Contributions to Particle Filters

and Sequential Monte Carlo Methods

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15+ papers · 19 years · 3 core themes · 2007–2026

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Five Research Phases

I Early Foundations 2007–08
Sequential simulation for SV & DSGE

II Particle Learning 2010–11
Core PL framework — landmark papers

III Surveys & Extensions 2012–16
Reviews, new model classes

IV PL for Stoch. Volatility 2018–19
Jumps, semi-parametric SV

V Recent Directions 2026
Count data, generative connections

Three Interlocking Themes

(1) Particle Learning (PL)

A new SMC paradigm carrying sufficient statistics in particles for exact sequential parameter updates.

(2) Stochastic Volatility (SV)

Online Bayesian inference for time-varying financial risk: Markov switching, jumps, factor models.

(3) Survey & Pedagogy

Multiple review articles and book chapters making SMC accessible to econometricians and statisticians.

Tag Legend

SMC	SMC / Particle Filter methodology	PL	Particle Learning framework
SV	Stochastic Volatility application	APP	Other applied domain
SURVEY	Survey / Introduction / Pedagogical	★	Landmark / invited paper

2007 Markov Switching SV SMC;SV

Simulation-based Sequential Analysis of Markov Switching Stochastic Volatility Models
with Carvalho *Computational Statistics and Data Analysis*, 51, 4526–4542

- Sequential particle filter for regime-switching volatility — first major SMC paper.
- Establishes the resample-propagate workflow that Particle Learning later formalises.

2008 DSGE Models SMC;APP

Sequential Monte Carlo Estimation of DSGE Models
with Chen & Petralia *Technical Report*, U. of Chicago Booth

- Demonstrates SMC in macroeconomic structural models.
- Shows online posterior tracking works beyond finance.

★ 2010 Particle Learning and Smoothing PL;SMC

Particle Learning and Smoothing
with Carvalho, Johannes & Polson — *Statistical Science*, 25, 88–106

- **Foundational paper** of the Particle Learning (PL) framework.
- Particles carry sufficient statistics; propagation = sequential parameter *and* state learning.
- Introduces smoothing within PL — cleaner than MCMC, more principled than IS.

★ 2010 PL for General Mixtures PL;SMC

Particle Learning for General Mixtures
with Carvalho, Polson & Taddy — *Bayesian Analysis*, 5, 709–740

- Extends PL to mixture models and Dirichlet Process mixtures.
- Sequential nonparametric Bayesian inference — mixture allocations updated online.

★ 2011 PL — Invited Paper with Discussion PL;SMC

Particle Learning for Sequential Bayesian Computation (with discussion)
with Carvalho, Johannes & Polson — *Bayesian Statistics 9*, 317–360

- Comprehensive exposition of PL at the Valencia/ISBA World Meeting.
- Theory, resample-propagate algorithms, and comparisons to other SMC methods.
- **Considered a seminal reference** for the PL literature.

2011 Factor Models PL;APP

Dynamic Stock Selection Strategies: A Structured Factor Model Approach (with discussion)
with Carvalho & Aguilar — *Bayesian Statistics 9*

- PL for dynamic factor models in portfolio management.

2011 Epidemic Tracking SMC;APP

Tracking Epidemics with Google Flu Trends and a State-Space SEIR Model
with Dukic & Polson — *JASA*, 107, 1410–1426

- Particle filter for real-time epidemic surveillance.
- SMC beyond finance — public health impact.

★ 2011 Finance Survey SMC;SV;SURVEY

Particle Filters and Bayesian Inference in Financial Econometrics
with Tsay *Journal of Forecasting*, 30, 168–209

- Comprehensive survey: SIR filters, auxiliary PF, parameter learning in SV & factor models.
- Includes R implementations — widely used as a course text.
- R example scripts available online

2010 Credit Crisis SMC;SV;APP

Extracting SP500 and NASDAQ Volatility: The Credit Crisis of 2007–2008
with Polson *Handbook of Applied Bayesian Analysis* (O'Hagan & West, Eds.), 319–342

- High-profile chapter: SMC tracking of volatility regimes during the 2008 financial crisis.
- Demonstrates the practical power of online Bayesian filtering.

2012 Resampling Perspective SMC; SURVEY

Bayesian Statistics with a Smile: A Resampling-Sampling Perspective
with Polson & Carvalho *BJPS*, 26, 358–371

- Unifies bootstrap, resampling and particle methods under a common Bayesian lens.
- Accessible intuition for why SMC works.

2013 Introduction to PF SMC; SURVEY

Online Bayesian Learning in Dynamic Models: An Illustrative Introduction to Particle Methods
with Carvalho *Bayesian Theory and Applications* (Oxford UP), 203–228

- Pedagogical chapter: filtering, smoothing, parameter learning with worked examples.

2013 Comparative Study SMC; SV; SURVEY

Evaluation and Analysis of Sequential Parameter Learning Methods in Markov Switching SV Models
with Rios *State-Space Models in Economics and Finance* (Springer), 23–61

- Systematic comparison of PL vs. competing particle methods in regime-switching volatility.

2013 Sequential AR Models SMC; APP

Sequential Parameter Learning and Filtering in Structured AR Models
with Prado *Statistics and Computing*, 23, 43–57

- PL extended to autoregressive models with structured priors.

2016 PL for Fat Tails PL; SMC

Particle Learning for Fat-Tailed Distributions
with Polson *Econometric Reviews*, 35, 1666–1691

- PL augmented for Student-t / stable error distributions.
- Direct applications to financial return modelling.

2018 Variance-Gamma Jumps (with discussion) PL; SV; SMC

Sequential Bayesian Learning for Stochastic Volatility with Variance-Gamma Jumps in Returns
with Warty & Polson *Applied Stochastic Models in Business and Industry*, 34, 460–483

- Sequential / particle-based inference for SV models with variance-gamma jump component.
- Discussion format (with two discussions + rejoinder) signals methodological significance.
- PL robustness demonstrated in the presence of non-Gaussian, jump-driven returns.

2019 Semi-Parametric SV PL; SV; SMC

Particle Learning for Bayesian Semi-Parametric Stochastic Volatility Model
with Virbickaite, Ausín & Galeano *Econometric Reviews*, 38, 1007–1023

- Fuses PL with Dirichlet Process priors for a semi-parametric SV model.
- Online inference: nonparametric flexibility + PL efficiency — a genuine methodological hybrid.

2026 Count Time Series SMC; APP

MCMC and Particle Filtering for Dynamic INAR Processes

with Soyer & Zhang — *Applied Stochastic Models in Business and Industry* (accepted)

- Particle filtering for integer-valued autoregressive (INAR) count-data models.
- Applications: insurance claim counts, epidemiology, operations.
- Compares MCMC and PF for dynamic parameter estimation in a non-Gaussian discrete setting.

2026 Foundations SMC; SURVEY

Uncertainty Quantification: From Weighted Bootstrap to Generators

with Polson & Sokolov — *Technical Report*

- Revisits conceptual roots of particle / bootstrap methods.
- Connects the weighted bootstrap — a core SMC building block — to modern **generative models** (diffusion, VAEs, normalising flows).
- Positions SMC as a bridge between classical resampling and deep generative AI.

Chronological Timeline

Summary: Key Papers at a Glance

Year	Paper (short title)	Venue	Tags	Lmk
2007	Markov Switching SV (with Carvalho)	CSDA 51	SMC; SV	
2010	Particle Learning & Smoothing	*Stat. Sci.* 25	PL; SMC	★
2010	PL for General Mixtures	*BA* 5	PL; SMC	★
2011	PL — Valencia invited (disc.)	*BS9*	PL; SMC	★
2011	PF in Financial Econometrics	*JoF* 30	SMC; SV; SURVEY	★
2011	SEIR Epidemic Tracking	*JASA* 107	SMC; APP	
2012	Bayesian Statistics with a Smile	*BJPS* 26	SMC; SURVEY	
2013	Introduction to Particle Methods	Oxford UP	SMC; SURVEY	
2013	Sequential AR Models	*Stat. Comp.* 23	SMC	
2016	PL for Fat-Tailed Distributions	*Econ. Rev.* 35	PL; SMC	★
2018	SV with VG Jumps (disc.)	*ASMBI* 34	PL; SV	
2019	Semi-Parametric SV	*Econ. Rev.* 38	PL; SV	
2026	PF for Dynamic INAR	*ASMBI* (acc.)	SMC; APP	
2026	Bootstrap to Generators	Tech. Report	SMC; SURVEY	

PL Particle Learning SMC SMC/PF SV Stoch.Volatility APP Application SURVEY Survey ★ Landmark

Three Interlocking Themes

(1) Particle Learning

- Sufficient statistics in particles
- Resample-propagate algorithm
- Exact sequential parameter learning
- Smoother than MCMC on long series

Key papers: Stat. Sci. 2010, BA 2010, BS9 2011, ER 2016

(2) Stochastic Volatility

- Markov switching regimes (2007)
- Factor SV & portfolio (2011)
- Jump-driven returns (2018)
- Semi-parametric DP prior (2019)

Key papers: CSDA 2007, JoF 2011, ASMBI 2018, ER 2019

(3) Survey & Pedagogy

- JoF 2011: finance tutorial with R
- Oxford UP 2013: chapter intro
- BJPS 2012: conceptual essay
- 2026: SMC to generative models

Consistent effort to broaden the SMC community

Thank you

Full paper list and PDFs:

https://hedibert.org/scientific-papers/

15 papers on PF / SMC · 2007–2026 · Particle Learning · Stochastic Volatility · Surveys