Markowitz-Optimal Portfolio Under Inflation in China

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Presentation Overview

Introduction

Background

- Global inflation has reached its highest level since 2008 in recent years due to the shock of covid-19, supply chain disruptions, and increasingly tense international conditions.
- Inflation implies a prolonged period of rising price levels, which leads to a contraction in the real value of assets.
- The erosion of the real return of a portfolio caused by inflation is one of the fundamental risks faced by investors in financial markets.

- Relationship between asset returns and inflation, in general
  - **real estate** has a high inflation-hedging ability
  - **stocks** has a limited inflation-hedging ability
  - **gold** has a high inflation-hedging ability in the long term.

- Asset allocation strategy under inflation risk
  - **Model**: Markowitz's mean-variance model
  - **Asset Categories**
    - stocks or equities
    - bonds
    - commodities (metals, agricultural products, and energy)
    - derivatives (swaps, options, futures, and spots)
    - real estate
    - collectibles (art, wine and stamps)

Inflation Hedging Ability

Model

- divide nominal return rate into three parts

$$E(R_t|\Omega_{t-1}) = E(r_t|\Omega_{t-1}) + \beta E(\pi_t|\Omega_{t-1}) + \gamma \left[\pi_t - E(\pi_t|\Omega_{t-1})\right] \quad (1)$$

  - $E(R_t|\Omega_{t-1})$: expected nominal return rate
  - $E(r_t|\Omega_{t-1})$: expected real return rate
  - $E(\pi_t|\Omega_{t-1})$: expected inflation rate
  - $[\pi_t - E(\pi_t|\Omega_{t-1})]$: unexpected inflation rate

Inflation Hedging Ability

Model

- can be rewritten as

$$R_t = \alpha + \beta E(\pi_t|\Omega_{t-1}) + \gamma \left[\pi_t - E(\pi_t|\Omega_{t-1})\right] + \eta_t \tag{2}$$

  - R_t: nominal return rate
  - α, β and γ: estimators
  - η_t: the error term

Inflation Hedging Ability

Model - Estimators

Table: The meanings of the parameters

	beta	gamma
<0	Negative hedging	Negative hedging
=0	No hedging effect	No hedging effect
(0,1)	Partially hedging	Partially hedging
=1	Completely hedging	Completely hedging
>1	Excess hedging	Excess hedging

Inflation Hedging Ability

Data

- **Inflation** *(2010.01-2021.12)*
  - real inflation rate: monthly year-on-year CPI in logarithmic form
  - expected inflation rate: one period lagged one-year national bond's yield to maturity
  - unexpected inflation rate: the difference between real and expected inflation rate

- **Commodity Futures** *(2010.01-2021.12)*
  - sixteen kinds from the Shanghai and Dalian futures exchange: Soybeans No. 1, soybeans No. 2, yellow corn, LLDPE, soybean meal, palm oil, soybean oil, PVC, cathode copper, aluminum, zinc, gold, natural rubber, fuel oil, rebar, and wire rod
  - settlement price at the end of each month to calculate returns

Inflation Hedging Ability

Data

- **Spot Gold** *(2010.01-2021.12)*
  - monthly closing price of gold T+D published by the Shanghai Gold Exchange.
- **Industry Stocks** *(2010.01-2021.12)*
  - monthly closing prices of the Hushen 300 industry index
  - energy, raw materials, industry, optional consumption, the main consumption, medicine and health care, finance and real estate, information technology, utility, and the telecommunication service
- **real estate** *(2011.06-2021.12)*
  - monthly data on residential prices
  - Tier 1, Tier 2, and Tier 3 cities

Inflation Hedging Ability

Empirical Results - Commodity Futures (1)

Table: The inflation hedging ability of commodity futures

	Dependent variable:			
	commodity futures			
	Soybeans No.1	Soybeans No.2	Yellow Corn	LLDPE
expected_inflation	-5.983***	-8.515***	4.295*	-1.201
	(2.063)	(2.253)	(2.480)	(2.207)
unexpected_inflation	0.280	1.704*	0.928	-2.303**
	(0.876)	(0.957)	(1.053)	(0.937)
Constant	0.205***	0.251***	-0.078	0.012
	(0.057)	(0.062)	(0.068)	(0.061)
Observations	144	144	144	144
R^2	0.071	0.157	0.021	0.042
Adjusted R^2	0.058	0.145	0.007	0.029
Residual Std. Error	0.138	0.151	0.166	0.148
F Statistic	5.366***	13.119***	1.530	3.103**
Note:				*p<0.1; **p<0.05; ***p<0.01

Inflation Hedging Ability

Empirical Results - Commodity Futures (2)

Table: The inflation hedging ability of commodity futures

	Dependent variable:			
	commodity futures			
	Soybean Meal	Palm Oil	Soybean Oil	PVC
expected_inflation	-2.744	-9.813***	-10.418***	-5.093**
	(2.186)	(2.878)	(2.420)	(2.575)
unexpected_inflation	0.616	2.774**	2.056**	-2.176**
	(0.928)	(1.222)	(1.028)	(1.042)
Constant	0.094	0.302***	0.311***	0.152**
	(0.060)	(0.079)	(0.067)	(0.072)
Observations	144	144	144	140
R^2	0.021	0.157	0.193	0.043
Adjusted R^2	0.007	0.145	0.182	0.029
Residual Std. Error	0.146	0.193	0.162	0.164
F Statistic	1.540	13.171***	16.912***	3.049*
Note:				*p<0.1; **p<0.05; ***p<0.01

Inflation Hedging Ability

Empirical Results - Commodity Futures (3)

Table: The inflation hedging ability of commodity futures

	Dependent variable:			
	commodity futures			
	Cathode Copper	Aluminum	Zinc	Gold
expected_inflation	-7.728**	-4.968**	-4.505	-7.502***
	(3.181)	(2.188)	(2.936)	(1.733)
unexpected_inflation	-1.291	-1.685*	-5.235***	5.103***
	(1.351)	(0.929)	(1.247)	(0.736)
Constant	0.251***	0.157***	0.145*	0.269***
	(0.087)	(0.060)	(0.081)	(0.048)
Observations	144	144	144	144
R^2	0.040	0.042	0.111	0.425
Adjusted R^2	0.027	0.029	0.098	0.417
Residual Std. Error	0.213	0.146	0.196	0.116
F Statistic	2.952*	3.113**	8.806***	52.096***
Note:				*p<0.1; **p<0.05; ***p<0.01

Inflation Hedging Ability

Empirical Results - Commodity Futures (4)

Table: The inflation hedging ability of commodity futures

	Dependent variable:			
	commodity futures			
	Natural Rubber	Fuel Oil	Rebar	Wire Rod
expected_inflation	-14.338***	-4.748	-2.444	0.377
	(3.966)	(4.215)	(3.704)	(3.346)
unexpected_inflation	3.739**	-1.961	-1.508	-0.351
	(1.685)	(1.790)	(1.535)	(1.387)
Constant	0.392***	0.095	0.080	0.015
	(0.109)	(0.116)	(0.102)	(0.093)
Observations	144	144	142	140
R^2	0.166	0.013	0.008	0.001
Adjusted R^2	0.154	-0.001	-0.007	-0.014
Residual Std. Error	0.265	0.282	0.241	0.218
F Statistic	14.007***	0.897	0.533	0.057
Note:				*p<0.1; **p<0.05; ***p<0.01

Inflation Hedging Ability

Empirical Results - Spot Gold

Table: The inflation hedging effect of spot gold

	Dependent variable:
	Spot Gold
expected_inflation	-7.454***
	(1.714)
unexpected_inflation	5.128***
	(0.728)
Constant	0.267***
	(0.047)
Observations	144
R^2	0.431
Adjusted R^2	0.423
Residual Std. Error	0.115
F Statistic	53.374***
Note:	*p<0.1; **p<0.05; ***p<0.01

Inflation Hedging Ability

Empirical Results - Industry Stocks (1)

Table: The inflation hedging ability of industry stocks

	Dependent variable:				
	industry stocks				
	Energy	Material	Industry	Optional	Main
expected_inflation	-2.188	-9.063**	-7.416	-3.864	-4.955
	(3.515)	(4.328)	(4.488)	(3.589)	(3.551)
unexpected_inflation	-2.023	-6.328***	-6.728***	-5.326***	-1.565
	(1.493)	(1.838)	(1.907)	(1.525)	(1.509)
Constant	-0.017	0.250**	0.206*	0.169*	0.300***
	(0.097)	(0.119)	(0.123)	(0.099)	(0.098)
Observations	144	144	144	144	144
R^2	0.013	0.082	0.082	0.080	0.016
Adjusted R^2	-0.001	0.069	0.069	0.067	0.002
Residual Std. Error	0.235	0.290	0.300	0.240	0.238
F Statistic	0.925	6.296***	6.287***	6.134***	1.126
Note:					*p<0.1; **p<0.05; ***p<0.01

Inflation Hedging Ability

Empirical Results - Industry Stocks (2)

Table: The inflation hedging ability of industry stocks

	Dependent variable:				
	industry stocks				
	Medicine	Finance	Info	Tele	Utility
expected_inflation	-11.363***	-2.650	-6.993*	4.802	-4.069
	(3.302)	(3.117)	(4.168)	(4.398)	(3.401)
unexpected_inflation	-4.228***	-5.384***	-2.201	-1.412	-7.689***
	(1.403)	(1.324)	(1.770)	(1.868)	(1.445)
Constant	0.416***	0.090	0.253**	-0.135	0.085
	(0.091)	(0.086)	(0.115)	(0.121)	(0.094)
Observations	144	144	144	144	144
R^2	0.098	0.108	0.023	0.019	0.171
Adjusted R^2	0.085	0.095	0.009	0.005	0.159
Residual Std. Error	0.221	0.208	0.279	0.294	0.228
F Statistic	7.641***	8.541***	1.625	1.390	14.542***
Note:					*p<0.1; **p<0.05; ***p<0.01

Inflation Hedging Ability

Empirical Results - real estate

Table: The inflation hedging ability of real estate

	Dependent variable:		
	real estate		
	first-tier	second-tier	third-tier
expected_inflation	0.720	2.110**	2.589***
	(1.294)	(0.850)	(0.835)
unexpected_inflation	-0.172	0.449	0.704*
	(0.568)	(0.373)	(0.367)
Constant	0.046	-0.010	-0.030
	(0.036)	(0.024)	(0.023)
Observations	127	127	127
R^2	0.004	0.049	0.079
Adjusted R^2	-0.012	0.034	0.064
Residual Std. Error	0.077	0.051	0.050
F Statistic	0.277	3.189**	5.338***
Note:		*p<0.1; **p<0.05; ***p<0.01	

Inflation Hedging Portfolio

Model Construction

The optimal **Mean-Variance** portfolio

- minimize the portfolio's volatility at the given expected return

$$\begin{aligned} \min \quad & \sigma_p^2 = \sum_{i=1}^{n} x_i^2 \sigma_i^2 + \sum_{j=1, j \neq i}^{n} x_i x_j \sigma_{ij} \\ s.t. \quad & E(R_p) = \sum_{i=1}^{n} E(R_i) = X^T \cdot R \\ & \sum_{i=1}^{n} x_i = 1 \end{aligned}$$

Exclude 8 assets that do **not** have obvious inflation-hedging effects and use the remaining 22 assets to construct the optimal portfolio under the inflation factor.

Portfolio Performance

Feasible Portfolio

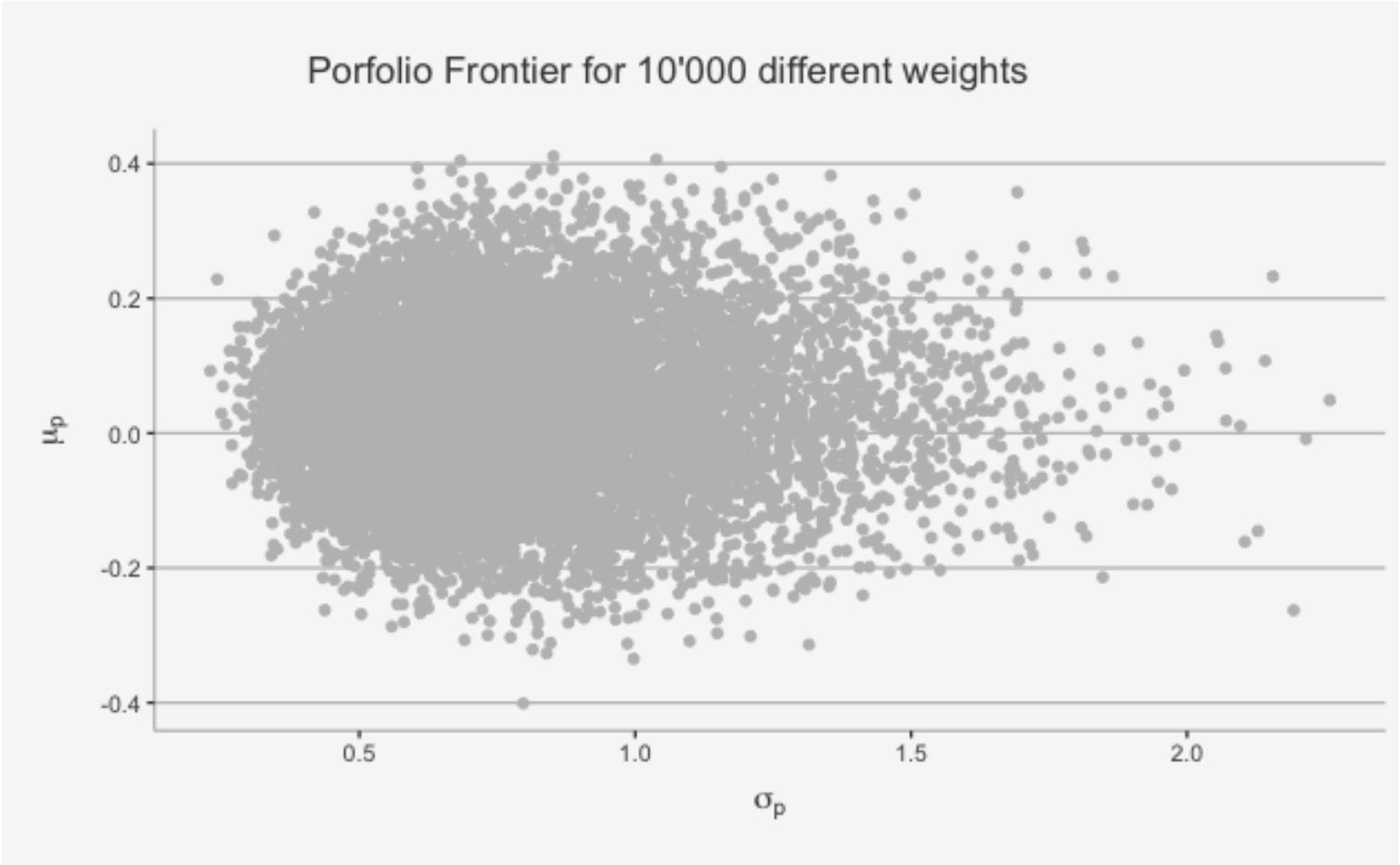

Figure: Feasible Portfolio

Portfolio Performance

Efficient Frontier

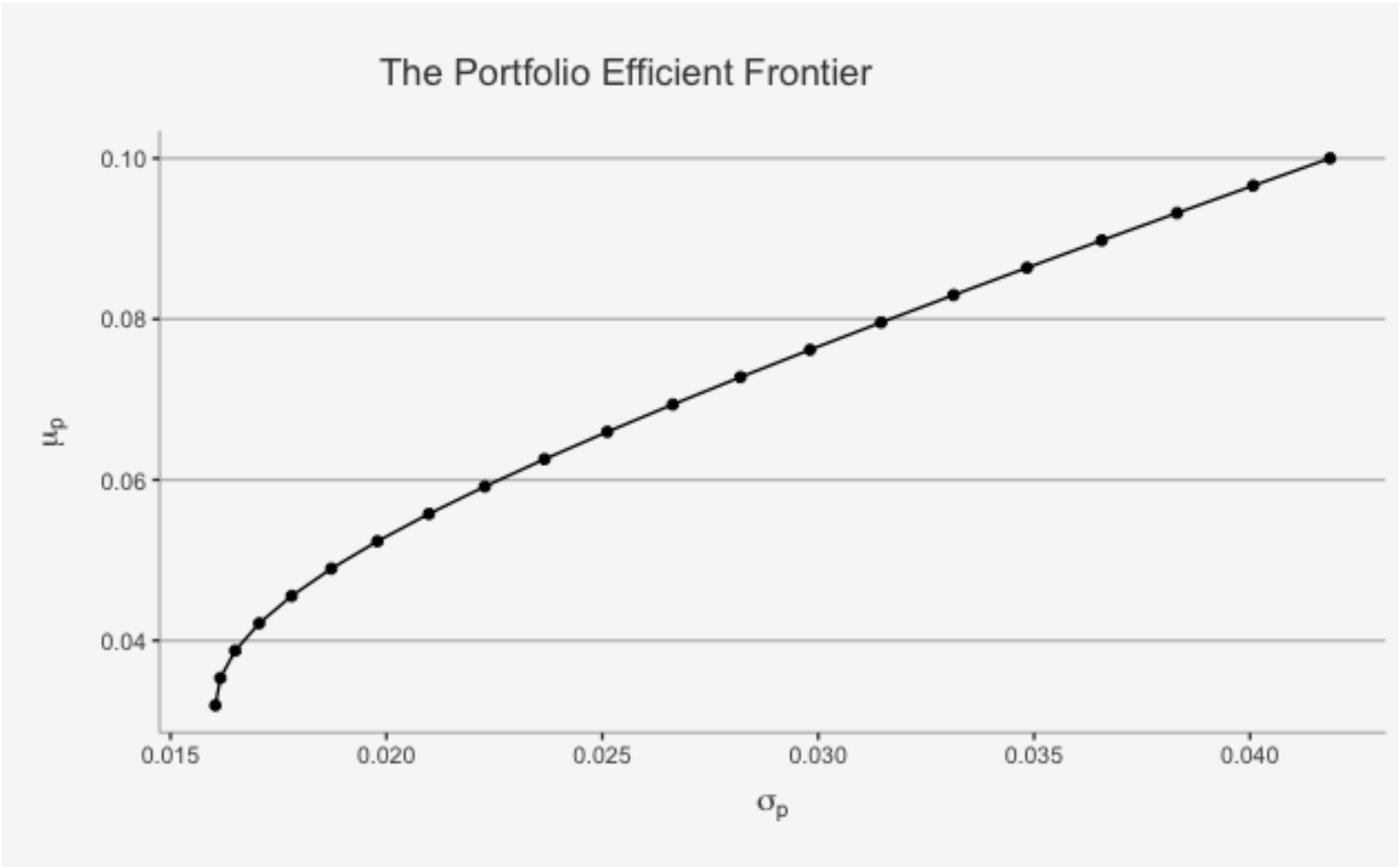

Figure: Efficient Frontier

Conclusion

Conclusion 1

Among the 30 kinds of assets, 8 assets do not have inflation-hedging effects, including **four commodity futures**, Soybean Meal, Fuel Oil, Rebar, Wire Rod, **three industry stocks**, Energy, Main Consumption, and Telecommunication services, and **first-tier real estate**. The remaining 22 assets are chosen to construct the portfolio.

Conclusion

Conclusion 2

The **minimum-variance** portfolio and the **tangency** portfolio are calculated without short-selling restrictions.

Investment in **real estate** plays a pivotal role in hedging inflation risks. Investors are recommended to short real estate in third-tier cities and long real estate in second-tier cities in China if there are no short-selling restrictions.

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Thanks for your time

Q&A