Learning (not) to trade

Swissquote, EPFL, SFI, UBC

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Two quick surveys

Survey I

Imagine you are a stock trader. You have performed very well during the last year: 10% of return. Now you wonder whether to keep trading or exit.

Other things equal, you'd be more likely to exit, if you:

- (A) have been trading for 10 years
- (B) have been trading for 2 years

Survey II

Imagine you are a stock trader. You have performed very poorly during the last year: -10% of return. Now you wonder whether to keep trading or exit.

Other things equal, you'd be more likely to exit, if you:

- A have been trading for 10 years
- B have been trading for 2 years

Research motivation and background

Exit procrastination?

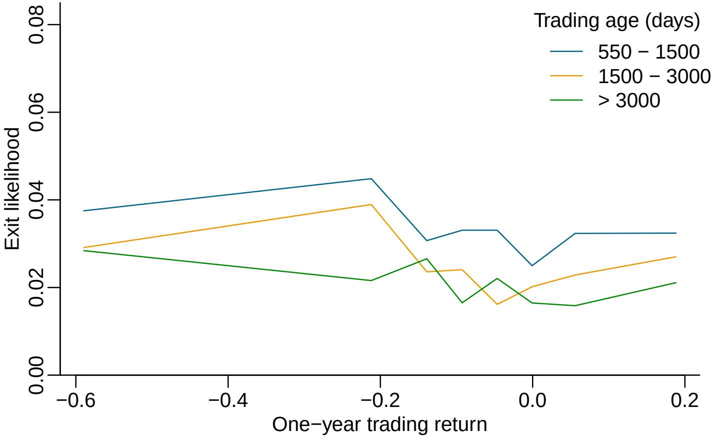


Figure 1: Given calendar time (2014-12-31) and trading performance (return), empirical exit likelihood decreases with age

Why is it relevant?

1. Trading platforms
   - should focus on retaining inexperienced traders
2. Investors
   - should understand their trading inertia might not be economically rational

Literature review

- [Seru et al., 2010]: two learning routes of investors—the first type improves over time by learning from their trading experience, while the second type realizes their ability is insufficient and ceases to trade.
- [Nicolosi et al., 2009]: investors benefit from trading experience and can learn to place more profitable trades.
- [Gervais and Odean, 2001]: traders develop assessments of their own trading ability through experience.
- [Schraeder, 2015]: young investors trade frequently but obtain lower returns.

Methodology

Data

- Source: one of the biggest stock trading platforms for retail traders in Switzerland
- $82,072$ traders' status (exit/remain) from 2001-05-04 to 2019-01-29
- $90,628$ traders' trading activity (buy/sell) from 2001-05-08 to 2018-12-31, with in total $6,766,393$ trader-action observations
- $64,037$ traders' daily account value from 2009-01-01 to 2018-12-28, with in total $107,332,300$ account-day observations

The model I

Assumptions

- Based on their trading skills, each trader falls in either of the two categories: (i) with trading skills, i.e. good type, denoted by G, or (ii) without trading skills, i.e. bad type, denoted by B.
- Traders do not know their types, but have a prior belief about their probability of being Type G equal to π_0.
- Type B traders never place successful trades with profits sufficient to cover the total trading cost.
- For type G traders, successful trades arrive at jump times of a time-inhomogeneous Poisson process, N_t, with an exogenously given intensity $f(t)$, namely, $\mathbb{P}[N_{t+dt} - N_t = 1] = f(t)dt$.
- Type G traders improve their trading skills with experience. Thus, $f(t)$ is a monotone increasing function of the trader's trade age, t.
- Traders learn about their types and continuously update their belief π_t from observing their trading history.

The model II

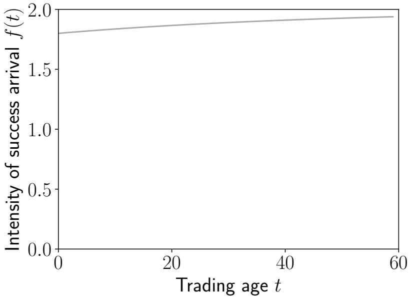
Assumptions

- Entry of new traders happens at a constant rate ρ_{entry}.
- Traders exit from trading for two reasons: (i) an exogenous "exit shock" that occurs at a Poisson intensity ρ_{exit}, or (ii) the trader's posterior probability of being Type G dropping below a threshold value, i.e. when the trader becomes sufficiently confident that he is Type B.
- Each trader has an idiosyncratic running fixed cost of trading φ

Time-inhomogeneous Poisson process I

The arrival of success becomes increasingly frequent for Type G.

$f(t) = -10e^{-0.02t} + 20$

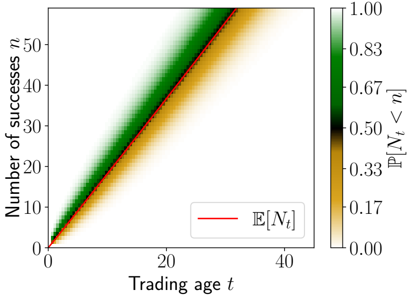


$f(t) = -1.5e^{-0.02t} + 2$

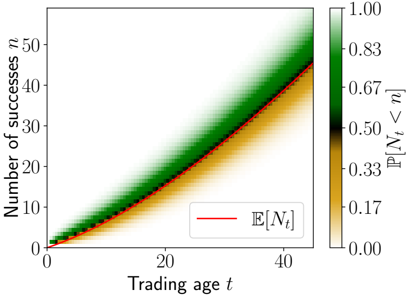
Time-inhomogeneous Poisson process II

Cum. prob. of no. of successes n achieved by age t (green-orange fan):
$\mathbb{P}[N_t < n] = \sum_{k=0}^{n-1} \frac{(F(t))^k}{e^{F(t)} k!}$
Expected no. of successes n by age t for Type G (red line):
$\mathbb{E}[N_t] = F(t) = \int_0^t f(t) dt$

$f(t) = -10e^{-0.02t} + 20$



$f(t) = -1.5e^{-0.02t} + 2$



Time-inhomogeneous Poisson process III

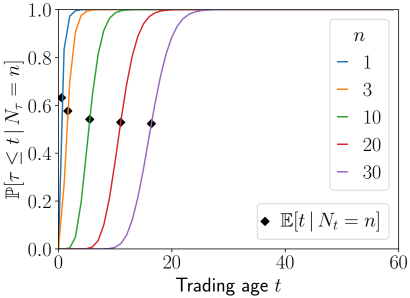
Probability of experiencing n successes by age t for Type G (color lines):

$\mathbb{P}[\tau \leq t \mid N_\tau = n] = 1 - \sum_{k=0}^{n-1} \frac{(F(t))^k}{e^{F(t)} k!}$

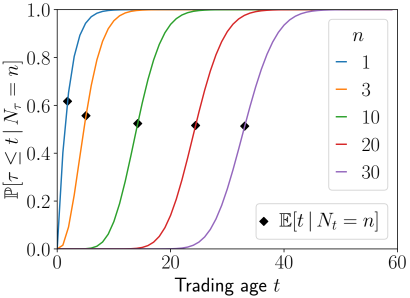
Expected time needed to achieve n successes (black diamonds):

$\mathbb{E}[t \mid N_t = n] = \int_0^\infty \frac{t f(t) (F(t))^{n-1}}{e^{F(t)} (n-1)!} dt$

$f(t) = -10e^{-0.02t} + 20$



$f(t) = -1.5e^{-0.02t} + 2$

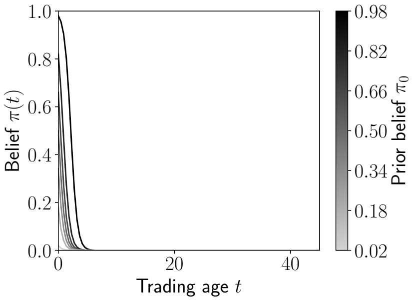


Time-inhomogeneous Poisson process IV

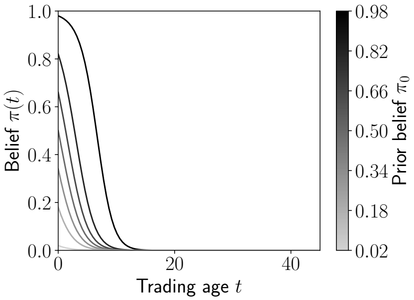
The belief of being Type G decreases before encountering the first success.

$\pi(t) = \frac{1}{(\frac{1}{\pi_0}-1)e^{F(t)}+1}, \;\; t < \tau_N$

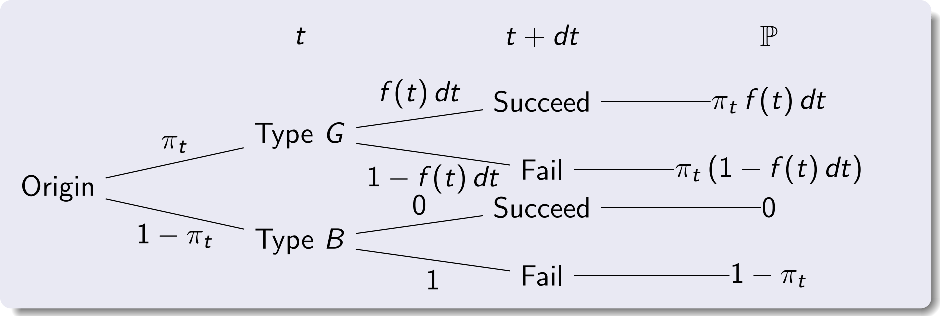
$f(t) = -10e^{-0.02t} + 20$



$f(t) = -1.5e^{-0.02t} + 2$



Evolution of belief I



$$d\pi_t = \pi_{t+dt} - \pi_t = \frac{\pi_t\big(1 - f(t)dt\big)}{\pi\big(1 - f(t)dt\big) + (1 - \pi_t)} - \pi_t = -f(t)\pi_t(1 - \pi_t)dt$$

for $t < \tau_N$, while $\pi_t = 1$ for $t \geq \tau_N$.

Evolution of belief II

Log transformation for mathematical convenience:

$$\ell_t \;=\; \ln \frac{\pi_t}{1-\pi_t}$$

By direct calculation, ℓ_t follows the dynamics:

$$d\ell_t \;=\; -f(t)dt$$

for $t < \tau_N$ and $\ell_t = \infty$ for $t \geq \tau_N$.

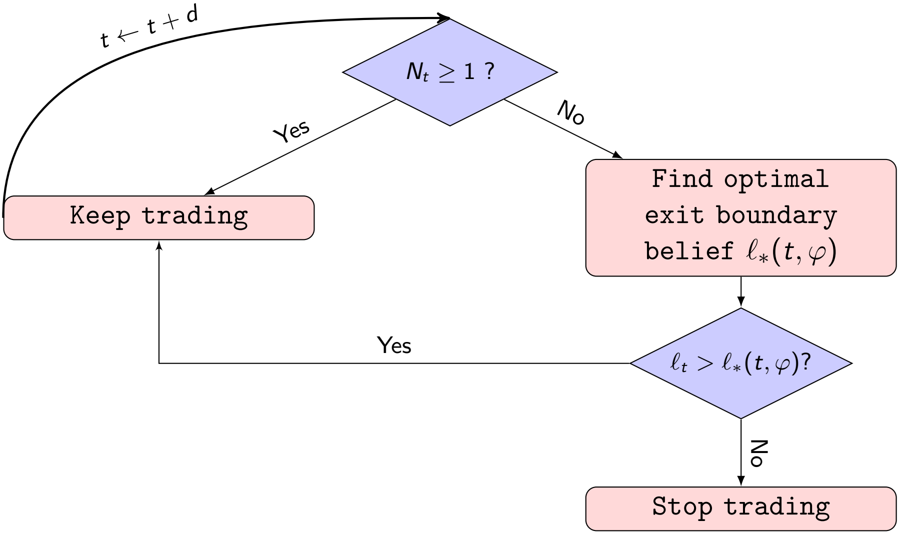


Figure 2: A trader's decision tree (absent exogenous shock)

Value functions

- Type G:
  $V_G(t,\varphi) \;=\; \int_t^\infty e^{-r(s-t)}\big(f(s) - (\varphi + 0.5c^{-1}\eta^2)\big)\,ds$
- Type unknown:
  $V(\ell,t,\varphi) \;=\; \max_{\tau_E} \mathbb{E}\Big[- \int_t^{\min\{\tau_E,\tau_N\}} e^{-rs}(\varphi + 0.5c^{-1}\eta^2)ds \;+$
  $e^{-r\tau_N}\mathbf{1}_{\tau_N<\tau_E}\big(1 \;+\; V_G(\tau_N,\varphi)\big)\Big]$

Theorems

- exit boundary $\ell_*(t,\varphi)$
  $\frac{e^{\ell_*(t,\varphi)}}{e^{\ell_*(t,\varphi)}+1} \;=\; \frac{\varphi}{f(t)(1+V_G(t,\varphi))}$

Variables and parameters I

Observable

- 1_{exit}: account status—closed/open
- R individual trading performance: one-year excess log return
- t trading age: time since account open
- $m(t)$ total trading mass by age: number of open accounts

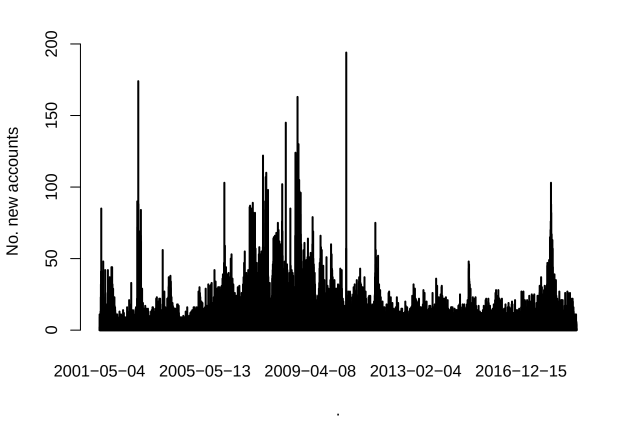
Unobservable

- Success
- Type (G or B) and its distribution
- ℓ belief of being Type G and its (conditional) distribution (given type)
- φ running cost and its distribution
- Conditional distribution (given type and belief) of R
- ρ_{exit} exit rate due to exogenous shock

Variables and parameters II

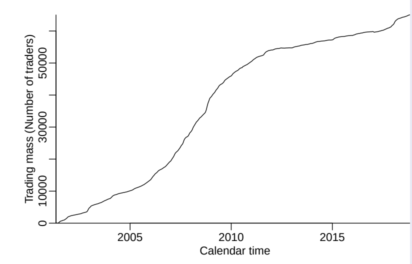
Other

- c cost factor per trading effort: arbitrarily fixed
- ρ_{entry} entry rate: assumed time invariant

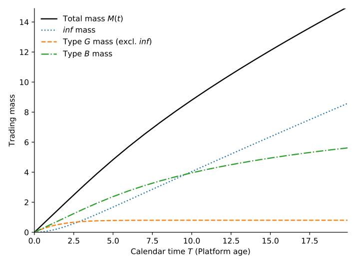


Trading mass I

Empirical, entry rate unnormalized

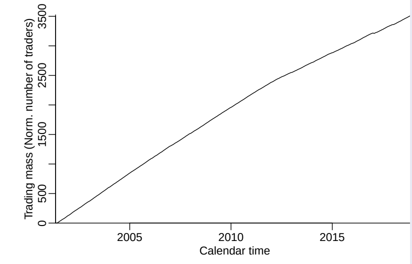


Model

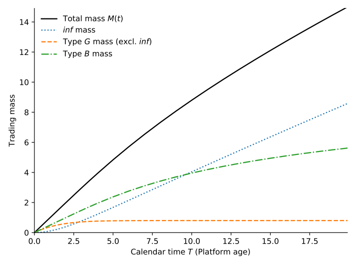


Trading mass II

Empirical, entry rate normalized

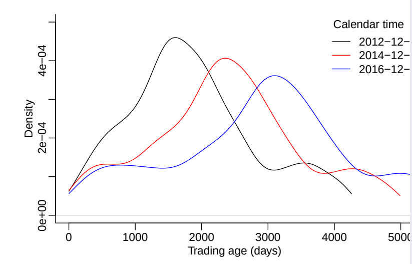


Model

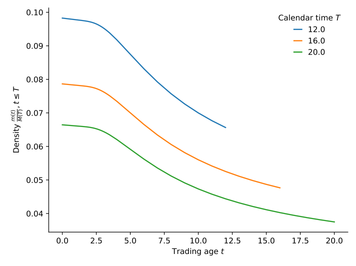


Trading mass III

Empirical, entry rate unnormalized

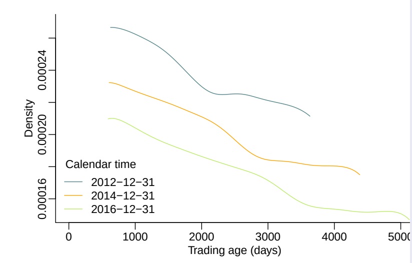


Model

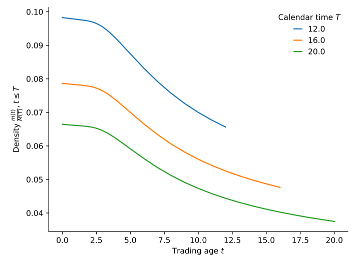


Trading mass IV

Empirical, entry rate normalized



Model



Further assumptions I

- Success arrival intensity: $f(t) = \alpha\, e^{\beta} + \gamma$, where $\alpha = -10, \beta = -0.02, \gamma = 20$
- Discount rate: $r = 0.1$
- Constant entry rate: $\rho_{entry} = 1$
- Exit rate due to exogenous shock: $\rho_{exit} = 0.4$
- c cost factor: 0.05

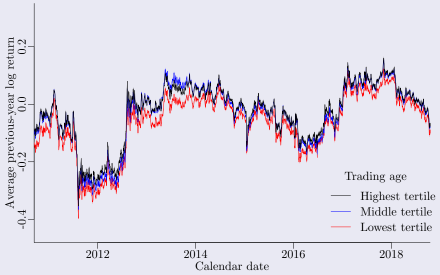
Further assumptions II

- Distribution of types at entry: Type G 10%, Type B 90%
- Distribution of φ at entry: uniform distribution on $[0, \varphi^*]$, where $\varphi^* = \alpha + \gamma - 0.5\,(r + \frac{\alpha\,\beta}{\alpha+\gamma})$
- Distribution of belief ℓ_0 at entry: inverse exponential distribution with $\lambda = 60$ for Type G and $\lambda = 50$ for Type B, on $[\ell(0, \varphi), +\infty)$
- Distribution of return based on true type and belief:
    - Being G believing G: $\mathbb{N}(2, 0.8^2)$
    - Being G believing B: $\mathbb{N}(1, 1^2) \leftarrow$ *underconfidence*
    - Being B believing G: $\mathbb{N}(-2, 1^2) \leftarrow$ *overconfidence*
    - Being B believing B: $\mathbb{N}(-1, 1.2^2)$

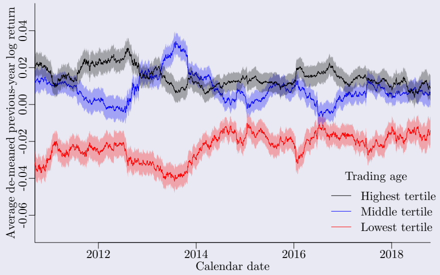
Empirical results

Belief lower boundary $\ell_*(t, \varphi)$

$\varphi = 0.01$



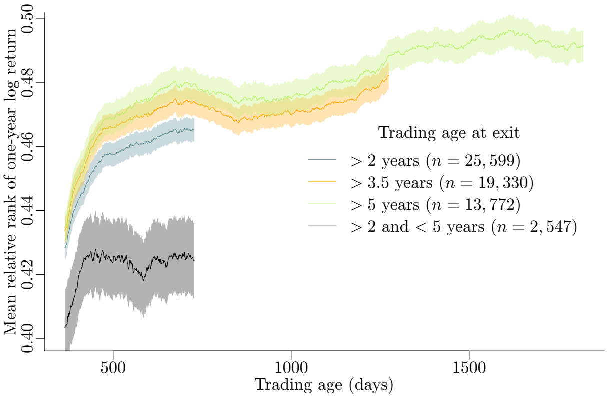
$\varphi = 9$



$$R_{i,t} = \alpha_T + \beta^t\, t + \boldsymbol{X}_i \beta^{\boldsymbol{X}} + \epsilon_{i,t}, \tag{1}$$

Table 1: xx.

Regressand: return $R_{i,t}$	(1)	(2)	(3)	(4)	(5)
Trading age t (days)	$1.0 \times 10^{-5***}$	$1.1 \times 10^{-5***}$	$1.1 \times 10^{-5***}$	$1.0 \times 10^{-5***}$	$1.0 \times 10^{-5***}$
	(0.000)	(0.000)	(0.000)		(0.000)
Gender (Female = 1)		0.0325^{***}			0.0293^{***}
		(0.000)			(0.000)
Biological age at entry (years)			0.0008^{***}		0.0007^{***}
			(0.000)		(0.000)
Trades options (Yes = 1)				-0.0667^{***}	-0.0658^{***}
				(0.000)	(0.000)
Time effect (dates)	Yes	Yes	Yes	Yes	Yes
No. obs.	106,564,611	106,564,611	106,398,965	106,564,611	106,564,611
R^2	0.001	0.001	0.002	0.003	0.003


Mean relative rank of one-year log return
0.40
0.42
0.44
0.46
0.48
0.50
500
1000
1500
Trading age (days)
Trading age at exit
> 2 years ($n = 25,599$)
> 3.5 years ($n = 19,330$)
> 5 years ($n = 13,772$)
> 2 and < 5 years ($n = 2,547$)

xx

$$R_{i,t} = \alpha_T + \beta^t\, t + \boldsymbol{X}_i \beta^{\boldsymbol{X}} + \epsilon_{i,t}, \tag{2}$$

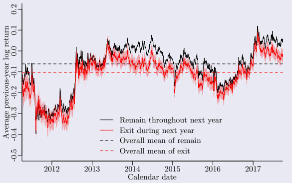
Table 2: xx.

Age range Cohort	1–1.5 years $\overline{\alpha}$	 β	1.5–2 years $\overline{\alpha}$	 β	2–3.5 years $\overline{\alpha}$	 β	3.5–5 years $\overline{\alpha}$	 β	 n
2-year	39.8***	0.0129***	45.0***	0.0025***					25,599
	(0.000)	(0.000)	(0.000)	(0.000)					
3.5-year	40.4***	0.0138***	46.1***	0.0024***	46.6***	0.0009***			19,330
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
5-year	40.1***	0.0152***	46.1***	0.0035***	47.4***	0.0007***	49.0***	0.0001**	13,772
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.013)	
2to5	39.6***	0.0060***	41.1***	0.0020***					2,547
	(0.000)	(0.000)	(0.000)	(0.000)					

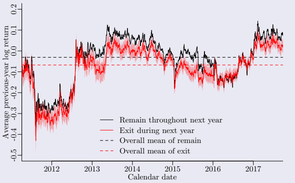
Belief lower boundary $\ell_*(t, \varphi)$

Original

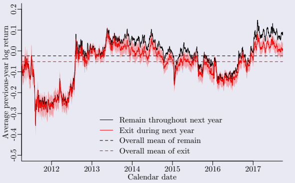
Lowest trading age tertile



Middle trading age tertile

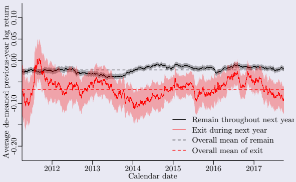


Highest trading age tertile

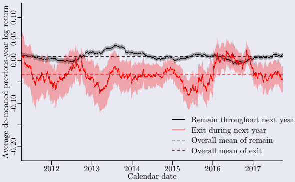


Demeaned

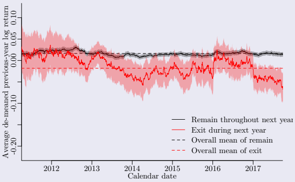
Lowest trading age tertile



Middle trading age tertile



Highest trading age tertile



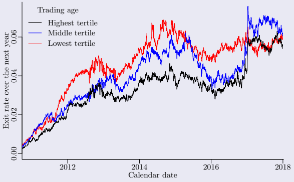
$$R_{i,t} = \alpha_T + \beta^t\, t + \boldsymbol{X}_i \beta^{\boldsymbol{X}} + \epsilon_{i,t}, \tag{3}$$

Table 3: Cox proportional hazard regressions with respect to trading performance and other control variables

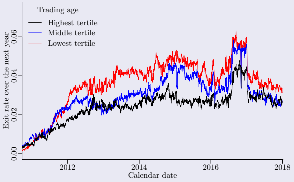
Regressand: log hazard $\ln h_i(t)$	(1)	(2)
One-year log return $R_{i,t}$	-0.7696^{***}	-0.7833^{***}
	(0.000)	(0.000)
Gender (Female $=$ 1)		0.2563^{***}
		(0.000)
Biological age at entry (years)		0.0019^{**}
		(0.022)
Trades Options (Yes $=$ 1)		-0.0133
		(0.746)
Individual effect	Yes	Yes
Concordance	0.563	0.567
No. obs.	106,564,611	106,398,965

Belief lower boundary $\ell_*(t, \varphi)$

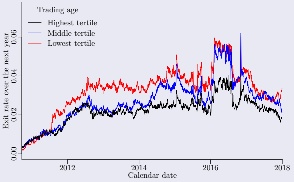
Lowest return tertile



Middle return tertile



Highest return tertile

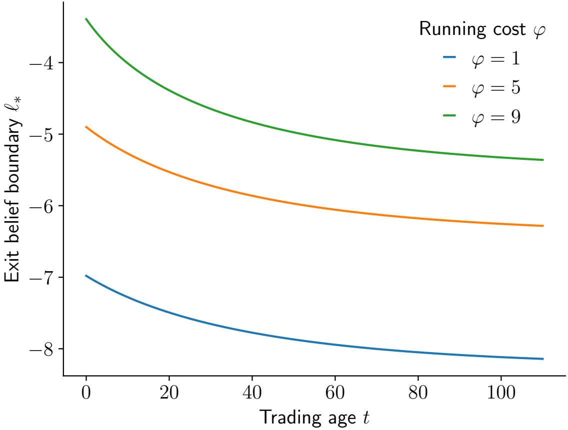


$$R_{i,t} = \alpha_T + \beta^t\, t + \boldsymbol{X}_i \beta^{\boldsymbol{X}} + \epsilon_{i,t}, \tag{4}$$

Table 4: Cox proportional hazard regressions with respect to trading performance and other control variables

	Full sample		Subsample: age $<$ 3 yr		Subsample: age $\geq$ 3	
	(1)	(2)	(3)	(4)	(5)	
Trading age (days) t	$-10.6 \times 10^{-5***}$	$-10.6 \times 10^{-5***}$	$1.0 \times 10^{-5***}$	$1.0 \times 10^{-5***}$	$-14.9 \times 10^{-5***}$	-14.9
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0
One-year log return $R_{i,t}$	-0.2747^{***}	-0.2877^{***}	-0.2971^{***}	-0.3020^{***}	-0.2709^{***}	$-$
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0
Gender (Female $=$ 1)		0.1921^{***}		0.1358^{***}		
		(0.000)		(0.000)		(0
Biological age at entry (years)		0.0030^{***}		-0.0035^{***}		
		(0.000)		(0.000)		(0
Trades options (Yes $=$ 1)		-0.0515^{***}		-0.1382^{***}		$-$
		(0.000)		(0.000)		(0
Time effect (dates)	Yes	Yes	Yes	Yes	Yes	
No. obs.	98,533,540	98,372,371	22,914,154	22,893,456	75,619,386	75,4

Belief lower boundary $\ell_*(t, \varphi)$

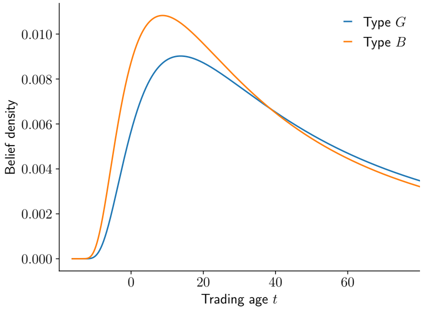


$\ell_*(t, \varphi)$ decreases with t—but does that translate into exit procrastination?

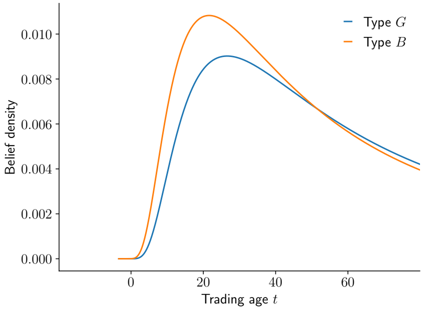
Initial belief distribution

Inverse exponential distribution on $[\ell - \ell_*(0, \varphi), +\infty)$

$\varphi = 0.01$



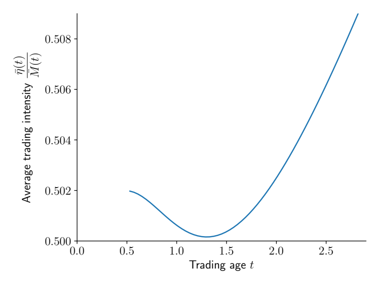
$\varphi = 9$



Average trading intensity

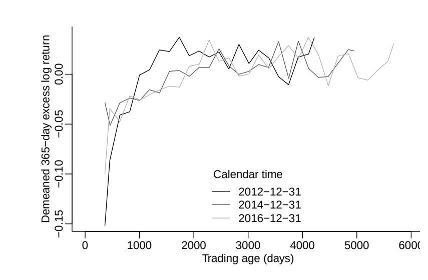
Empirical

Model

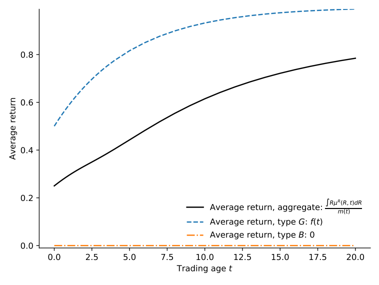


Average return I

Empirical

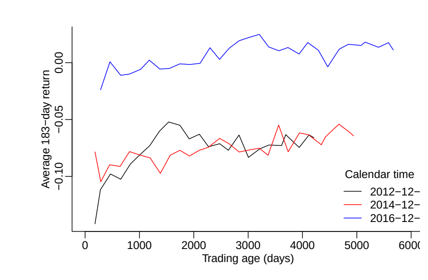


Model

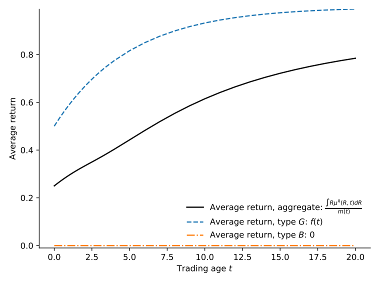


Average return II

Empirical



Model

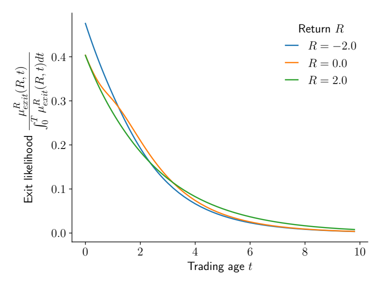


Exit I

At a given calendar time and return level, exit likelihood decreases with trading age.

Empirical

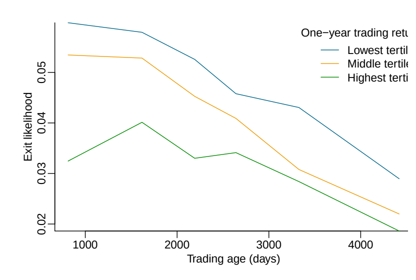
Model



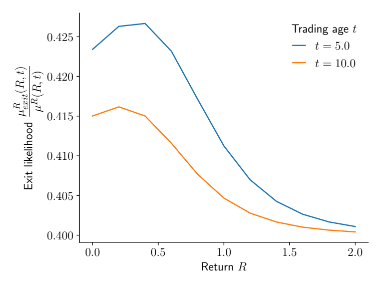
Exit II

At a given calendar time and return level, exit likelihood decreases with trading age.

Empirical: 2014-12-31



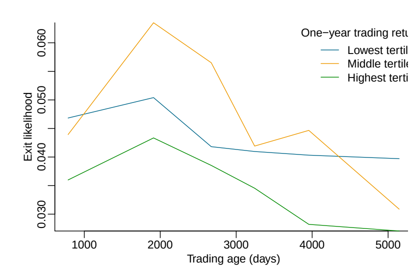
Model



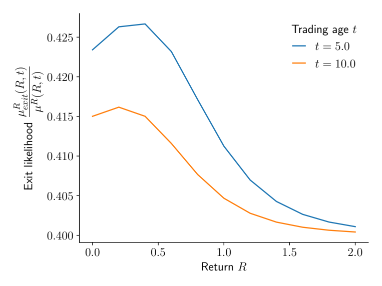
Exit III

At a given calendar time and return level, exit likelihood decreases with trading age.

Empirical: 2016-12-31



Model



Summary

We build a model which demonstrates, in accordance with empirical findings, that:

- Experienced traders perform on average better than inexperienced traders.
- Nevertheless, survivorship bias does not explain everything: at a given performance level, experienced traders are less likely to exit than inexperienced traders.
  - There exists a downward moving exit boundary.
- Inexperienced traders trade more intensively, possibly in order to discover their trading skill level.

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The End