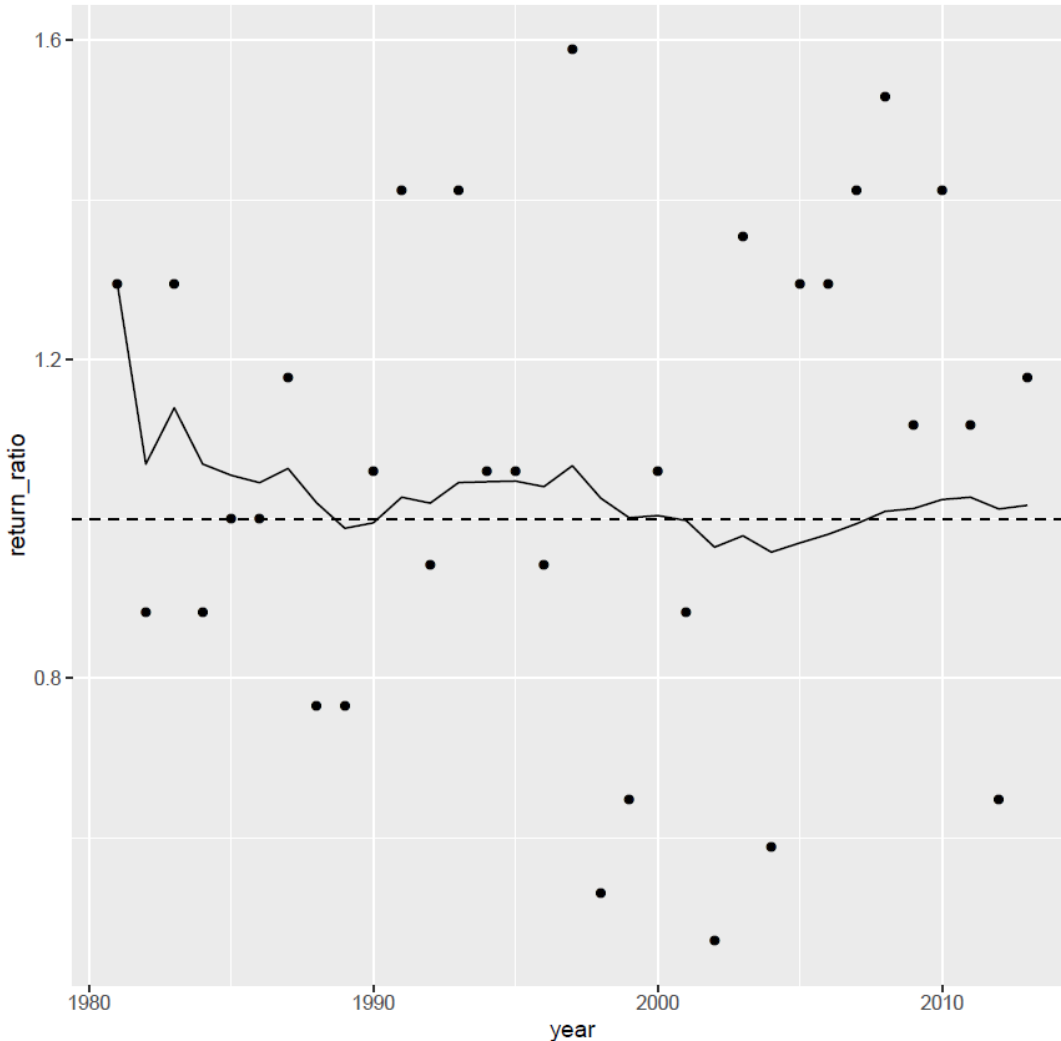


Let's Play!

Back to the map

See all results in a table

Playing roulette at Edinburg



Skill score (RPSS) = 0.02

Return ratio = 1.017

Interest rate = 1.7%

From 10€ inverted,
17.4€ returned after 33 runs



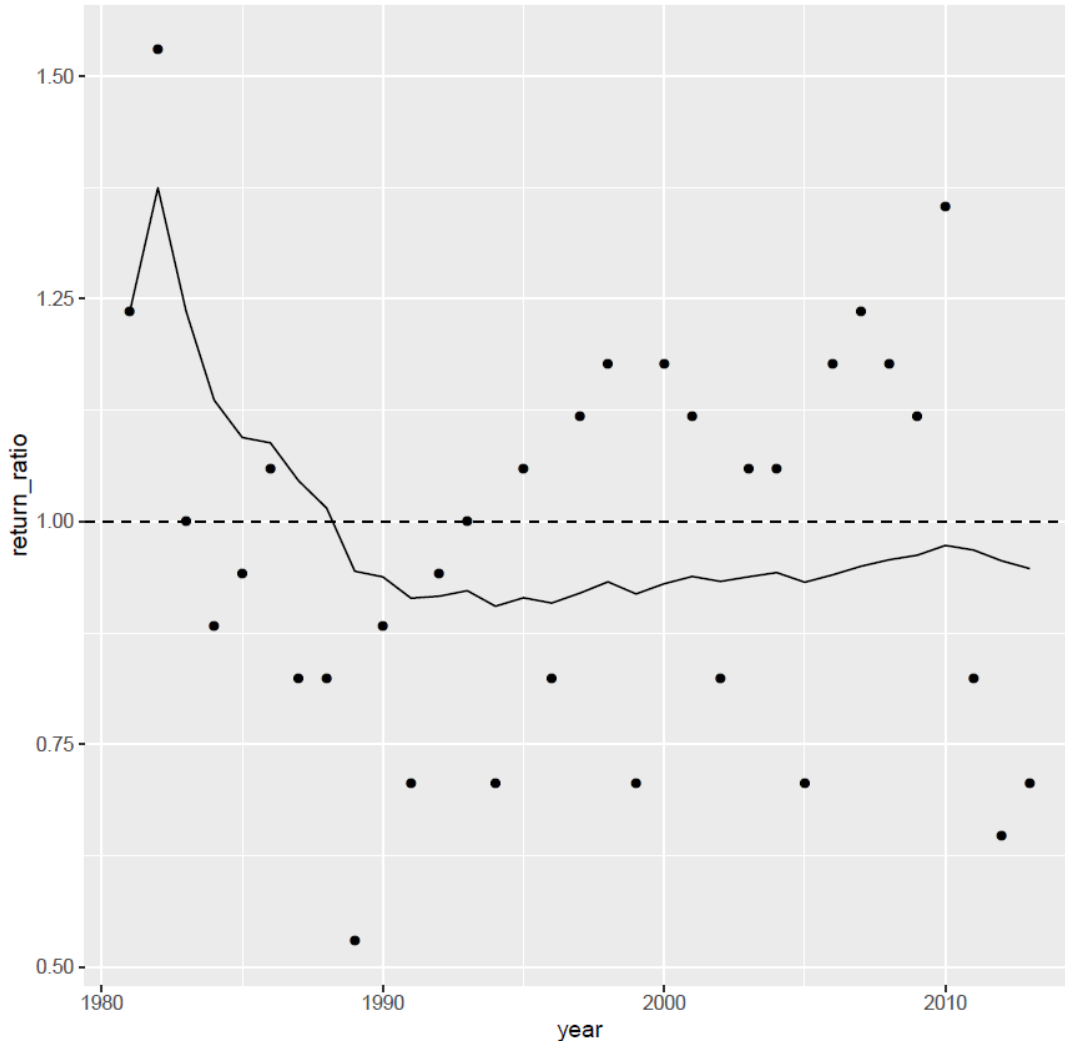


Let's Play!

Back to the map

See all results in a table

Playing roulette at Bretagne



Skill score (RPSS) = -0.04
Return ratio = 0.947
Interest rate = -5.3%

From 10€ inverted,
1.7€ returned after 33 runs



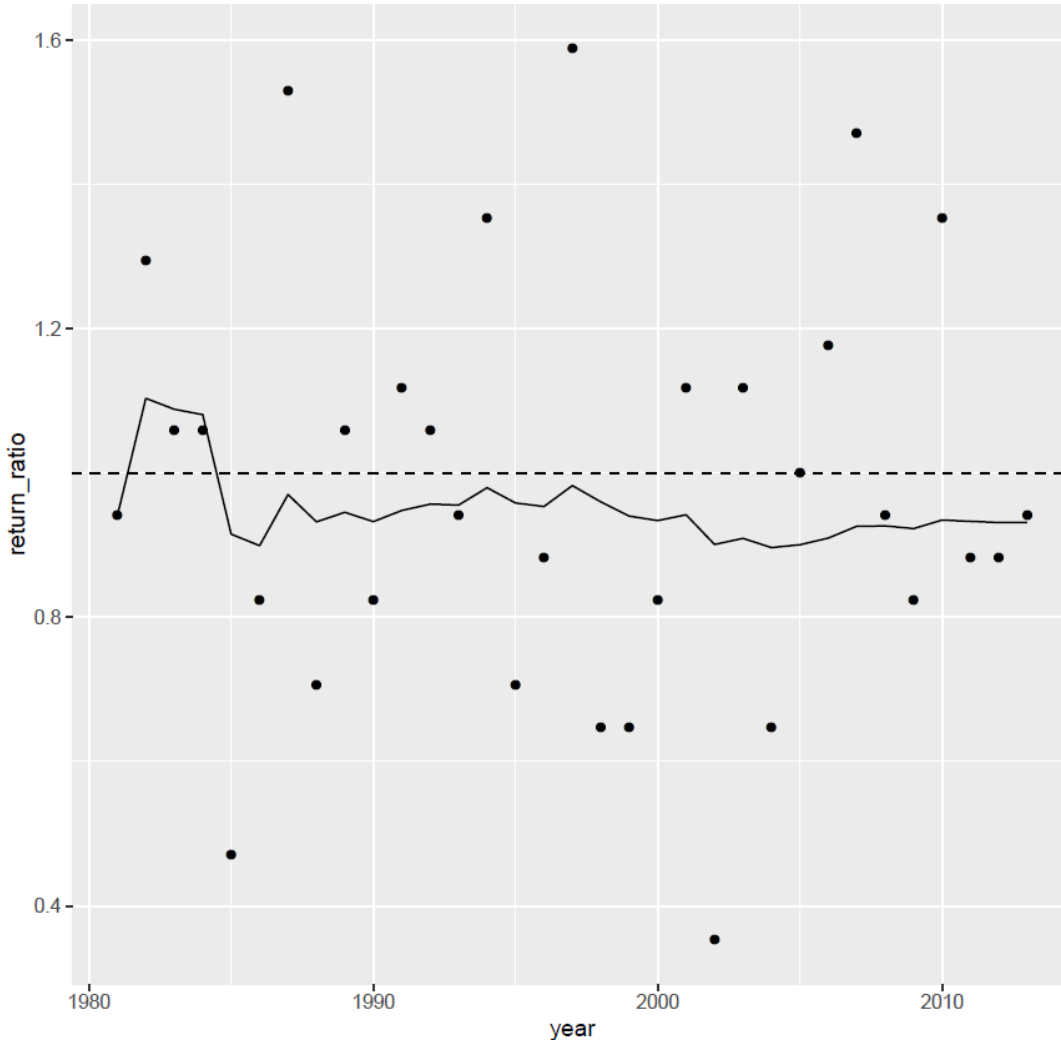


Let's Play!

Back to the map

See all results in a table

Playing roulette at Magdeburg



Skill score (RPSS) = -0.05
Return ratio = 0.932
Interest rate = -6.8%

From 10€ inverted,
1€ returned after 33 runs



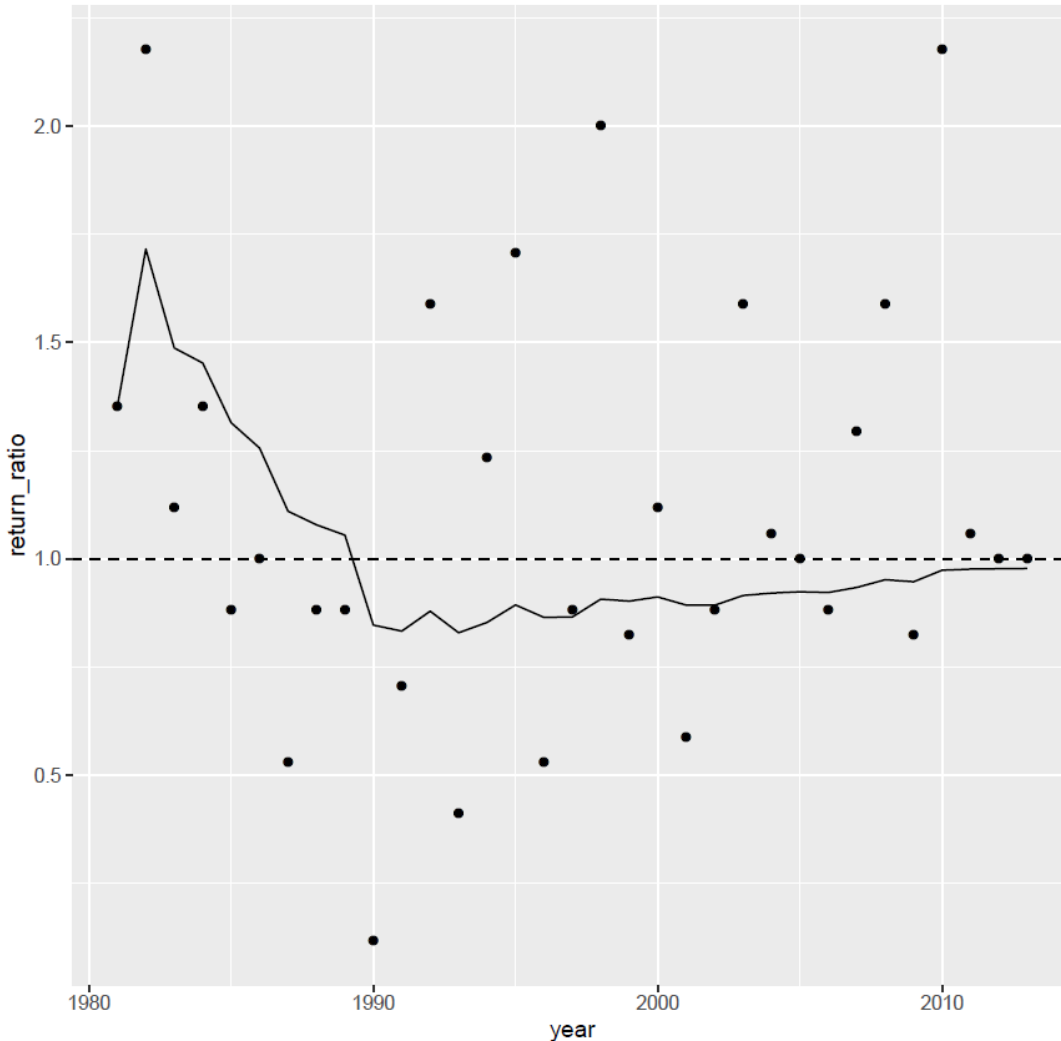


Let's Play!

Back to the map

See all results in a table

Playing roulette at CapeTown



Skill score (RPSS) = -0.01
Return ratio = 0.978
Interest rate = -2.2%

From 10€ inverted,
4.8€ returned after 33 runs





Let's Play!

Back to the map

See all results in a table

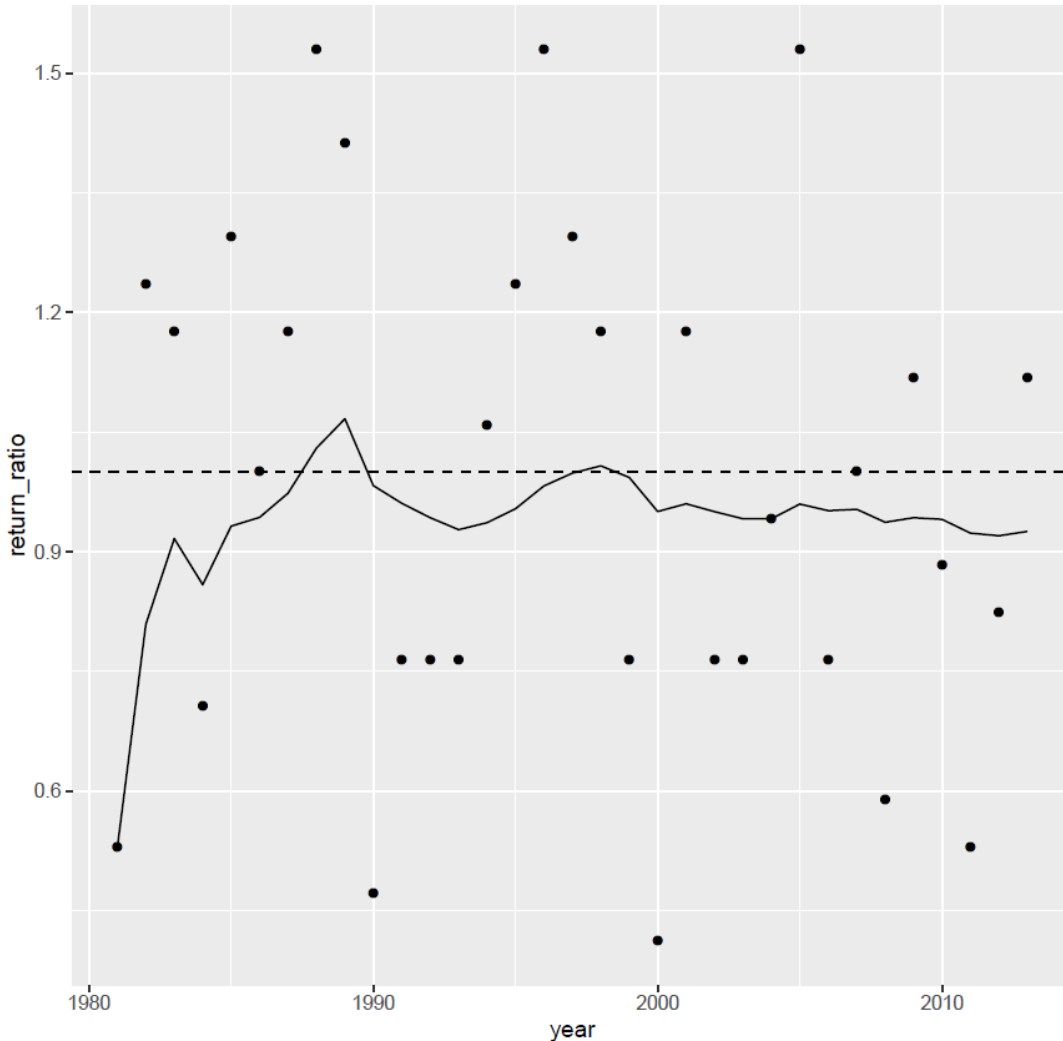
Skill score (RPSS) = -0.06

Return ratio = 0.925

Interest rate = -7.5%

From 10€ inverted,
80cent returned after 33 runs

Playing roulette at Karnataka





Let's Play!

Back to the map

See all results in a table

Skill score (RPSS) = -0.1

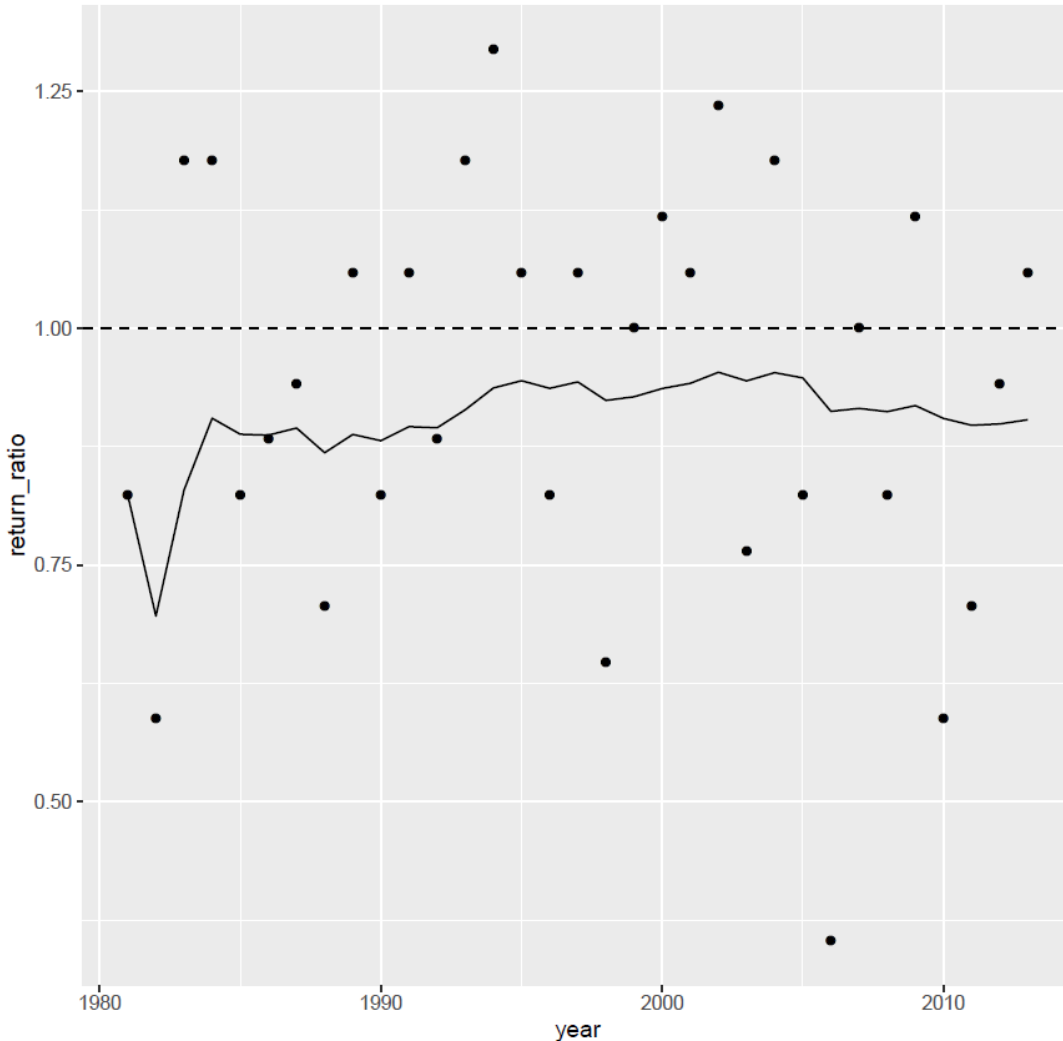
Return ratio = 0.903

Interest rate = -9.7%

From 10€ inverted,
30cent returned after 33 runs



Playing roulette at TamilNadu





Let's Play!

Back to the map

See all results in a table

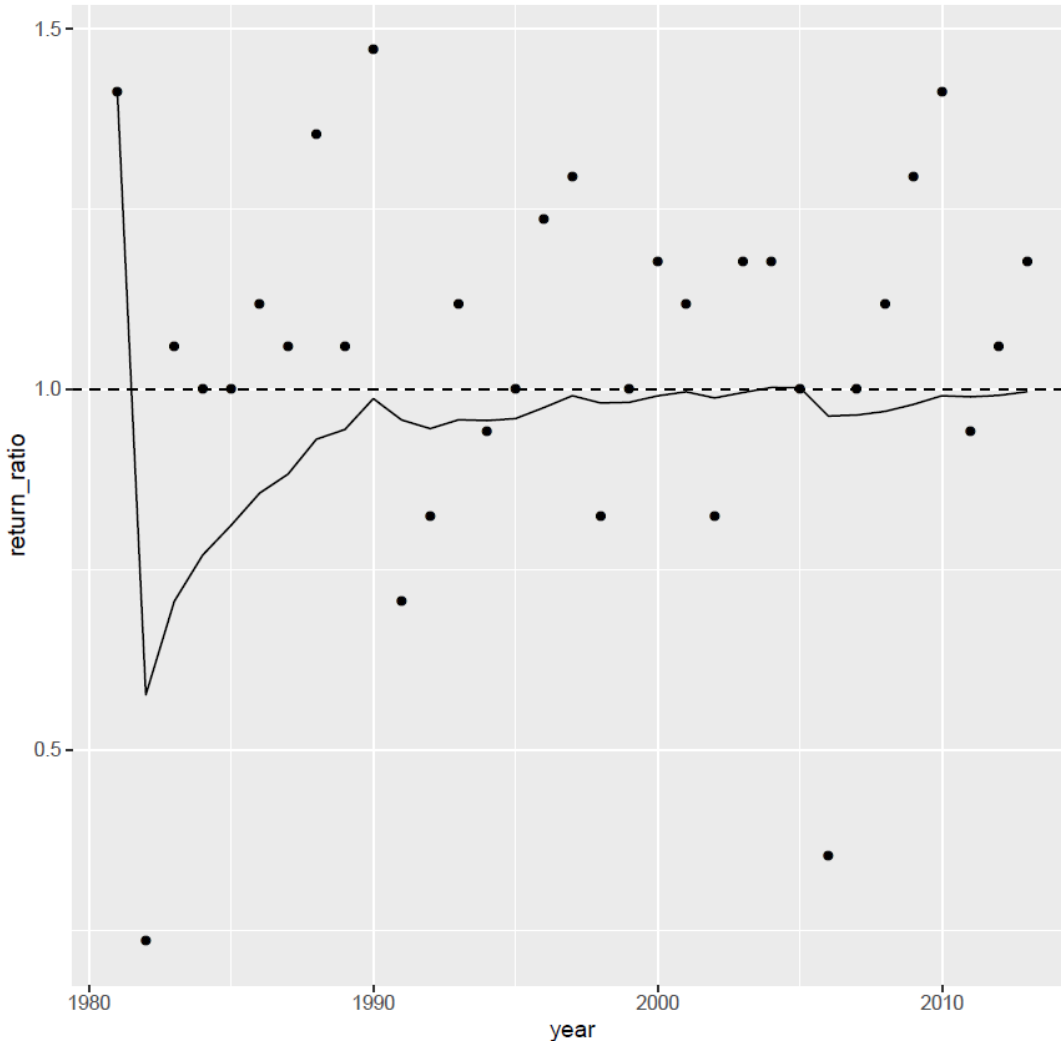
Skill score (RPSS) = 0

Return ratio = 0.997

Interest rate = -0.3%

From 10€ inverted,
8.9€ returned after 33 runs

Playing roulette at Shangai



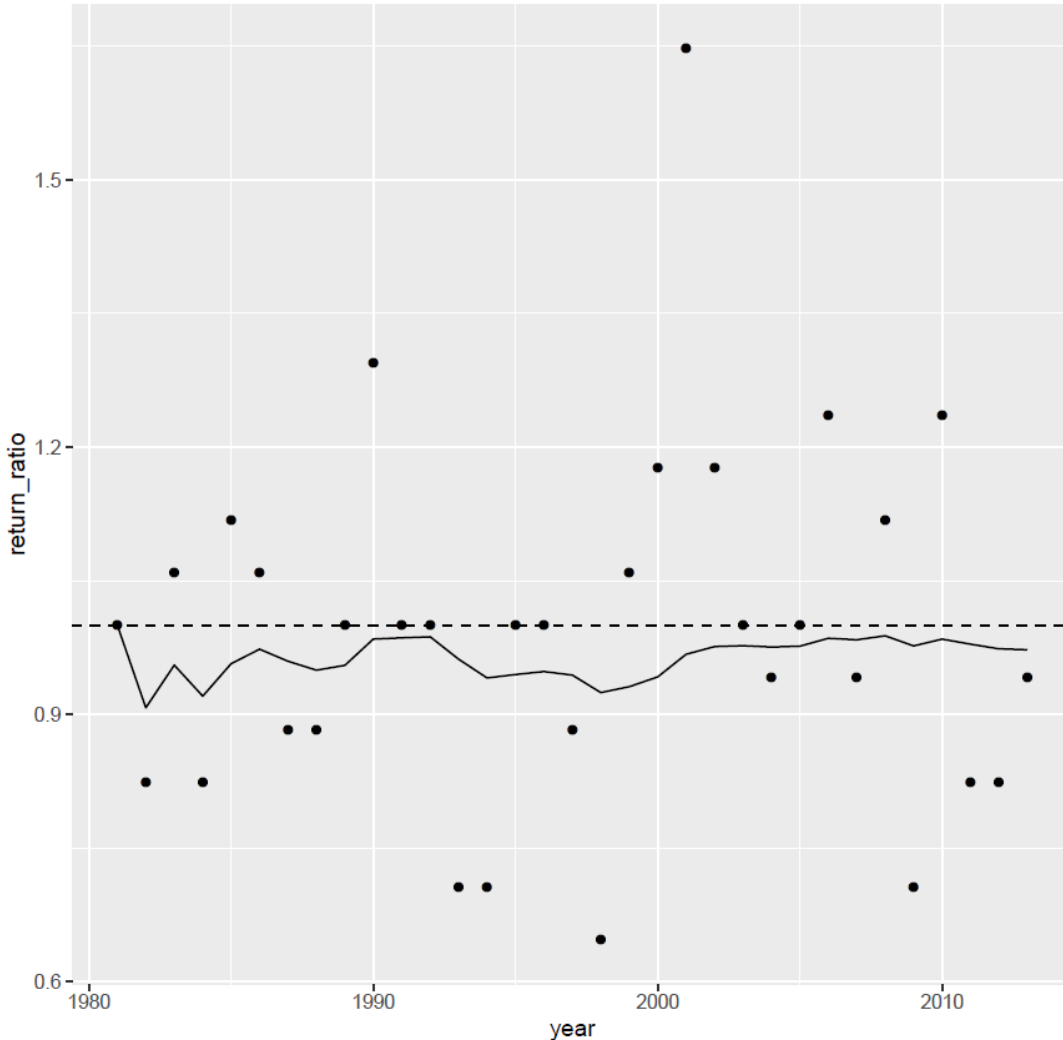


Let's Play!

Back to the map

See all results in a table

Playing roulette at Melbourne



Skill score (RPSS) = -0.06
Return ratio = 0.973
Interest rate = -2.7%

From 10€ inverted,
4€ returned after 33 runs





Let's Play!

Back to the map

● Wind farms in areas with Skill scores >0

Name	Country	ISS	RPSS	Return ratio	Interest rate	Capital
SWGalapagos	Niño	0,41544854	0,55	1,578	57,8%	34772654,8
Guajira	Colombia	0,25282698	0,35	1,320	32,0%	95666,8
Talara	Perú	0,18957353	0,29	1,232	23,2%	9656,8
Orlando	USA, Florida	0,14536596	0,23	1,173	17,3%	1944,4
BuffaloGap	USA, Texas	0,13818133	0,22	1,164	16,4%	1498,5
Indiana	USA, Indiana	0,07474927	0,18	1,086	8,6%	150,3
Galapagos	Ecuador	0,0692019	0,12	1,079	7,9%	122,9
RioGrandeNorte	Brazil	0,05236713	0,13	1,059	5,9%	66,8
Faeroe	Faeroe	0,03794958	0,08	1,043	4,3%	39,6
ShepherdFlats	USA, Oregon	0,0316247	0,06	1,035	3,5%	31,5
Iowa	USA, Iowa	0,02736987	0,03	1,031	3,1%	27,0
Marcona	Perú	0,0217341	0,08	1,024	2,4%	22,0
Edinburg	UK	0,01523402	0,02	1,017	1,7%	17,4

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● Wind farms in areas with Skill scores ≤ 0

Back to the map

Name	Country	ISS	RPSS	Return ratio	Interest rate	Capital
Guanacaste	CostaRica	0,00465578	0,00	1,005	0,5%	11,8
Shangai	China	-0,00309463	0,00	0,997	-0,3%	8,9
Campania	Italy	-0,01394017	-0,03	0,985	-1,5%	6,0
Oslo	Finland	-0,01839976	0,02	0,980	-2,0%	5,1
CapeTown	SouthAfrica	-0,02031751	-0,01	0,978	-2,2%	4,8
Oklahoma	USA, Oklahoma	-0,02249513	0,06	0,976	-2,4%	4,4
Melbourne	Australia	-0,02526114	-0,06	0,973	-2,7%	4,0
HornRevs	Denmark	-0,0274035	-0,03	0,970	-3,0%	3,7
Stavanger	Norway	-0,03060747	-0,02	0,967	-3,3%	3,3
Fantanele	Rumania	-0,03187434	-0,01	0,966	-3,4%	3,1
Coquimbo	Chile	-0,03921145	0,03	0,958	-4,2%	2,4
Uruguay	Uruguay	-0,04051668	-0,01	0,956	-4,4%	2,3
Ebro	Spain	-0,04524107	-0,05	0,952	-4,8%	1,9
Bretagne	France	-0,04945709	-0,04	0,947	-5,3%	1,7
Magdeburg	Germany	-0,06432401	-0,05	0,932	-6,8%	1,0
Karnataka	India	-0,07067669	-0,06	0,925	-7,5%	0,8
LaVentosa	México	-0,07242712	-0,09	0,924	-7,6%	0,7
Lugo	Spain	-0,07977718	-0,08	0,916	-8,4%	0,6
Appalachian	USA, Pennsilvania	-0,08252204	-0,07	0,913	-8,7%	0,5
RioGrandeSur	Brazil	-0,08360425	0,01	0,912	-8,8%	0,5
Tarifa	Spain	-0,08534977	-0,06	0,910	-9,0%	0,5
TamilNadu	India	-0,09253552	-0,10	0,903	-9,7%	0,3
TehachapiPass	USA, California	-0,1036274	-0,12	0,892	-10,8%	0,2
Belgium	Belgium	-0,13830422	-0,10	0,859	-14,1%	0,1

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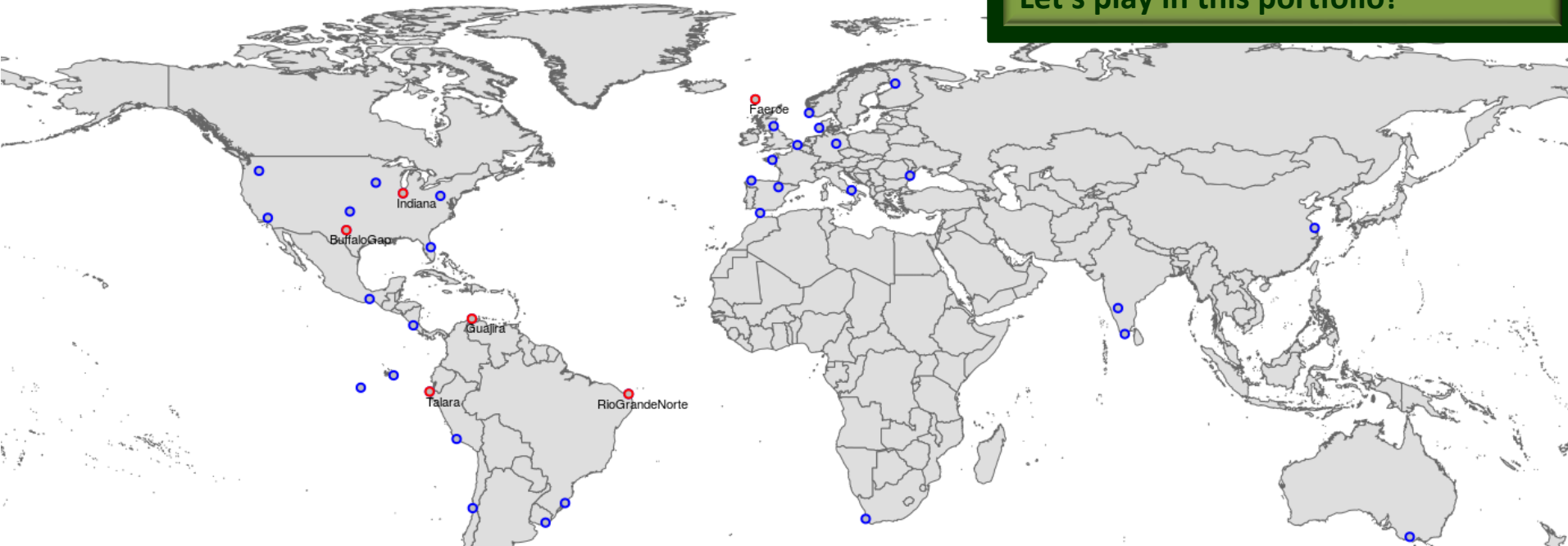


Let's Play!

Back to single wind farm game

Let's play in this portfolio!

It is common practice in the energy sector to make assessments in portfolios in order to reduce the variability of individual sites



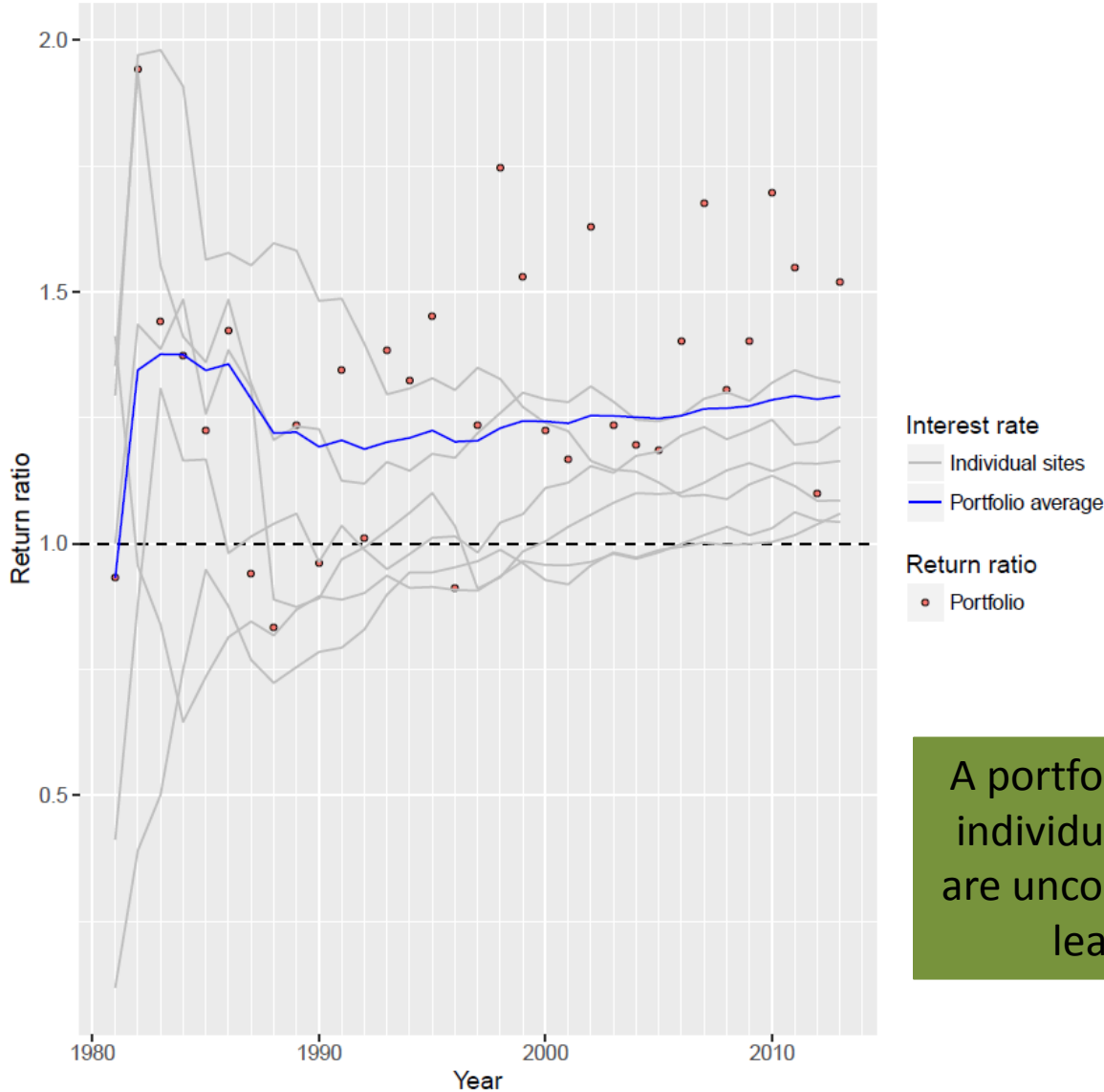
- From the list of 37 wind farms we have selected a portfolio of 6 wind farms with skill over 0.08
- we have bet 10€ in each wind farm
- After each run, the benefits are equally reinvested in the 6 wind farms

Let's play in this portfolio!



Let's Play!

Playing roulette at 6 sites



Back to the map

See portfolio result in a table

Skill score (RPSS)
from 0.08 to 0.35

Return ratio = 1.29
Interest rate = 29%

From 60€ inverted,
289 314€ returned after 33 runs

A portfolio assessment usually outperforms individual forecasts when the model errors are uncorrelated. Because this uncorrelation leads to compensation of errors.



Name	Country	ISS	RPSS	Return ratio	Interest rate	Capital
Guajira	Colombia	0,252827	0,35	1,320	32,0%	95667
Talara	Perú	0,189574	0,29	1,232	23,2%	9657
BuffaloGap	USA, Texas	0,138181	0,22	1,164	16,4%	1499
Indiana	USA, Indiana	0,074749	0,18	1,086	8,6%	150
RioGrandeNorte	Brazil	0,052367	0,13	1,059	5,9%	67
Faeroe	Faeroe	0,03795	0,08	1,043	4,3%	40
					Sum of individual games	107079
					PORTFOLIO GAME	289314

A portfolio assessment usually outperforms individual forecasts when the model errors are uncorrelated. This happens uncorrelation leads to compensation of errors.

Back



- One single prediction is not representative of the performance of climate predictions even if it is from an area where the model has skill.
- Skill is the scientific approach to assess a model performance, however weather roulette translation in interest rate provides a more familiar way of interpreting probabilistic predictions in terms of economic value.
- A portfolio assessment usually outperforms individual forecasts when the model errors are uncorrelated. This leads to compensation of errors.
- As long as the user chooses areas with skill climate predictions will be better
- We encourage energy users to adopt climate predictions in the areas that have skill. In the long run it will help them to increase the benefits.

- This work will be further developed into an App within the project EUPORIAS
- If you want to have more information contact us at info-services-es@bsc.es



User needs & seasonal pred.

Weather Roulette information

Climate predictions can provide new insights in the future variability of climate from sub-seasonal to decadal time scales.

This information can potentially benefit the wind energy sector.

However, current energy practice relies on climatology to estimate what is going to happen in the future. Assuming that future conditions will be similar to the past.

Not taking into account extreme events, limited information of the past, variability in past conditions or climate change.

Next



A CLIMATE SERVICE FOR WIND INDUSTRY

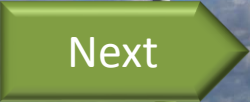
RESILIENCE is a semi-operational prototype that provides seasonal wind speed predictions for the energy sector.

Based on ECMWF S4 data, seasonal predictions are tailored and post-processed into a final service (more info in project-ukko.net and resilience.euporias.eu)

However, to foster the adoption of new technology we have to demonstrate the value of the predictions compared to climatology

This is currently done with skill scores but... Is there a better way to present this to users? How can we improve the communication of probabilistic predictions?

- Introduction
- User needs & seasonal pred.
- Weather Roulette information





User needs & seasonal pred.

Weather Roulette information

Understanding and quantifying wind resources is a key element to multiple user profiles in the wind energy sector both in pre and post-construction.

- Site selection
- Resource assessment for the windfarm lifetime (ca. 15 years)
- Operation & Maintenance
- Energy trading
- ...

WHY is not used? (or at least generate interest?)

There are many factors: Untailored and complex information, difficulties to access data and its interpretation, lack of integration with the decisions making processes, etc.

Need for Climate Services