

Bubbles Talk: Narrative Augmented Bubble Prediction

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1 Overview

- Research question
- Motivation

2 Methodology & data

- Bubble (bubbliness) measures
- Narrative features
- Narratives augmented bubble forecasting

3 Results

- Predictive power on bubbliness
- Predictive power out of sample
- Predict ex-post bubble conditional on signals

4 Conclusion

5 Appendix

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- Can market narratives help predict financial market bubbles and their bursts?

- Bubbles are hard to detect and predict (see Greenwood et al., (2019))
- Bubble theories place emphasis on the role of investor beliefs in bubble development, but these are largely unobservable.
 - ▶ Rational bubbles
 - ▶ Disagreement-based models
 - ▶ Irrational bubbles
- Narratives contain rich information but are understudied and have potential in bubble studies (Shiller, 2017)
 - ▶ Narrative factors outperform standard characteristic-based factor models in terms of out-of-sample Sharpe ratios (Bybee et al., 2023)
 - ▶ “... the price increase appears to be driven less by future expectations than by the proliferation of stories and talk that draw attention to the asset that is booming, thereby fueling the bubble.” (Shiller (2019), p 217)

- Directed Acyclic Graph (DAG)

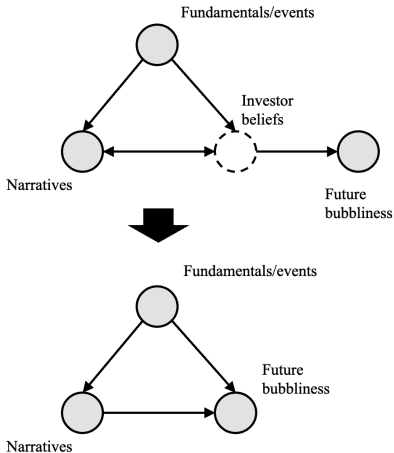


Figure: Directed Acyclic Graph

- What does it mean to consider the role of narratives?
- For a start, we humbly set on focusing on narrative features
- Narrative features are aspects of textual corpora that can only refer to narratives

- Optimism: Opportunity and Optimistic Narratives
 - ▶ Aliber and Kindleberger (2015) associate the mania phase of a bubble with a sense of “we never had it so good” and “making money never seemed easier.”
 - ▶ Shiller (2015) highlights the role of the psychological epidemic of investor enthusiasm during the “irrational exuberance” periods
- Opinion Disagreement
 - ▶ Harrison and Kreps (1978) propose that the relevant notion of intrinsic value is decided by aggregate investor assessments and attribute speculation to heterogeneous beliefs.
- Topic Homogeneity and Attention Intensity
 - ▶ Shiller (2019) suggests that dominant and viral narratives lead to many economic events.

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- Price explosiveness (Phillips et al. (2015))

$$BSADF_{c,t}(w_0) = \sup_{w_1 \in [0, t-w_0]} ADF_{c,w_1}^t. \quad (1)$$

$$BubbleSignal_{PSY,c,t} = \mathbb{1}(BSADF_{c,t} > cv_{c,t}), \quad (2)$$

- Price elevation (as in Greenwood et al. (2019))

$$Elevation_{c,w,t} = \frac{PI_{c,t} - PI_{c,(t-w)}}{PI_{c,(t-w)}}. \quad (3)$$

- Price deviation (as in Jordà et al. (2015))

$$Deviation_{c,t} = \log PI_{c,t} - \log PI_{c,trend,t}, \quad (4)$$

Bubbliness measures

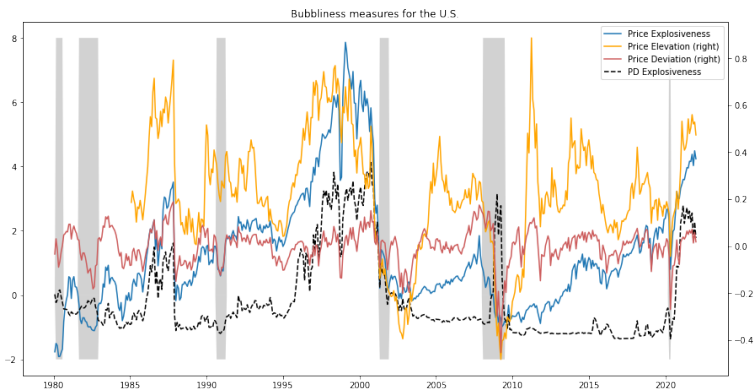
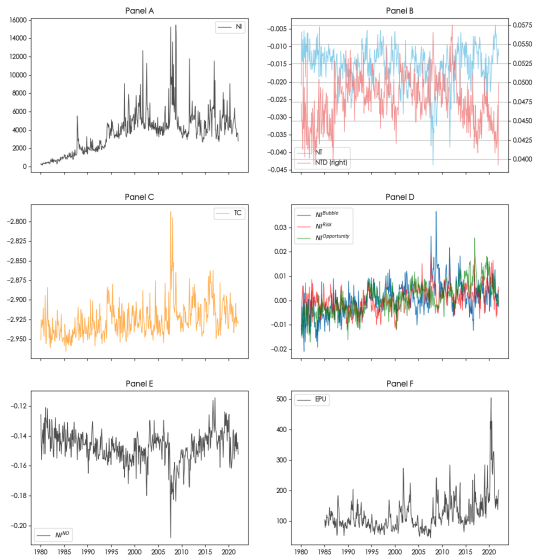


Figure: Alternative bubbliness measures for the U.S.

- Textual data selection: searching query design
 - 1 Contain the keyword - “market”
 - 2 Major media news (from LexisNexis)
 - 3 “Economy Economic indicators” and “Financial Market Updates” subject tags
 - 4 January 1st 1975 - December 31st 2021
 - 5 765,645 articles
- Language processing
 - 1 Break down the articles into sentences
 - 2 Use named-entity-recognition to add country tags to each sentence

- Narrative features
 - ① Narrative Intensity (NI, count of sentences)
 - Sign prediction: negative according to Vozlyublennaia (2014)
 - ② Narrative Tone (NT, L&M word lists)
 - Sign prediction: positive according to Shiller (2015), Abreu and Brunnermeier (2003) and rational bubbles
 - ③ Narrative Tone Dispersion (NTD, standard deviation of NT)
 - Sign prediction: positive according to Scheinkman and Xiong (2003), negative according to irrational bubbles
 - ④ Topic Consensus (TC, Shannon entropy on LDA topic probabilities)
 - Sign prediction: positive according to irrational bubbles
 - ⑤ Relative Intensity of Competing Narratives (NI^{NO} “opportunity narratives” - “risk narratives” - “bubble narratives”)
 - Sign prediction: positive according to irrational bubbles

Narrative features



- Predicting the change of bubblieness measures

$$\Delta B_{c,t+1} = \alpha_c + \boldsymbol{\theta} \cdot \mathbf{X}_{c,t} + \gamma \cdot N_{c,t} + \epsilon_{c,t+1} \quad (5)$$

- $\mathbf{X}_{c,t} = [\text{DY PE PB IR Inflation RGDP InvGDP VO CLI}]$
- Out of sample forecasting performance
 - ▶ Train the models with expanding windows, predict one month ahead out of sample
 - ▶ Models include: Financial/economic variables; narrative variables; multi-variate or uni-variate models; ensemble
 - ▶ The Diebold & Mariano test (Diebold and Mariano, 2002) and the Clark & West test (Clark and West, 2007) with MSE as the loss function

- Predicting the scale of future market drops

$$\Delta \text{MaxDrop}_{c,t+13|t+1} = \alpha_c + \boldsymbol{\theta} \cdot \mathbf{X}_{c,t} + \gamma \cdot N_{c,t} + \epsilon_{c,t+1}. \quad (6)$$

$$\text{MaxDrop}_{c,t} = -\min\left(\frac{PI_{c,t+j}}{PI_{c,t+i}}, 0\right), \quad \forall i \in [0, 11], j \in [1, 12] \text{ and } i < j.$$

- Predicting ex-post bubbles conditional on signals (bad booms)
 - ▶ Logistic regression

$$\text{Prob}(\text{Bubble}_{c,t} | \text{Signal}_{c,t}) = \frac{1}{e^{-(\alpha + \boldsymbol{\theta} \cdot \mathbf{X}_{c,[t-w,t]} + \gamma \cdot N_{c,[t-w,t]} + \epsilon_t)}}. \quad (7)$$

- ▶ Up-sampling (SMOTE) to deal with imbalanced data
- Narrative regime-dependent forecasting with financial/economic variables

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Table: Bubblieness prediction with U.S. data

Panel A: Univariate regressions									
	NI	NT	NTD	TC	<i>NI^{NO}</i>	<i>NI^{Opportunity}</i>	<i>NI^{Bubble}</i>	<i>NI^{Risk}</i>	EPU
Coefficient	-0.19*** (0.069)	0.197*** (0.057)	-0.105* (0.058)	-0.091** (0.043)	0.16*** (0.059)	0.094* (0.057)	-0.071 -0.045	-0.048 (0.039)	-0.107 (0.07)
Controls	No	No	No	No	No	No	No	No	No
No. of obs.	503	503	503	503	503	503	503	503	443
Adj. R-squared	3.43%	3.68%	0.90%	0.63%	2.37%	0.69%	0.30%	0.03%	0.93%

Panel B: Regressions with controls									
	NI	NT	NTD	TC	<i>NI^{NO}</i>	<i>NI^{Opportunity}</i>	<i>NI^{Bubble}</i>	<i>NI^{Risk}</i>	EPU
Coefficient	-0.193*** (0.07)	0.22*** (0.064)	-0.132** (0.06)	-0.102** (0.044)	0.156*** (0.056)	0.086 (0.058)	-0.054 (0.048)	-0.044 (0.039)	-0.138 (0.092)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	501	501	501	501	501	501	501	501	442
Adj. R-squared	5.22%	5.87%	3.35%	2.65%	3.99%	2.35%	1.93%	1.84%	3.18%

Panel C: Univariate regressions using the FinEcon variables									
	DY	PE	PB	IR	Inflation	RGDP	InvGDP	VO	CLI
Coefficient	0.019 (0.038)	-0.039 (0.043)	-0.067 (0.053)	-0.094* (0.053)	-0.0 (0.035)	0.045 (0.052)	0.029 (0.048)	-0.002 (0.047)	0.049 (0.044)
No. of obs.	503	503	503	503	502	503	503	503	503
Adj. R-squared	-0.16%	-0.05%	0.25%	0.65%	-0.20%	0.00%	-0.12%	-0.20%	0.04%

Table: Granger causality tests p-values

Panel A: Narrative Variables									
	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
To bubblieness	0.0%	0.0%	2.6%	2.4%	0.1%	2.0%	25.3%	15.5%	0.0%
From bubblieness	38.9%	57.7%	63.1%	61.7%	23.7%	2.7%	75.1%	38.0%	69.9%

Panel B: Financial/Economic Variables									
	DY	PE	PB	IR	Inflation	RGDP	InvGDP	VO	CLI
To bubblieness	59.8%	95.8%	17.1%	2.1%	59.5%	77.1%	90.9%	92.4%	0.6%
From bubblieness	18.3%	6.0%	1.3%	39.4%	45.2%	1.0%	1.6%	52.0%	80.0%

Table: Bubbliness prediction with international data

U.S. data excluded									
Panel A: Univariate regressions									
	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
Coefficient	-0.053** (0.025)	0.163*** (0.034)	-0.061*** (0.013)	-0.001 (0.017)	0.087*** (0.028)	0.081*** (0.022)	0.009 (0.016)	-0.051*** (0.017)	-0.063*** (0.022)
Controls	No	No	No	No	No	No	No	No	No
No. of obs.	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	3,488
Adj. R-squared	0.31%	2.62%	0.41%	0.04%	0.77%	0.68%	0.04%	0.29%	0.43%
Panel B: Regressions with controls									
	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
Coefficient	-0.028* (0.016)	0.174*** (0.056)	-0.085*** (0.02)	-0.022 (0.025)	0.107*** (0.041)	0.108*** (0.032)	0.022 (0.021)	-0.064** (0.028)	-0.058** (0.023)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	2,371	2,371	2,371	2,371	2,371	2,371	2,371	2,371	2,135
Adj. R-squared	1.96%	4.73%	2.59%	1.93%	2.97%	2.99%	1.93%	2.27%	2.29%
U.S. data included									
Panel C: Univariate regressions									
	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
Coefficient	-0.08*** (0.026)	0.164*** (0.033)	-0.06*** (0.013)	-0.004 (0.016)	0.091*** (0.028)	0.081*** (0.022)	0.004 (0.016)	-0.05*** (0.016)	-0.066*** (0.025)
Controls	No	No	No	No	No	No	No	No	No
No. of obs.	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	3,931
Adj. R-squared	0.66%	2.61%	0.38%	0.02%	0.81%	0.66%	0.02%	0.26%	0.45%
Panel D: Regressions with FinEcon variables									
	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
Coefficient	-0.085** (0.035)	0.171*** (0.051)	-0.081*** (0.02)	-0.029 (0.025)	0.108*** (0.038)	0.103*** (0.029)	0.011 (0.021)	-0.057** (0.023)	-0.068** (0.028)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	2,873	2,873	2,873	2,873	2,873	2,873	2,873	2,873	2,578
Adj. R-squared	2.58%	4.61%	2.53%	1.96%	2.99%	2.88%	1.89%	2.19%	2.23%

Table: OOS performance in bubblieness prediction

Model	Benchmark: FinEcon			Benchmark: Historical mean			Benchmark: Zero (global mean)		
	MSE ratio	DM/CW statistic	p-value	MSE ratio	DM/CW statistic	p-value	MSE ratio	DM/CW statistic	p-value
FinEcon	1.000			1.218	0.47	31.92%	1.221	0.42	33.88%
NI	0.823	2.163	1.53%	1.002	2.59	0.48%	1.004	2.54	0.55%
NT	0.857	1.776	3.79%	1.044	4.35	0.00%	1.046	4.28	0.00%
NTD	0.831	2.175	1.48%	1.013	1.27	10.17%	1.015	1.13	12.94%
TC	0.821	2.342	0.96%	1.000	2.24	1.25%	1.002	2.12	1.68%
<i>NJ^{NO}</i>	0.826	2.280	1.13%	1.006	3.24	0.06%	1.008	3.19	0.07%
<i>NJ^{Opportunity}</i>	0.807	2.599	0.47%	0.983	3.23	0.06%	0.985	3.15	0.08%
<i>NJ^{Bubble}</i>	0.818	2.369	0.89%	0.996	1.98	2.38%	0.998	1.80	3.60%
<i>NJ^{Risk}</i>	0.836	2.157	1.55%	1.018	0.81	20.87%	1.021	0.69	24.56%
EPU	0.833	2.197	1.40%	1.015	1.32	9.37%	1.017	1.29	9.87%
Narrative	0.882	1.423	7.73%	1.074	5.06	0.00%	1.076	5.02	0.00%
FinEcon + Narra	1.042	3.690	0.01%	1.269	3.63	0.01%	1.272	3.60	0.02%
Ensemble	0.780	3.151	0.08%	0.950	2.22	1.33%	0.952	2.16	1.55%

Notes: This table presents out-of-sample bubblieness forecast comparison tests. “Narra” stands for narrative variables. A model is tested using the Clark and West (2007) test when the benchmark model is a nested model. The ensembles model was tested using the Diebold and Mariano (2002) tests. Bold and italic values indicate significance at the 1% level, Bold values indicate significance at the 5% level, and italic values indicate significance at the 10% level.

Table: After-the-fact bubble prediction

	1 month	6 months	12 months	24 months	1 month	6 months	12 months	24 months
NI	-0.029 (0.099)	0.022 (0.112)	0.041 (0.122)	-0.031 (0.174)	-0.256 (0.176)	-0.218 (0.171)	0.04 (0.114)	-0.032 (0.149)
NT	-0.747** (0.336)	-0.306 (0.257)	-0.309 (0.252)	-0.116 (0.234)	-1.003*** (0.363)	-0.406 (0.381)	-0.353 (0.392)	-0.13 (0.351)
NTD	-0.376 (0.234)	0.139 (0.239)	-0.158 (0.249)	0.018 (0.276)	-0.648** (0.287)	0.166 (0.326)	0.259 (0.263)	0.13 (0.348)
TC	0.021 (0.336)	0.645* (0.352)	0.631** (0.306)	0.612* (0.333)	0.875 (0.605)	1.487*** (0.537)	1.594*** (0.479)	1.271** (0.509)
<i>NI/NO</i>	-0.622*** (0.222)	-0.546** (0.24)	-0.641*** (0.221)	-0.421** (0.209)	-0.608* (0.367)	-0.384 (0.312)	-0.497 (0.306)	-0.322 (0.29)
Obs. of signals	125	125	123	121	102	102	101	98
Obs. of crashes	30	30	29	28	24	24	24	24
Pseudo R-squared	6.19%	5.93%	6.19%	3.84%	16.21%	15.12%	11.83%	9.12%
Controls	No	No	No	No	Yes	Yes	Yes	Yes

(Narrative) Regime-dependent forecasting

Table: Forecasting in high V.S. low opportunity narrative regimes

Panel A: Whole								
	F1	F2	F3	F4	F5	F6	F7	F8
Coefficient	-0.077 (0.063)	0.146*** (0.052)	-0.018 (0.042)	-0.108** (0.05)	0.004 (0.075)	0.03 (0.04)	0.288*** (0.076)	0.071* (0.042)
No. of obs.	503	503	503	503	503	503	503	503
Adj. R-squared	0.39%	1.93%	-0.17%	0.96%	-0.20%	-0.11%	8.09%	0.31%

Panel B: Low								
	F1	F2	F3	F4	F5	F6	F7	F8
Coefficient	-0.079 (0.064)	0.074 (0.047)	-0.003 (0.049)	-0.133 (0.103)	0.018 (0.069)	0.007 (0.037)	0.198*** (0.057)	0.044 (0.057)
No. of obs.	252	252	252	252	252	252	252	252
Adj. R-squared	0.16%	0.24%	-0.40%	0.70%	-0.36%	-0.40%	3.55%	-0.21%

Panel C: High								
	F1	F2	F3	F4	F5	F6	F7	F8
Coefficient	-0.077 (0.098)	0.268*** (0.095)	-0.037 (0.07)	-0.094** (0.045)	-0.016 (0.105)	0.051 (0.051)	0.403*** (0.137)	0.103 (0.069)
No. of obs.	251	251	251	251	251	251	251	251
Adj. R-squared	0.26%	5.49%	-0.28%	0.88%	-0.38%	-0.08%	15.60%	0.71%

Table: Controlling for macro factors from Ludvigson and Ng (2009)

	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
Coefficient	-0.068 (0.048)	0.104** (0.051)	-0.113** (0.049)	-0.03 (0.034)	0.081** (0.035)	-0.033 (0.036)	0.023 (0.054)	-0.009 (0.049)	0.008 (0.048)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LN controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	501	501	501	501	501	501	501	501	442
Adj. R-squared	10.70%	11.08%	11.56%	10.42%	10.91%	10.45%	10.39%	10.34%	12.21%

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Findings

- Narrative features can predict bubbliness/bubble growth measures and the scale of future market drops.
- The forecasting power is robust out-of-sample
- Narratives can predict bursts conditional on booms (after-fact bubbles)
- Financial/economic variables can better forecast bubbles during opportunity narrative regimes
- Bubbles talk, listen carefully

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Table: Max drop prediction with U.S. data

	NI	NT	NTD	TC	<i>NI^{NO}</i>	<i>NI^{Opportunity}</i>	<i>NI^{Bubble}</i>	<i>NI^{Risk}</i>	EPU
Coefficient	-0.178** (0.09)	0.14** (0.07)	-0.109* (0.057)	-0.039 (0.055)	0.114* (0.066)	0.11* (0.057)	-0.031 (0.056)	-0.015 (0.062)	-0.185** (0.091)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	490	490	490	490	490	490	490	490	431
Adj. R-squared	7.16%	5.91%	5.25%	4.25%	5.35%	5.25%	4.19%	4.12%	8.36%

Table: Max drop prediction with international data

U.S. data excluded									
Panel A: Univariate regressions									
	NI	NT	NTD	TC	NI/NO	NJOpportunity	NJBubble	NJRisk	EPU
Coefficient	-0.11** (0.046)	0.2*** (0.036)	-0.067*** (0.02)	-0.012 (0.021)	0.131*** (0.034)	0.125*** (0.031)	-0.025 (0.017)	-0.044** (0.018)	-0.109*** (0.042)
Controls	No	No	No	No	No	No	No	No	No
No. of obs.	5,248	5,248	5,248	5,248	5,248	5,248	5,248	5,248	3,547
Adj. R-squared	1.22%	3.92%	0.45%	0.01%	1.67%	1.55%	0.06%	0.19%	1.21%
Panel B: Regressions with controls									
	NI	NT	NTD	TC	NI/NO	NJOpportunity	NJBubble	NJRisk	EPU
Coefficient	-0.099* (0.056)	0.164*** (0.035)	-0.024 (0.028)	-0.013 (0.031)	0.146*** (0.043)	0.107*** (0.035)	-0.049* (0.028)	-0.056* (0.033)	-0.077* (0.045)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	2,302	2,302	2,302	2,302	2,302	2,302	2,302	2,302	2,066
Adj. R-squared	3.60%	5.24%	2.69%	2.65%	4.73%	3.76%	2.86%	2.93%	3.14%
U.S. data included									
Panel A: Univariate regressions									
	NI	NT	NTD	TC	NI/NO	NJOpportunity	NJBubble	NJRisk	EPU
Coefficient	-0.1** (0.039)	0.196*** (0.036)	-0.066*** (0.019)	-0.012 (0.021)	0.13*** (0.034)	0.124*** (0.03)	-0.026 (0.017)	-0.043** (0.018)	-0.115*** (0.043)
Controls	No	No	No	No	No	No	No	No	No
No. of obs.	5,739	5,739	5,739	5,739	5,739	5,739	5,739	5,739	3,978
Adj. R-squared	1.01%	3.79%	0.44%	0.01%	1.64%	1.53%	0.07%	0.18%	1.34%
Panel B: Regressions with controls									
	NI	NT	NTD	TC	NI/NO	NJOpportunity	NJBubble	NJRisk	EPU
Coefficient	-0.099*** (0.036)	0.157*** (0.034)	-0.027 (0.027)	-0.013 (0.03)	0.143*** (0.041)	0.108*** (0.034)	-0.047* (0.027)	-0.051* (0.031)	-0.086* (0.047)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	2,792	2,792	2,792	2,792	2,792	2,792	2,792	2,792	2,497
Adj. R-squared	3.72%	5.12%	2.81%	2.75%	4.75%	3.87%	2.95%	2.99%	3.40%

Table: OOS performance in max drop prediction

Model	Benchmark: Controls			Benchmark: Zero		
	MSE ratio	DM/CW statistic	p-value	MSE ratio	DM/CW statistic	p-value
Controls	1.000			1.088	4.81	0.00%
NI	0.902	0.79	21.43%	0.981	2.61	0.46%
NT	0.936	0.52	30.11%	1.018	1.58	5.72%
NTD	0.922	0.64	26.19%	1.002	0.62	26.82%
TC	0.932	0.55	29.09%	1.013	1.47	7.06%
<i>NI^{NO}</i>	0.913	0.71	23.86%	0.993	2.83	0.23%
<i>NI^{Opportunity}</i>	0.903	0.80	21.24%	0.982	3.07	0.11%
<i>NI^{Bubble}</i>	0.925	0.61	27.22%	1.006	-1.17	87.96%
<i>NI^{Risk}</i>	0.934	0.54	29.60%	1.016	0.29	38.48%
EPU	0.896	0.84	20.07%	0.975	3.04	0.12%
Narra	0.923	0.63	26.53%	1.003	3.34	0.04%
Controls + Narra	1.008	1.86	3.14%	1.097	4.90	0.00%
Ensemble	0.873	1.07	14.22%	0.950	3.42	0.03%

Table: Alternative bubblieness prediction with panel data

Panel A: Price Elevation									
	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
Coefficient	-0.089*** (0.026)	0.249*** (0.041)	-0.11*** (0.026)	-0.05** (0.024)	0.181*** (0.039)	0.155*** (0.03)	-0.028 (0.025)	-0.096*** (0.027)	-0.082** (0.035)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	2,793	2,793	2,793	2,793	2,793	2,793	2,793	2,793	2,576
Adj. R-squared	4.45%	9.46%	4.87%	3.92%	6.81%	5.98%	3.76%	4.55%	4.51%
Panel B: Price Deviation									
	NI	NT	NTD	TC	NI^{NO}	$NI^{Opportunity}$	NI^{Bubble}	NI^{Risk}	EPU
Coefficient	-0.127*** (0.036)	0.35*** (0.044)	-0.089*** (0.024)	-0.025 (0.036)	0.211*** (0.034)	0.193*** (0.033)	-0.032 (0.031)	-0.094*** (0.029)	-0.138*** (0.048)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	2,873	2,873	2,873	2,873	2,873	2,873	2,873	2,873	2,578
Adj. R-squared	6.70%	16.51%	5.89%	5.18%	9.39%	8.67%	5.21%	5.96%	6.72%

Table: OOS forecasting performance in alternative bubblieness measures

Model	Price Elevation						Price Deviation					
	Benchmark: Controls			Benchmark: Historical mean			Benchmark: Controls			Benchmark: Historical mean		
	MSE ratio	DM/CW statistic	p-value	MSE ratio	DM/CW statistic	p-value	MSE ratio	DM/CW statistic	p-value	MSE ratio	DM/CW statistic	p-value
Controls	1.000			1.124	3.07	0.11%	1.000			1.288	0.46	32.43%
NI	0.858	2.27	1.16%	0.964	4.19	0.00%	0.737	1.98	2.37%	0.949	4.36	0.00%
NT	0.838	2.54	0.56%	0.942	6.72	0.00%	0.719	2.14	1.61%	0.926	7.18	0.00%
NTD	0.874	2.06	1.99%	0.983	3.64	0.01%	0.773	1.73	4.20%	0.995	2.26	1.19%
TC	0.884	1.90	2.90%	0.993	3.11	0.09%	0.765	1.78	3.78%	0.986	3.11	0.10%
<i>NI^{NO}</i>	0.866	2.15	1.58%	0.973	4.85	0.00%	0.748	1.93	2.69%	0.963	4.69	0.00%
<i>NI^{Opportunity}</i>	0.866	2.22	1.31%	0.973	4.46	0.00%	0.731	2.08	1.86%	0.942	4.94	0.00%
<i>NI^{Bubble}</i>	0.893	1.74	4.06%	1.004	0.37	35.50%	0.770	1.74	4.10%	0.992	2.21	1.35%
<i>NI^{Risk}</i>	0.891	1.77	3.82%	1.001	2.32	1.02%	0.784	1.64	5.05%	1.009	1.10	13.57%
EPU	0.883	1.93	2.71%	0.993	3.20	0.07%	0.764	1.80	3.56%	0.984	2.66	0.39%
Narra	0.842	2.50	0.63%	0.946	7.49	0.00%	0.707	2.27	1.16%	0.911	7.20	0.00%
Controls + Narra	0.911	5.70	0.00%	1.024	7.67	0.00%	0.864	4.80	0.00%	1.113	5.14	0.00%
Ensembl	0.815	3.25	0.06%	0.916	5.98	0.00%	0.707	2.39	0.83%	0.910	4.12	0.00%

Table: Prediction with U.S. data and PCA

	Bubbliness		Max drop	
	(1)	(2)	(1)	(2)
pc1	-0.186*** (0.057)	-0.271*** (0.077)	-0.183* (0.100)	-0.185* (0.106)
pc2	0.040 (0.045)	0.054 (0.049)	-0.046 (0.058)	-0.009 (0.056)
pc3	0.024 (0.054)	-0.043 (0.080)	-0.152** (0.064)	-0.162** (0.078)
Controls	No	Yes	No	Yes
No. of obs.	443	443	431	431
Adj. R-squared	3.0%	7.5%	5.2%	9.4%

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