Nowcasting Net Asset Values: The Case of Private Equity

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Research Background

- Valuing illiquid assets accurately is hard but necessary for many critical investment decisions made by institutional investors.
  - Private equity (PE) investments are a prime example.
  - secondary markets are undeveloped for private equity and likely reflect the marginal utility to trade of an unrepresentative investor
  - various stakeholders rely heavily on infrequently-reported Net Asset Values (NAVs) provided by fund managers

Research background

- Nowcasting: the prediction of the present, the very near future and the very recent past.
  - Mainly macroeconomic variables
  - But NAVs is much more complex than variables like GDP
  - → need new method for NAV nowcasting

- → estimate unbiased asset values at the relevant data arrival frequency (in our case weekly), i.e., to nowcast PE fund “true” NAVs
- → learn about risk, return, and reporting quality characteristics of individual funds

Motivation

- Existing work
  - Relies on reported NAVs and attempts to remove autocorrelation induced by smoothing via a distributed lag market-model
  - disregards the NAV information and relies solely on funds' realized cash flow data.
  - Focus on quarterly returns

- → this paper model true asset values and returns of a fund by State Space Model (SSM) at high frequencies and individual PE fund level.

- This paper
  - Use fund-level data on cash flows and reported NAVs to identify NAVs and risk exposure
  - Unsmooth weekly cumulative returns, rather than quarterly returns

Research questions

- Whether state space model perform better in nowcasting PE's NAV?
- What can we know about PE fund-level risk and returns?

Contribution

- Methodological contribution: State space model of private equity
- New findings about fund-level risk and return

Methodology

- Naïve nowcasting benchmark
- "grow" the latest NAV report using a public market rate of return and subtract (add) the value of distributions (contributions) as they occur.

$$NAV_t = (NAV_{t-1} + C_t - D_t) * (1 + r_{m,t})$$

- Strong assumptions:
  - A1: the NAV report reflects the true asset value (or at least an unbiased estimate),
  - A2: the returns of the benchmark fully describe those of the fund, and therefore the systematic risk of the fund equals that of the selected public benchmark.

Methodology

- State space model
  - S1. The fund cash flow and NAV reports are used jointly as distinct data points.
    - NAVs are informative but with error
    - Distributions represent cash flows from actual transactions
  - S2. We unsmooth asset values (as opposed to periodic returns) at a higher frequency and allow for a time-varying bias.
    - Instead of returns with fixed coefficient

$$\bar{r}_{0:t} = \left(1 - \lambda(\cdot)_t\right) r_{0:t} + \lambda(\cdot)_t \bar{r}_{0:t-1}, \tag{1}$$

$$\lambda(\cdot)_t := \lambda \cdot (1 - w_t), \tag{2}$$

  - S3. There is no pooling of fund-specific series but instead a partial imputation of hard-to-identify parameters from peer funds with better data.
    - Test for significant heterogeneity
    - Estimation quality

$$R_t = \exp\{\alpha + \beta r_{mt} + \eta_t\}, \quad (5) \qquad R^*_{ct} = \exp\{r_t \cdot \beta_c + \psi + \eta_{ct}\}, \quad (6)$$

$$V_t = V_{t-1}R_t - D_t + C_t, \quad V_0 = C_0 - D_0 > 0 \quad (7) \qquad R_{0:t} = \prod_{\tau=1}^{t} R_\tau \equiv V_t \cdot M_t, \quad (8)$$

$$\bar{r}_{0:t} = \Big(1 - \lambda(\cdot)_t\Big) r_{0:t} + \lambda(\cdot)_t \bar{r}_{0:t-1}, \quad (9) \qquad \text{NAV}_t = \exp\{\bar{r}_{0:t} - m_t + \epsilon_{nt}\}, \quad (10)$$

$$D_t = \delta(\cdot)_t \Big(V_t + D_t\Big) \exp\{\epsilon_{dt}\} \quad \text{iff } D_t > 0, \quad (11) \qquad R^*_{ct} = \exp\{r_{ct} - (b - \beta_c \cdot \beta) r_{mt}\}, \quad (12)$$

with $\eta_{ct} \sim \mathcal{N}(0, F_c^2 \cdot h_t)$, $\epsilon_{nt} \sim \mathcal{N}(0, \sigma_n^2)$, $\epsilon_{dt} \sim \mathcal{N}(0, \sigma_d^2)$, $\eta_t \sim \mathcal{N}(0, F^2 \cdot h_t)$, and $\lambda(\cdot)_t := \lambda \cdot (1 - w_t)$.

The economic interpretations for δ and σ are, respectively, the trend and the noise of the distribution density

b is the OLS slope of the projection of Rct on Rm at weekly frequency

Latent at weekly frequency

V_t :	Asset value of the fund	$r_{0:t}$:	Log returns from inception until t
R_t :	Gross return of the fund	$\bar{r}_{0:t}$:	Smoothed log returns from inception until t

Observed at weekly frequency

R_{mt} :	Gross return on the market	h_t :	The common factor of conditional variance
R_{ct} :	Gross return on Comparable Asset		in idiosyncratic returns of R_t and R_{ct}
V_t^0 :	Naïve nowcasts of fund NAVs	w_t :	Fraction of $C_t + D_t$ in $V_t^0 + D_t$

Observed at low (e.g. quarterly) or irregular frequency

NAV_t :	NAVs reported by the fund's manager	D_t :	Distributions from the fund
		C_t :	Capital calls by the fund

$$R_t = \exp\{\alpha + \beta r_{mt} + \eta_t\}, \quad (5) \qquad R^*_{ct} = \exp\{r_t \cdot \beta_c + \psi + \eta_{ct}\}, \quad (6)$$

$$V_t = V_{t-1}R_t - D_t + C_t, \quad V_0 = C_0 - D_0 > 0 \quad (7) \qquad R_{0:t} = \prod_{\tau=1}^{t} R_\tau \equiv V_t \cdot M_t, \quad (8)$$

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Fund's risk-return

β :	systematic risk	F :	h_t-normalized idiosyncratic risk
α :	abnormal return		

Fund's reporting quality		*Fund's distribution process*	
λ :	smoothing intensity	δ :	distribution's intensity trend
σ_n :	reporting noise	σ_d :	distribution's intensity noise

Comparable Asset

β_c :	slope to the fund's idiosync. return	F_c :	h_t-normalized idiosyncratic risk level
ψ :	log return intercept to the fund		to the fund's returns

Methodology

- Parameter Estimation
  - (i) maximum likelihood (ML)
  - (ii) partial imputation

  - In both, we utilize a penalty function in the spirit of Ridge estimators, and an iterative procedure in the spirit of the Expectation Maximization (EM) algorithm
  - numerical Hessian method as in Miranda and Fackler (2004).

- Fund-specific estimates
  - 61% of the sample

- Partially imputed parameter estimates
  - 95% of the samples
  - define peer funds:
    - Peer-imputed: same strategy, same or adjacent vintage year, same industry
    - Average-imputed: Set parameters to buyout or venture fund average
    - Literature-imputed: Fix the β from Ang et al.(2018)

Methodology

- Performance assessment
  - the closer given return series are to the true fund returns, the closer the PME computed with these series should be to 1.0

(i) Variances and autocorrelations of the filtered weekly returns between $t=1$ and T using the standard estimators at weekly and quarterly frequency. model misspecification and the sensitivity to different parameterization

(ii) $\text{PME}_{0:t}$ that are the Kaplan and Schoar PMEs on a to-date basis that utilize filtered returns and asset values along with the complete history of fund cash flows realized up to period t. nowcasting performance

(iii) $\text{PME}_{\tau:t}$ that are PMEs on the to-date basis in which capital calls up to period $\tau < t$, are replaced with $\hat{V}_\tau$ (using θ with data up to τ) and $\hat{R}_{0:t}$ are replaced with $\hat{R}_{\tau:t}$.

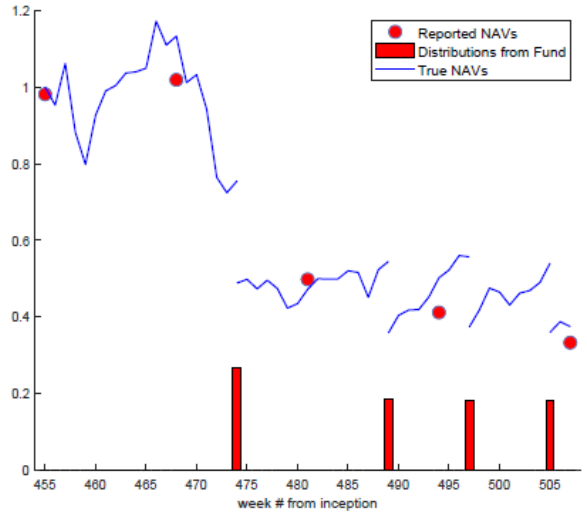
- Error metrics

1. **In-Sample RMSE** – mean squared difference of $(\text{PME}_{0:t} - 1)$ over the period $t = \tau_0, ..., \tau$ where τ_0 and τ are within the span of data used to estimate θ;
2. **Out-of-Sample (OOS) RMSE** – mean squared deviation of ($\text{PME}_{\tau:T}$ -1) such that no fund-specific data beyond week $\tau - 1$ is used to estimate θ;
3. **Hybrid RMSE** – mean squared deviation of ($\text{PME}_{0:t}$-1) over periods $t = \tau, ..., T$ such that no fund-specific data beyond week $\tau - 1$ is used to estimate θ. It is a hybrid between in-sample and out-of-sample data because, even though it utilizes the out-of-sample NAVs only, all since-inception cash flows are included.

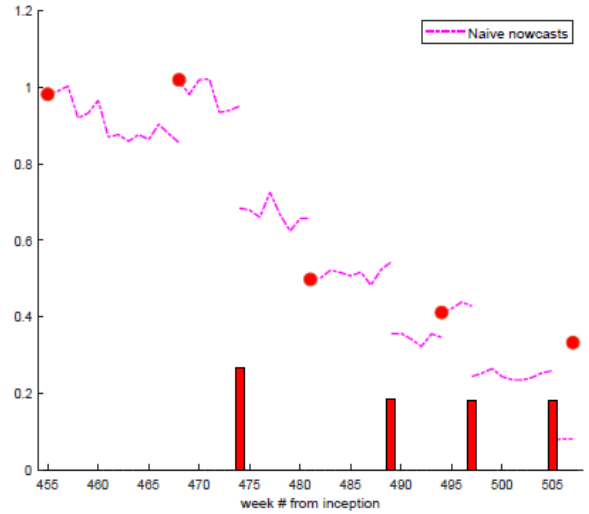
Simulation experiment

- 1. Key parameters are consistently estimated
- 2. partial imputation may reduce the estimation error on β and λ by a factor of 1.2 to 1.6
- 3. The median OOS nowcast error of 0.126 represents a 42% reduction relative to the naïve nowcast, yielding an improvement for 68% of the funds; partial imputation of parameters also yields a modest improvement in the nowcasting performance..

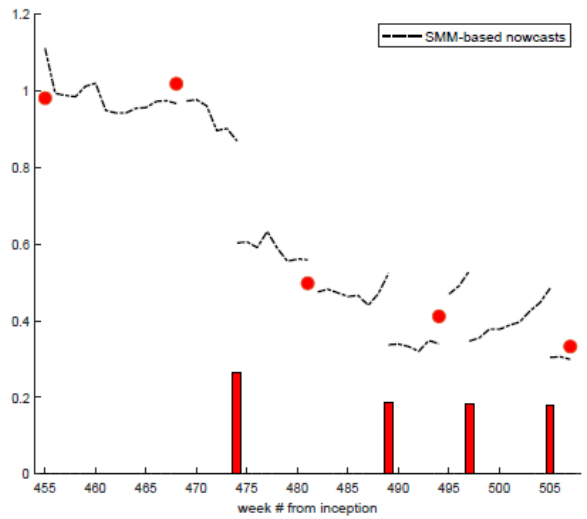
Panel A



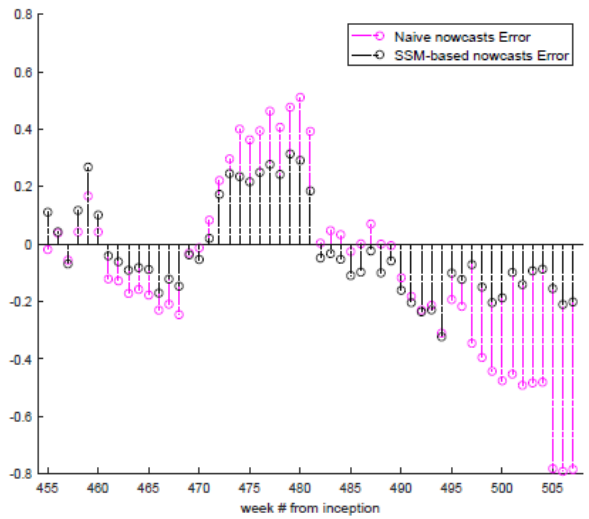
Panel B



Panel C



Panel D



Data

- Data source: Burgiss
  - The data include fund-level history of cash flows between each fund and its investors, fund NAVs reports for most quarters, as well as time-invariant data such as fund strategy, vintage year, and industry
- Sample funds: 2,444 buyout funds, 1,679 venture funds
  - vintage year is between 1983 and 2014,
  - operated for at least 24 quarters, and reported NAVs for at least 20 quarters,
  - made at least two distributions,
  - have at least two peer funds for which we obtain fund-specific estimates (Section 3.3.1).

Empirical results

- Fund-specific estimates
  - 61% of the sample

Summary of fund-specific estimates

Number of fund-estimates: 2,513

	mean	sd	skew	p10	p25	p50	p75	p90
			A. Parameter estimates					
Main parameters:								
α: Abnormal return (p.a.)	0.047	0.15	2.03	−0.116	−0.048	0.030	0.114	0.210
β: Systematic risk	1.30	0.33	0.18	0.839	1.040	1.307	1.548	1.684
F: Idiosync. volatility (×)	3.50	2.26	1.51	1.392	2.092	2.903	3.994	6.858
λ: NAV smoothing bias	0.86	0.25	−2.53	0.520	0.899	0.961	0.983	0.990
σ_n: NAV report noise	0.066	0.041	0.59	0.018	0.037	0.057	0.089	0.140
δ: Dist intensity trend	0.014	0.019	13.3	0.004	0.006	0.011	0.017	0.027
σ_d: Dist intensity noise	1.51	0.66	1.09	0.797	1.031	1.405	1.891	2.360
Parameter mapping to Comparable asset:								
ψ: Intercept to fund return (p.a.)	−0.001	0.049	0.13	−0.059	−0.030	−0.003	0.028	0.062
β_c: Loading on fund return	0.16	0.19	2.95	0.010	0.010	0.177	0.217	0.294
F_c: IdVol vs fund return (×)	0.88	0.16	−2.35	0.707	0.799	0.918	0.998	1.027

- the idiosyncratic volatility parameter is hard to identify at the individual fund level.

	B. Filtered return properties							
Autocorrelations:								
Reported NAVs (quarterly)	0.25	0.22	0.47	−0.011	0.090	0.227	0.381	0.552
SSM estimates (quarterly)	0.077	0.30	−0.18	−0.332	−0.112	0.092	0.286	0.445
SSM estimates (weekly)	0.014	0.17	2.09	−0.119	−0.091	−0.033	0.056	0.212
Naïve nowcast (weekly)	0.12	0.17	1.68	−0.024	0.011	0.070	0.183	0.353
Variances:								
Reported NAVs (quarterly)	0.035	0.046	2.86	0.006	0.010	0.019	0.038	0.080
SSM estimates (quarterly)	0.038	0.042	2.62	0.011	0.016	0.024	0.039	0.081
	C. Nowcasted performance assessment							
In-sample RMSE	0.062	0.066	2.51	0.009	0.019	0.041	0.080	0.139
Hybrid RMSE SSM	0.070	0.077	2.53	0.009	0.020	0.045	0.092	0.159
Hybrid RMSE naïve	0.44	0.56	4.01	0.061	0.136	0.281	0.514	0.973
OOS RMSE naïve	0.34	0.42	4.73	0.042	0.110	0.233	0.432	0.694
OOS RMSE SSM	0.20	0.28	4.67	0.018	0.052	0.120	0.251	0.459

- Partially-imputed: buyout fund

	Number of fund-level estimates: fund-specific—1,654, partially-imputed—2,300							
	mean	p25	p50	p75	mean	p25	p50	p75
Panel A. Selected parameters								
	α (p.a.)				β			
Fund-specific	0.063	−0.016	0.050	0.127	1.146	0.962	1.101	1.307
Peer-imputed	0.046	−0.025	0.045	0.120	0.983	0.868	0.929	1.092
Average-imputed	0.051	−0.023	0.048	0.125	0.969	0.912	0.912	0.912
Literature-imputed	0.011	−0.073	0.007	0.089	1.346	1.250	1.250	1.250
	F_c				λ			
Fund-specific	0.895	0.832	0.943	1.008	0.835	0.871	0.954	0.981
Peer-imputed	0.908	0.850	0.964	1.011	0.886	0.831	0.910	0.968
Average-imputed	0.908	0.819	0.964	1.012	0.839	0.673	0.926	0.955
Literature-imputed	0.871	0.801	0.922	1.002	0.860	0.901	0.964	0.985

- Partially-imputed

Panel B. Fund return properties

	Weekly return autocorrelation				Annualized Standard Deviations			
Naive nowcast	0.119	0.004	0.064	0.173	0.278	0.206	0.239	0.280
Fund-specific	0.031	−0.080	−0.015	0.072	0.343	0.230	0.288	0.378
Peer-imputed	0.076	−0.054	0.029	0.146	0.333	0.231	0.286	0.367
Average-imputed	0.067	−0.056	0.020	0.129	0.340	0.230	0.289	0.388
Literature-imputed	0.016	−0.084	−0.025	0.048	0.377	0.265	0.317	0.401

Panel C. Nowcast performance assessment

	Hybrid RMSE				OOS RMSE			
Naive nowcast	0.396	0.141	0.288	0.522	0.335	0.118	0.251	0.454
Fund-specific	0.066	0.019	0.042	0.083	0.176	0.045	0.104	0.213
Peer-imputed	0.059	0.016	0.035	0.070	0.164	0.037	0.088	0.184
Average-imputed	0.068	0.031	0.050	0.081	0.160	0.047	0.099	0.178
Literature-imputed	0.075	0.020	0.046	0.094	0.206	0.046	0.113	0.233

	Hybrid Improv. %	OOS Improv. %	Autocorr. Improv. %
Fund-specific	88.8	71.2	58.1
Peer-imputed	92.2	74.6	56.5
Average-imputed	90.1	74.3	57.3
Literature-imputed	88.9	69.6	59.2

- Venture fund

Table 6
Venture fund estimates comparison

	# of fund-level estimates: fund-specific 858, partially imputed 1,622							
	mean	p25	p50	p75	mean	p25	p50	p75
	A. Selected parameters							
	α (p.a.)				β			
Fund-specific	0.016	−0.094	−0.021	0.061	1.603	1.455	1.621	1.684
Peer-imputed	−0.015	−0.111	−0.030	0.048	1.427	1.342	1.415	1.480
Average-imputed	−0.008	−0.107	−0.024	0.061	1.391	1.339	1.339	1.339
Literature-imputed	−0.059	−0.167	−0.081	0.011	1.800	1.800	1.800	1.800
	F_C				λ			
Fund-specific	0.851	0.768	0.865	0.971	0.913	0.936	0.969	0.984
Peer-imputed	0.839	0.739	0.867	0.980	0.932	0.899	0.951	0.980
Average-imputed	0.832	0.758	0.846	0.977	0.911	0.901	0.963	0.979
Literature-imputed	0.812	0.736	0.822	0.957	0.924	0.953	0.976	0.987
	B. Fund return properties							
	Weekly return autocorrelation				Annualized standard deviations			
Naïve nowcast	0.116	0.011	0.070	0.176	0.326	0.199	0.268	0.386
Fund-specific	−0.017	−0.105	−0.071	0.022	0.405	0.296	0.343	0.431
Peer-imputed	0.001	−0.102	−0.057	0.043	0.403	0.285	0.335	0.423
Average-imputed	−0.009	−0.104	−0.058	0.024	0.395	0.286	0.338	0.420
Literature-imputed	−0.030	−0.108	−0.076	−0.006	0.443	0.336	0.381	0.456
	C. Nowcast performance assessment							
	Hybrid RMSE				OOS RMSE			
Naïve nowcast	0.531	0.199	0.377	0.634	0.393	0.159	0.314	0.522
Fund-specific	0.084	0.027	0.056	0.114	0.235	0.064	0.147	0.282
Peer-imputed	0.069	0.020	0.042	0.085	0.206	0.055	0.126	0.236
Average-imputed	0.082	0.034	0.056	0.097	0.201	0.070	0.139	0.249
Literature-imputed	0.093	0.026	0.058	0.122	0.237	0.061	0.141	0.281

	Hybrid improv. %	OOS improv. %	Autocorr. improv. %
Fund-specific	90.7	63.2	56.0
Peer-imputed	93.8	73.5	56.4
Average-imputed	93.2	71.1	57.0
Literature-imputed	91.9	68.6	55.6

- Fund-level heterogeneity

Table 5. Fund characteristics and *Systematic risk* exposure

This table regresses the fund-specific β (Panel A) and the natural logs of λ (Panel B) estimates the fund's αestimates as well as selected characteristics of the fund and the period it was operating. The sample includes PE funds described in Table 1 as well as REPE funds per Online Appendix Table A.2. ***/**/* denotes significance at 1/5/10% confidence level, t-statistics robust to error clustering at vintage level are reported in parentheses.

Panel A. Fund-specific β estimates

	(1)	(2)	(3)	(4)	(5)
log(Size USD)	−0.005	0.005	0.008**		0.013**
	(−1.48)	(1.41)	(2.15)		(2.44)
log(∑Distrib./Size)		0.085***	0.082***		0.102***
		(10.25)	(9.72)		(9.00)
log(# Distrib.)		−0.036***	−0.034***		−0.049***
		(−4.49)	(−4.28)		(−4.53)
Industry variance			−2.502***		−2.592***
			(−7.07)		(−5.17)
Market variance			1.359***		0.465
			(3.64)		(0.92)
Previous fund's β				0.032*	0.039**
				(1.66)	(2.00)
Previous fund's λ				0.018	0.005
				(0.82)	(0.26)
Fixed effects:			Industry, Region, Fund type		
Observations	2,811	2,811	2,811	1,492	1,492
R^2	0.781	0.790	0.793	0.799	0.814

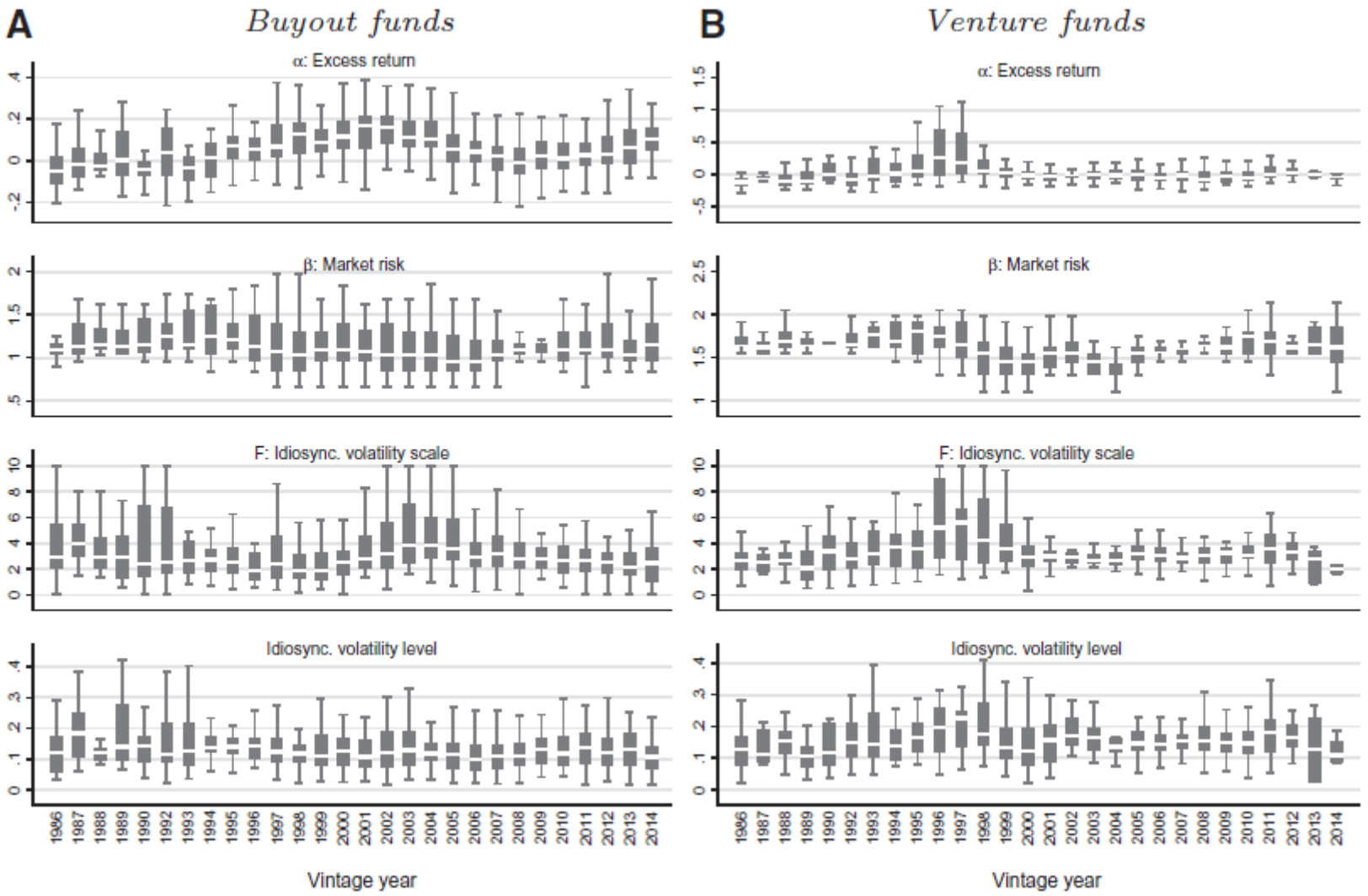
Panel B. Fund-specific λ estimates

	(1)	(2)	(3)	(4)	(5)
log(SizeUSD)	0.055***	0.041**	0.044**		0.030
	(3.06)	(2.03)	(2.09)		(1.10)
log(∑Distrib./Size)		−0.102**	−0.105**		−0.071
		(−2.17)	(−2.21)		(−1.18)
log(# Distrib.)		0.055	0.053		0.007
		(1.22)	(1.17)		(0.13)
Industry variance			−0.621		1.825
			(−0.31)		(0.79)
Market variance			1.530		0.086
			(0.86)		(0.04)
Previous fund's β				−0.042	−0.041
				(−0.54)	(−0.53)
Previous fund's λ				0.230**	0.234**
				(2.05)	(2.08)
Fixed effects:			Industry, Region, Fund type		
Observations	2,811	2,811	2,811	1,492	1,492
R^2	0.040	0.042	0.042	0.044	0.048

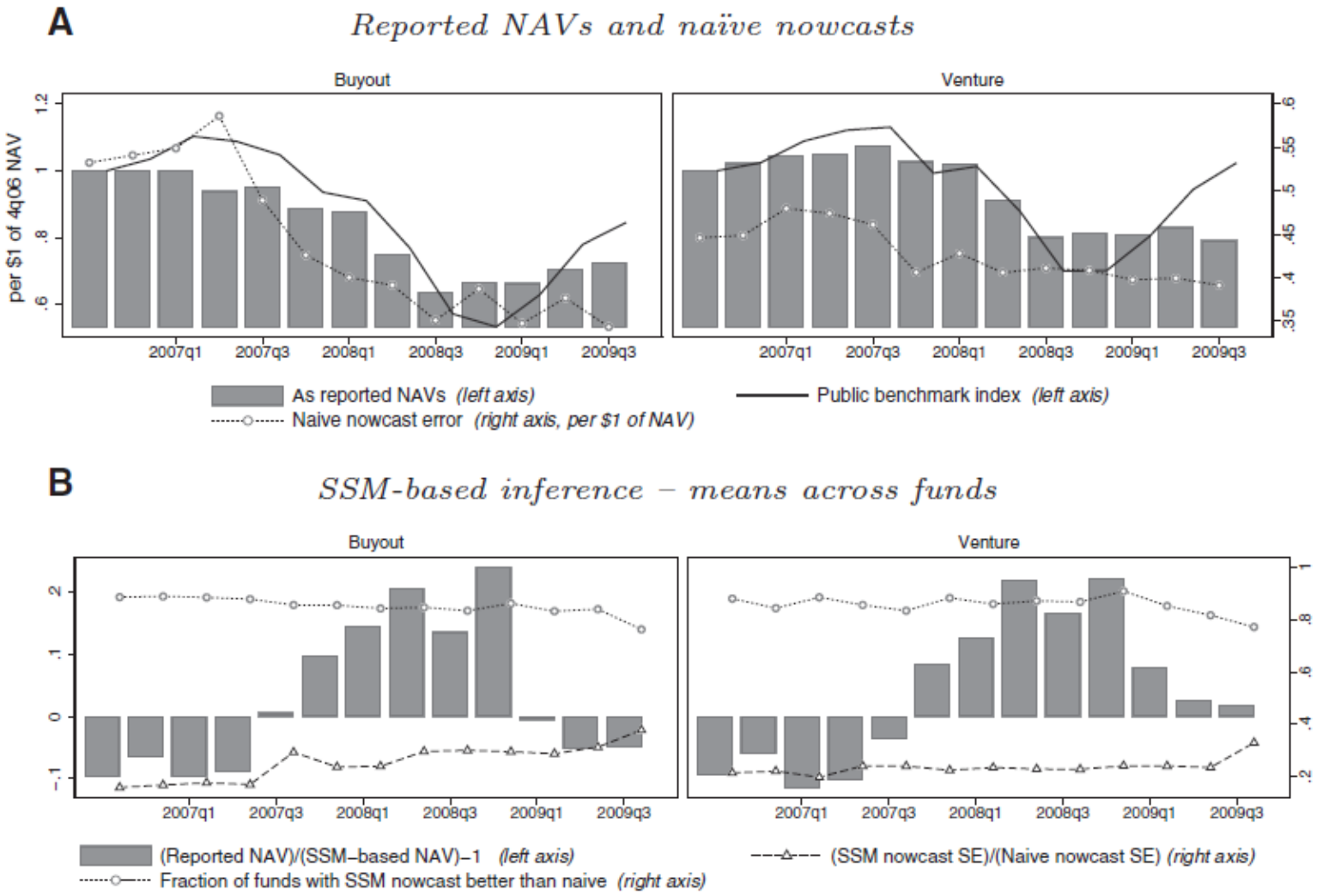
Panel A2. Risk factor exposures of the Buyout funds index

	Total returns					Excess returns	
	comp	Naive		SSM		Naive	SSM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Market	1.086***	1.032***	1.022***	1.223***	1.212***	−0.061***	0.134***
	(64.11)	(57.69)	(91.04)	(108.92)	(99.15)	(−7.10)	(8.07)
SMB			0.226***		0.184***		
			(11.39)		(13.61)		
HML			0.230***		0.114***		
			(11.61)		(5.28)		
Market lag						−0.066***	0.005
						(−6.79)	(0.72)
Constant	0.060***	0.084**	0.076*	0.068***	0.065***	0.096**	0.066***
	(3.43)	(2.14)	(1.89)	(4.90)	(6.37)	(2.35)	(5.84)
T	1,780	1,780	1,780	1,780	1,780	1,779	1,779
RMSE	0.635	0.914	0.813	0.437	0.338	0.745	0.396
St.Dev.	2.661	2.620		2.944		0.774	0.509

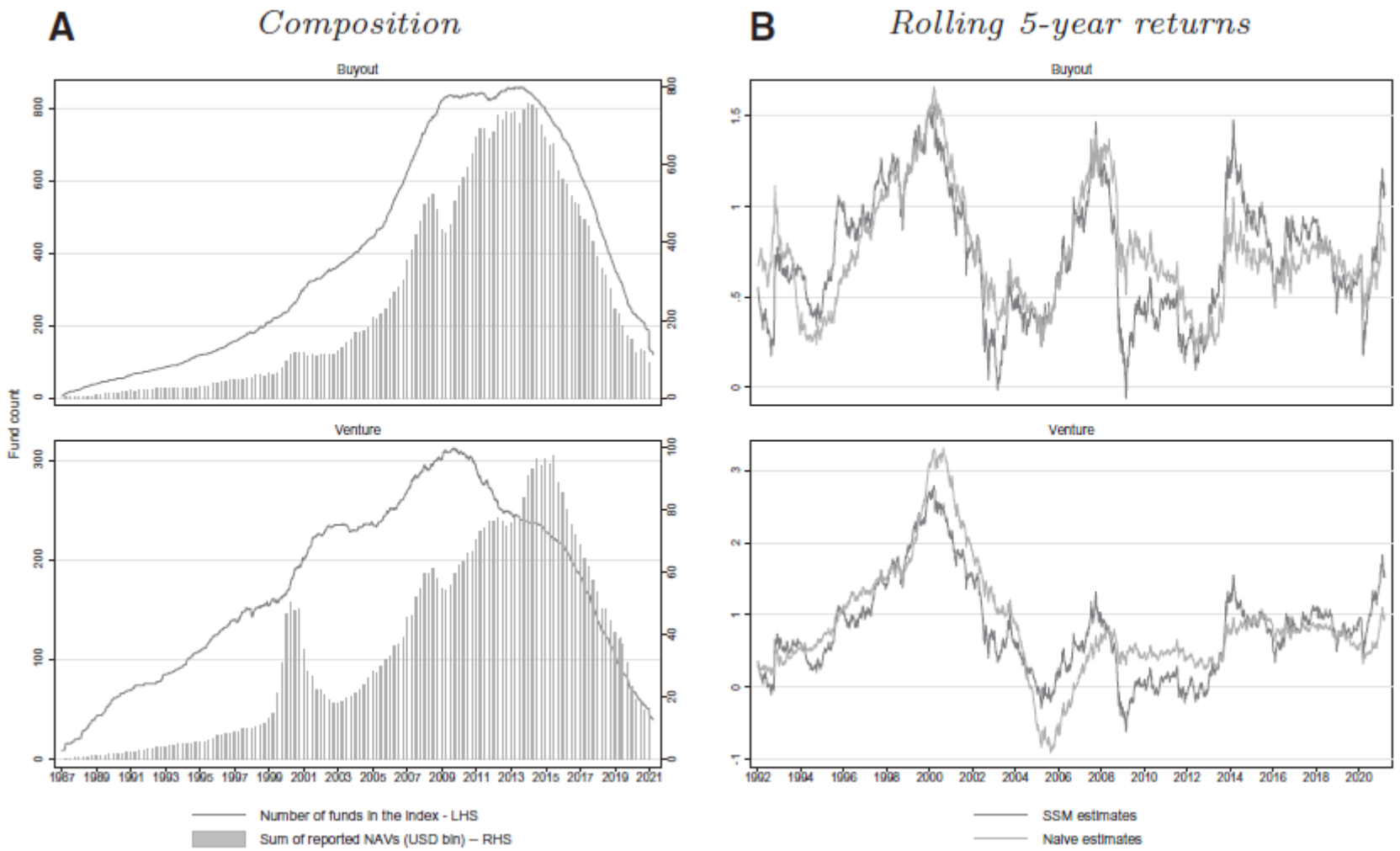
- Trends in PE fund risk



- NAV bias and nowcasting around the GFC



- Private equity index



Conclusion

- This paper develops a new method that provide reliable nowcasts of PE fund asset values at high frequency.
- This paper shed light on the risk temporal and cross-sectional variation in manager risk and reporting-quality characteristics