The Value of Public Insurance Against Idiosyncratic Income Risk: A Variance-Adjustment Statistic

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Athens

Outline

Motivation

- Household incomes feature risky fluctuations
- Under risk aversion $\rightarrow$ welfare consequences
- Policies buffer household disposable income against fluctuations
  - Transfers like unemp. insurance
  - Progressive income taxes

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Q What is the value of this insurance?

Challenge

- Ingredients to assess insurance:
  1. Income before taxes
  2. Income after taxes
  3. Consumption expenditures

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$\Rightarrow$ Tractable method to assess insurance value in such settings

- Inputs: gross and net incomes (feature statistical differences)
- Gives: welfare-equivalent variance adjustment

Approach

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- BPP (08): Cov. of income and consumption $\rightarrow$ insurance coeff
- We: structural assumptions $\rightarrow$ insurance coeff
  - preferences, incomplete asset markets, flexible income process
  - extends BPP to capture differences beyond variance

Applications

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   - Benchmark: high-quality admin. data
   - Tax register data 1976–2011
   - Detailed info on gross earnings + transfers - taxes
   - **Partial insurance** by taxes+transfers
     = welfare equivalent **variance reduction by** 48.6%
2. **USA**
   - PSID data: income and consumption
   - Obtain consumption pass-through of gross and net income shocks→back out government-provided variance reduction
   - **Direct & model-based give** $\sim$ 25%

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- Assume households **draw income from a distribution**
- Preferences captured by $U()$ with derivatives of alternating signs
- Consider **mean-preserving change of distribution**
- For any change: **welfare-equivalent variance adjustment** Δvar
- Role of **higher-order** distributional features:

$\rightarrow$ affect Δvar to extent **households care** about those

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$$
\begin{aligned}
& U(\bar{Y}) + U'(\bar{Y})\mathbb{E}(Y^{pre} - \bar{Y}) + \frac{1}{2}U''(\bar{Y})(1-\lambda^{gov})\mu_2(Y^{pre}) \\
& = U(\bar{Y}) + U'(\bar{Y})\mathbb{E}(Y^{post} - \bar{Y}) + \frac{1}{2}U''(\bar{Y})\mu_2(Y^{post}),
\end{aligned}
$$

where $\bar{Y} = \mathbb{E}\left[Y^{pre}\right] = \mathbb{E}\left[Y^{post}\right]$

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where $\bar{Y} = \mathbb{E}[Y^{pre}] = \mathbb{E}\left[Y^{post}\right]$

- Under mean-preserving change, simplifies to

$$\lambda^{gov} = 1 - \frac{\mu_2(Y^{post})}{\mu_2(Y^{pre})} \tag{1}$$

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- which yields:

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- Consider: gov. **reduces variance** and induces **right-skewness** ($\mu_3() > 0$)
  - If agents like right-skewness (they do: $-U'''(.)/U''(.) > 0$)...

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- Consider: gov. **reduces variance** and induces **right-skewness** ($\mu_3() > 0$)
  - If agents like right-skewness (they do: $-U'''(.)/U''(.) > 0$)...
  - then **welfare-equivalent variance reduction** is larger: $\lambda^{gov} \uparrow$
  - (for the same variance difference between Y^{pre} & Y^{post})

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Model: Stochastic Endowment Economy

- Discrete time
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       (wash out within island)
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       (wash out across islands)
- Island=group of agents with same history of island-level shocks

Model

Endowments and Preferences

Endowment process: Permanent and transitory components

$$
\begin{aligned}
y_{i,t}^{\tau} &= z_{i,t}^{\tau,island} + z_{i,t}^{\tau,idio} + \varepsilon_{i,t}^{\tau,idio}, \quad \varepsilon_{i,t}^{\tau,idio} \sim F_{\varepsilon} \\
z_{i,t}^{\tau,l} &= z_{i,t-1}^{\tau,l} + \eta_{i,t}^{\tau,l}, \quad \eta_{i,t}^{\tau,l} \sim F_{\eta,x_t}^{l}, \text{ for } l \in \{island, idio\}; x_t \sim H(x_{t-1})
\end{aligned}
$$

Normalize $\int \exp\left(x_t^i\right) dF_{x,t}^i = 1$ for $i \in \{island, idio\}$ and $x \in \{\varepsilon, \eta\}$

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Normalize $\int \exp\left(x_t^i\right) dF_{x,t}^i = 1$ for $i \in \{island, idio\}$ and $x \in \{\varepsilon, \eta\}$

Preferences (standard)

- Per-period utility $U(c)$
- Time- and state-separable utility
- $\max$ present-value expected lifetime utility:

$$\mathbb{E}_{\tau} \sum_{t=\tau}^{\infty} (\beta\delta)^{t-\tau} U\left(c_{i,t}\right)$$

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Asset Market Structure

- Full set of idiosyncratic-state-contingent claims
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- Budget constraint of generation-τ household:

$$c^{\tau}_{i,t} + \int_x \int_s q(s,x;s_i^{\tau,t},x^t) b^{within}(s,x;s_i^{\tau,t},x^t) dF(s^{\tau}_{i,t+1};x_{t+1}) dF(x_{t+1}) +$$
$$\int_x \int_s q^{across}(s,x;s_i^{\tau,t},x_t) b^{across}(s,x;s_i^{\tau,t},x_t) dF(s^{\tau,idio}_{i,t+1};x_{t+1}) dF(x_{t+1})$$
$$= \exp\left(y^{\tau}_{i,t}\right) + b^{within}(s^{\tau}_{i,t},x_t;s_i^{\tau,t-1},x^{t-1}) + b^{across}(s^{\tau,idio}_{i,t},x_t;s_i^{\tau,t-1},x^{t-1})$$

with
$$s^{\tau,idio}_{i,t+1} \equiv \left\{ z^{\tau,idio}_{i,t+1}, \varepsilon^{\tau,idio}_{i,t+1} \right\} \quad \leftarrow \text{idiosyncratic shocks}$$
$$s^{\tau}_{i,t+1} \equiv \left\{ z^{\tau,idio}_{i,t+1}, \varepsilon^{\tau,idio}_{i,t+1}, z^{\tau,island}_{i,t+1} \right\} \quad \leftarrow \text{idio. \& island shocks}$$

Model

Equilibrium

→ No-(across-island)-trade equilibrium:

(Heathcote, Storesletten & Violante '14; Boerma & Karabarbounis '21)

- Within-island shocks fully insured
- Island-level shocks uninsured

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- Equilibrium log consumption:

$$\ln c_{i,t}^{\tau}\left(z_{i,t}^{\tau,island}, z_{i,t}^{\tau,idio}, \varepsilon_{i,t}^{idio}\right) = z_{i,t}^{\tau,island} + \ln \int \exp\left(y^{\tau,idio}\right) dF_{y^{\tau,idio},t}^{\tau}$$

- Depends on time t: distributions of shocks depend on t
- Depends on age $t-\tau$: permanent shocks accumulate →widening distribution

Model

Implied Consumption Changes

$$\begin{aligned}
&\Delta \ln c_{i,t}\left(z_{i,t}^{\tau,island}, z_{i,t}^{\tau,idio}, \varepsilon_{i,t}^{idio}\right) \\
&\qquad = \eta_{i,t}^{island} + \ln \frac{\int \exp\left(\eta_{i,t}^{idio}\right) dF_{\eta,t}^{idio} \int \exp\left(\varepsilon_{i,t}^{idio}\right) dF_{\varepsilon,t}^{idio}}{\int \exp\left(\varepsilon_{i,t-1}^{idio}\right) dF_{\varepsilon,t-1}^{idio}} \\
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Implied Consumption Changes

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\end{aligned}
$$

$\rightarrow$ **Partial insurance**

- Relate to benchmark BPP (08) measure based on pass-through:

$$
\beta = \frac{\text{cov}(\Delta \ln c_{i,t}, \eta_{i,t})}{\text{var}(\eta_{i,t})} \Leftrightarrow \lambda = 1 - \beta
$$

on actual shock as in Kaplan & Violante ('10)

Model

Measure of Partial Insurance in Model

- Pass-through in model:

$$\Delta \ln c_t = \beta_0 + (1 - \lambda_{perm})\eta_t$$

$$\begin{aligned} 1 - \lambda_{perm} &= \frac{\text{cov}(\Delta \ln c_t, \eta_t)}{\text{var}(\eta)} = \frac{\text{cov}(\eta_t^{island}, \eta_t^{island} + \eta_t^{idio})}{\text{var}(\eta_t)} \\ &= \frac{\text{var}(\eta_t^{island})}{\text{var}(\eta_t^{island} + \eta_t^{idio})} = \frac{\text{var}(\eta_t^{island})}{\text{var}(\eta_t^{island}) + \text{var}(\eta_t^{idio})} \end{aligned}$$

- **Degree of partial insurance λ_{perm}:**
  fraction of variance accounted for by idiosyncratic component

Model

Measuring the Insurance Value of Taxes and Transfers

- Earnings process is fundamental
- Degree of partial insurance λ exogenous

  (= fraction of shocks accounted for by idio. vs. island shocks)

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- Consider two separate worlds:

1. Households face income process *POST* (post-government)
2. Households face income process *PRE* (pre-government)

Model

Measuring the Insurance Value of Taxes and Transfers

Exercise:

- fix insurance under POST: $\lambda^{post} = 0$
- find λ^{pre} s.t. indifferent (ex ante)

$\rightarrow$ Measure of insurance provided by tax and transfer system

$$(1 - \lambda^{pre}) = (1 - \lambda^{post})(1 - \lambda^{gov})$$

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Notice:

- Focus: direct redistribution/insurance
- Endogeneity of PRE to taxes not captured
- Silent on government expenditures

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  Overall permanent shocks $\sim \mathcal{N}()$ **and homoskedastic**

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- Insurance degree λ gives

$$F_{\eta,t}^{\tau,island} = \mathcal{N}\left(-(1-\lambda)\sigma_\eta^2/2, (1-\lambda)\sigma_\eta^2\right)$$

- Analytical solution for degree of insurance by taxes & transfers:

Derivation

$$\lambda^{gov} = 1 - \frac{\sigma_\eta^{2,post}}{\sigma_\eta^{2,pre}}$$

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$$\lambda^{gov} = 1 - \frac{\sigma^{2,post}_\eta}{\sigma^{2,pre}_\eta}$$

- **Variance ratio as sufficient statistic** for insurance

Outline

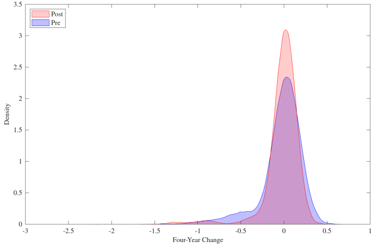
Public Insurance in Sweden

Steps of analysis:

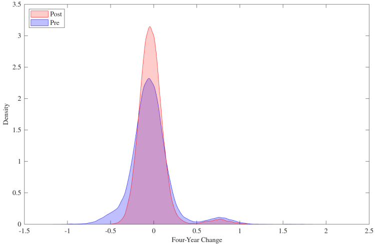
1. Estimate statistical models for y^{pre} and y^{post} ▸ Process
2. Illustrate permanent income trajectory of a Swedish cohort
3. Measure degree of insurance by taxes and transfers
   - Overall insurance value
   - Decomposition of different aspects
   - Role of risk-attitudes

Estimated Permanent Shock Component in Sweden

1989–1993 (GDP growth: −3.68%)

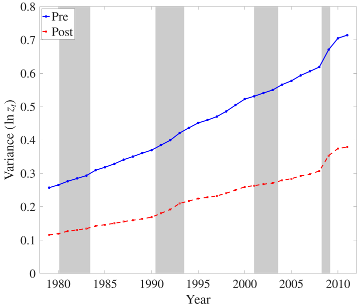


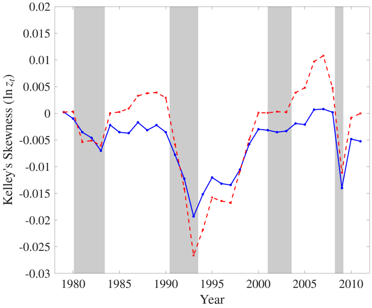
1996–2000 (GDP growth: 17.11%)



Year	Variance		P90-P10		Skewness	
	Pre	Post	Pre	Post	Pre	Post
1989–1993	0.0602	0.0460	0.5206	0.3512	−1.6445	−3.0244
1996–2000	0.0625	0.0311	0.4814	0.3314	1.2223	2.2714
	Kelley		P50-P10		P90-P50	
	Pre	Post	Pre	Post	Pre	Post
1989–1993	−0.2098	−0.0984	0.3149	0.1929	0.2057	0.1583
1996–2000	0.0111	0.0516	0.2380	0.1572	0.2434	0.1743

Permanent Income Distribution For One Cohort





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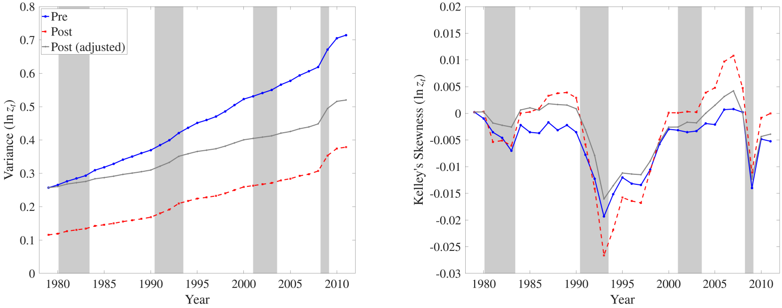

- Decomposition 1: Fix initial distribution to PRE, shocks accumulate as in POS

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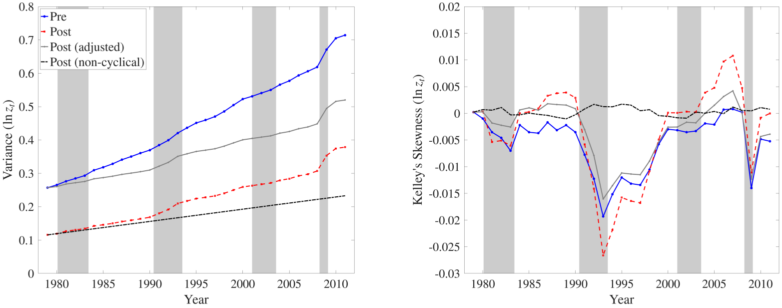

- Decomposition 2: Fix initial distribution to POS, remove cyclicality

Insurance Measures For Sweden

		Higher-Order Risk Present		Gaussian with same Variance	
	Scenario:	$\lambda^{pre} = \lambda^{gov}$	*CEV*	$\lambda^{pre} = \lambda^{gov}$	*CEV*
	From pre-government income to...	*ln* utility			
(I)	...post-government income (post)	**48.56%**	11.73%	**49.74%**	11.40%
(II)	...post adjusted for initial dispersion	17.57%	4.13%	17.27%	3.82%
(III)	...post w/o cyclicality	63.50%	15.53%	62.88%	14.61%
(IV)	...post w/o cyclicality and adjusted	32.24%	7.68%	30.40%	6.80%

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From pre- to post-government income	Higher-Order Risk		Gaussian	
	$\lambda^{pre} = \lambda^{gov}$	*CEV*	$\lambda^{pre} = \lambda^{gov}$	*CEV*
ln utility	**48.56%**	11.73%	**49.74%**	11.40%
Risk Aversion $= 2$	48.46%	24.96%	49.58%	24.86%
Risk Aversion $= 3$	45.44%	40.62%	49.26%	42.10%
Risk Aversion $= 4$	**37.40%**	56.59%	**48.82%**	65.53%

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Taking Consumption on Board

Consider scenario with consumption data (like PSID)

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Two ways to incorporate this

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    - Estimate consumption pass-through to discipline λ^{post}
    - Feed λ^{post} into framework with estimated processes for y^{pre} & y^{post}
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2. Outside our framework
   - Directly estimate pass-through: $y^{pre} \to c$ & $y^{post} \to c$
   - Back out $\lambda^{gov} = 1 - \beta^{pre}_{perm}/\beta^{post}_{perm}$ where β=pass-through

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1. Within our framework
   - Estimate consumption pass-through to discipline λ^{post}
   - Feed λ^{post} into framework with estimated processes for y^{pre} & y^{post}
   - Recover λ^{gov}

2. Outside our framework
   - Directly estimate pass-through: $y^{pre} \to c$ & $y^{post} \to c$
   - Back out $\lambda^{gov} = 1 - \beta^{pre}_{perm}/\beta^{post}_{perm}$ where β=pass-through

Difference: model-based λ^{gov} captures higher-order moments

PSID Results: Model-Based vs. Direct Measure

Consider model with ln utility

	Model-based		Direct estimates
	BPP input	direct estimate	
β^{post}	0.64	0.242	0.242
β^{pre}	–	–	0.183
λ^{gov}	**0.239**	**0.243**	**0.245**

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- Pass-through estimates in 1999–2010 sample differ from BPP
  - Different period (BPP: 1978–92)
  - Sample selection
  - Biennial structure 1999–2010 sample
  - Ghosh & Theloudis ('25) find the same

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- Only interest: partial insurance attributed to taxes and transfers
- Measurement framework robust to λ^{post}
- Direct estimates align
- What about higher-order risk?

PSID Results: Role of Higher-Order Risk

- Consider income process w/o higher-order risk
- For different risk attitudes

PSID Results: Role of Higher-Order Risk

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From pre- to post- government income	Higher-Order Risk λ^{gov}	Gaussian λ^{gov}
ln utility	**24.26%**	**25.30%**
Risk Aversion $= 2$	25.76%	25.50%
Risk Aversion $= 3$	28.04%	25.88%
Risk Aversion $= 4$	**31.17%**	**26.43%**

PSID Results: Role of Higher-Order Risk

- Consider income process w/o higher-order risk
- For different risk attitudes

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- For **symmetric** distribution: no big role for risk attitudes
- For **non-Gaussian** distribution:
  stronger risk attitudes$\rightarrow$larger welfare-equivalent Δvar

Outline

Conclusion

- Taxes & transfers partially insure households against income risk

$\rightarrow$ introduce framework to assess value of insurance

- Builds around welfare-equivalent variance adjustment
- Based on incomplete markets framework
- Works without consumption data
- Gaussian shocks: variance ratio is sufficient statistic

- Application to Sweden
- Application to PSID: aligns with consumption-based measure

Appendix

Special Case: Sufficient Statistic

- Consumption distribution of gen τ in t:

$$\ln c_{i,t}^{\tau} \sim \mathcal{N}\left(-\frac{(t+1-\tau)(1-\lambda)\sigma_\eta^2}{2}, (t+1-\tau)(1-\lambda)\sigma_\eta^2\right)$$

- Degree of insurance solves:

$$\mathbb{E}_{i|\tau}\sum_{i,t=\tau}^{\infty}(\beta\delta)^{t-\tau}\frac{\left((c_{i,t}^{\tau,pre})^{1-\gamma}-1\right)}{1-\gamma} = \mathbb{E}_{i|\tau}\sum_{i,t=\tau}^{\infty}(\beta\delta)^{t-\tau}\frac{\left((c_{i,t}^{\tau,post})^{1-\gamma}-1\right)}{1-\gamma}$$

- simplifies to

$$\sum_{i,t=\tau}^{\infty}(\beta\delta)^{t-\tau}\exp\left(-(t+1-\tau)\frac{1}{2}\gamma(1-\gamma)(1-\lambda^{pre})\sigma_\eta^{2,pre}\right) =$$
$$\sum_{i,t=\tau}^{\infty}(\beta\delta)^{t-\tau}\exp\left(-(t+1-\tau)\frac{1}{2}\gamma(1-\gamma)(1-\lambda^{post})\sigma_\eta^{2,post}\right)$$

- which implies $(1-\lambda^{pre})\sigma_\eta^{2,pre} = (1-\lambda^{post})\sigma_\eta^{2,post}$
  $\rightarrow \lambda^{gov} = 1 - \frac{\sigma_\eta^{2,post}}{\sigma_\eta^{2,pre}}$ Back

Income Process

$$y_t = z_t + \varepsilon_t, \quad z_t = z_{t-1} + \eta_t \tag{3}$$

- η_t follows mixture of three normals

$$\eta_t \sim \begin{cases} \mathcal{N}(\bar{\mu}_{\eta,t} + \mu_{\eta,1} + \phi_1 x_t, \sigma^2_{\eta,1}) & \text{with prob. } p_{\eta,1} \\ \mathcal{N}(\bar{\mu}_{\eta,t} + \mu_{\eta,2} + \phi_2 x_t, \sigma^2_{\eta,2}) & \text{with prob. } p_{\eta,2} \\ \mathcal{N}(\bar{\mu}_{\eta,t} + \mu_{\eta,3} + \phi_3 x_t, \sigma^2_{\eta,3}) & \text{with prob. } p_{\eta,3} \end{cases}$$

- x_t: standardized log GDP growth
- $\bar{\mu}_\varepsilon$ and $\bar{\mu}_{\eta,t}$ such that $\mathbb{E}\left[\exp(\varepsilon)\right] = 1$ and $\mathbb{E}\left[\exp(\eta_t)\right] = 1$
- ε_t follows mixture of two normals:

$$\varepsilon_t \sim \begin{cases} \mathcal{N}(\bar{\mu}_\varepsilon, \sigma^2_{\varepsilon,1}) & \text{with prob. } p_{\varepsilon,1} \\ \mathcal{N}(\bar{\mu}_\varepsilon, \sigma^2_{\varepsilon,2}) & \text{with prob. } 1 - p_{\varepsilon,1} \end{cases}$$

back