Risk Free Interest Rates

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Discussion:

EBEN LAZARUS
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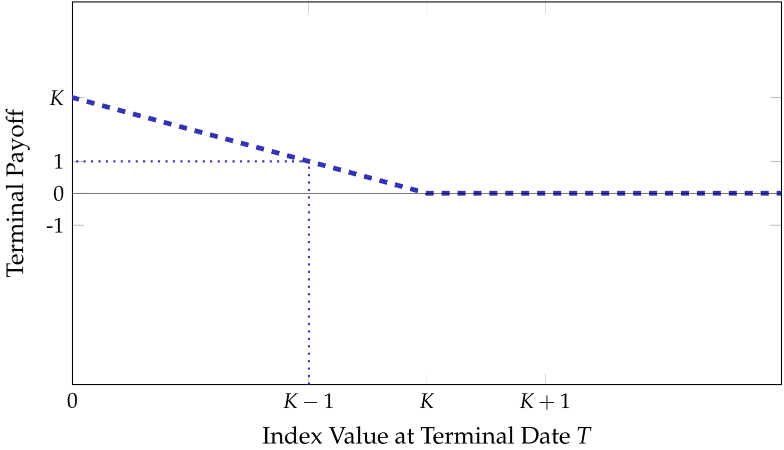
Outline

1. What the paper does
2. How to interpret it

This Paper's Framework

Simple no-arbitrage relationship:

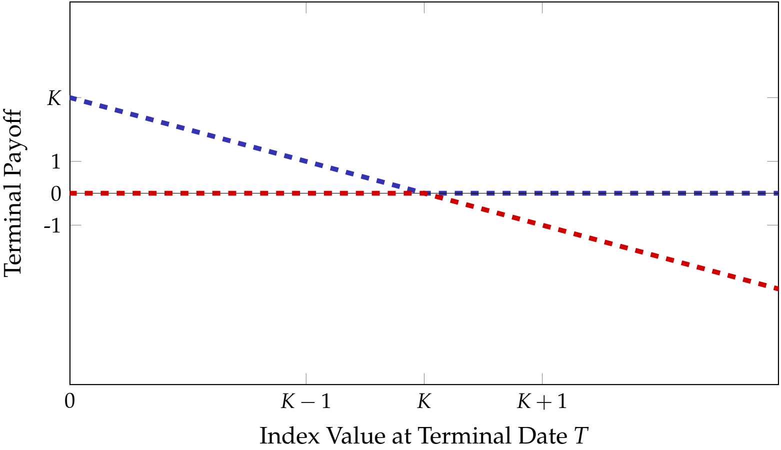
- On date 0, buy European put option expiring at T with strike K. Payoff:



This Paper's Framework

Simple no-arbitrage relationship:

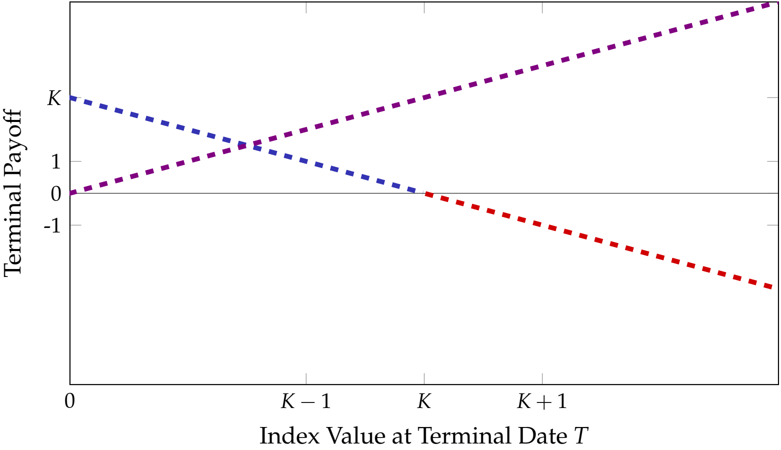
- On date 0, buy European put option expiring at T with strike K
- Sell call option with same strike



This Paper's Framework

Simple no-arbitrage relationship:

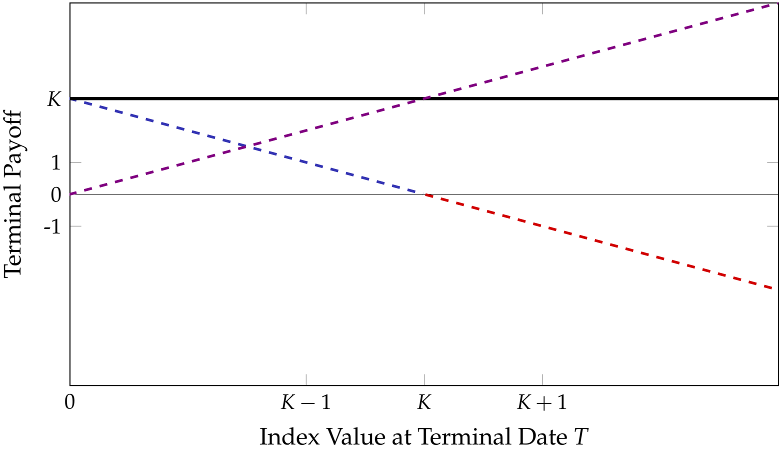
- On date 0, buy European put option expiring at T with strike K
- Sell call option with same strike... and buy underlying index



This Paper's Framework

Simple no-arbitrage relationship:

- On date 0, buy European put option expiring at T with strike K
- Sell call option with same strike... and buy underlying index. **All together:**



This Paper's Framework

Simple no-arbitrage relationship:

- On date 0, buy European put option expiring at T with strike K
- Sell call option with same strike... and buy underlying index
- Risk-free payoff of $K \Longrightarrow$ upfront price is $\exp(-r^f_{0,T}T)K \Longrightarrow$ back out $r^f_{0,T}$ using prices of *just* risky assets
- This is a rearrangement of put-call parity, but *don't actually trade risk-free bond*
- Can be done across multiple K; for each one,

$$p_{0,T,K} - c_{0,T,K} + S_0 = \exp(-r^f_{0,T}T)K$$

- So to use the whole cross-section of options, estimate regression of LHS on constant and K, and then $r^f_{0,T} = -\frac{1}{T}\log(\beta)$
  - Estimator actually used in the paper is (trivially) different, and they also consider a separate estimator for robustness

Should We Trust Output?

People do seem to use this to borrow/lend synthetically!

CME Group

STOCK INDEXES

Option Box Spreads as a Financing Tool

Should We Trust Output?

People do seem to use this to borrow/lend synthetically!

. . .but proceed with caution before doing so yourself: need European rather than American options to avoid risk of early exercise!

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Trader says he has 'no money at risk,' then promptly loses almost 2,000%

Published: Jan 22, 2019 2:43 p.m. ET

Reddit:

*"The way he bought it was set up like a hedge, so it didn't matter if the stock went up or down because he had options that covered him no matter what. But then 283 of those options were exercised by the guy on the other end of his trade meaning he had to come up with 28,300 shares of that stock which he didn't have. I guess then Robinhood took the liberty of exercising his call options to pay for the options that got exercised from him and then it was just a whole ****show after that."*

Should We Trust Output?

People do seem to use this to borrow/lend synthetically!

- Index options (SPX, DJX) considered here are European options
- "Loans" are exchange-traded and thus carry no counterparty risk
- So get risk-free rate without any convenience yield
- Can then compare to Treasury yields and interpret difference as convenience yield on Treasuries
- And can then do whatever you want with these convenience yields: event studies (QE, fed funds changes), bond-return predictability, . . .
  - Really just scratching the surface here

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Convenience Yields

Question 1: What's being measured?

- Interpretation of $r_{0,T}^{f,\text{options}} - r_{0,T}^{f,\text{Tsy}}$ is as convenience yield to holding Treasuries
- How to disentangle this from time-varying limits to arbitrage? (Same thing?)
  - Options require margin ("cost" of which varies over time), a bit of settlement risk, . . .
  - In fact $r_{0,T}^{f,\text{options}} - r_{0,T}^{f,\text{Tsy}}$ was virtually nonexistent pre-1987 crash:

JOURNAL OF FINANCIAL AND QUANTITATIVE ANALYSIS VOL. 32, NO. 1, MARCH 1997

Box Spread Arbitrage Profits following the 1987 Market Crash: Real or Illusory?

Michael L. Hemler and Thomas W. Miller, Jr.*

Abstract

We examine market efficiency before and after the 1987 Market Crash using the box spread strategy implemented with European-style S&P 500 Index (SPX) options. Before the Crash, apparent arbitrage opportunities were rare and simulated trades were unprofitable assuming a one-minute execution delay. After the Crash, apparent arbitrage opportunities were frequent and simulated trades were profitable even assuming a five-minute execution delay. Our analysis makes the routine assumption that quotes are good until updated to construct a time series of prevailing quotes sampled at 30-second intervals. If this assumption is valid, then arbitrage profits were actually available. If this assumption is invalid, then such profits could have been illusory. Either scenario, however, implies that SPX market efficiency decreased following the Crash—prevailing price quotes repeatedly failed to satisfy the fundamental parity relation underlying the box spread.

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- Interpretation of $r_{0,T}^{f,\text{options}} - r_{0,T}^{f,\text{Tsy}}$ is as convenience yield to holding Treasuries
- How to disentangle this from time-varying limits to arbitrage? (Same thing?)
- Last few sections of the paper do a very nice job trying to address this
  - Construct multiple other arbitrage spreads: T-bills vs. notes/bonds maturing on same date (with no coupon payments left), on-the-run vs. off-the-run, CIP deviations, spot-futures parity for commodities, . . .
  - True that all these spreads (and $r_{0,T}^{f,\text{options}} - r_{0,T}^{f,\text{Tsy}}$) share a common component: first principal component explains 34% of variation. . .
  - . . .but $r_{0,T}^{f,\text{options}} - r_{0,T}^{f,\text{Tsy}}$ have considerably less unexplained variation, and are predicted mostly by their own past values

Convenience Yields

Question 1: What's being measured?

Table 7
VAR(1) Analysis of Arbitrage Spreads

	djx	spx	lessthan6	metal	notesbonds	ontherun
djx	0.6798	0.0634	0.0032	-0.0585	0.0001	-0.0002
spx	0.2662	0.9103	-0.0400	0.4142	-0.0002	0.0001
lessthan6	-0.0066	-0.0323	0.5319	1.4711	-0.0018	-0.0015
metal	0.0005	-0.0002	0.0031	0.0223	0.0000	0.0000
notesbonds	1.6658	0.4304	0.2773	4.7072	0.7044	-0.0094
ontherun	0.0671	0.1230	-0.4992	-8.0279	-0.0037	0.4580
constant	2.7326	0.6319	-1.8320	41.4707	0.0078	-0.0281
$R\hat{2}$	0.8332	0.9403	0.3494	0.0126	0.5004	0.2147

(But where are CIP deviations in this table?)

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  - True that all these spreads (and $r_{0,T}^{f,\text{options}} - r_{0,T}^{f,\text{Tsy}}$) share a common component: first principal component explains 34% of variation. . .
  - . . .but $r_{0,T}^{f,\text{options}} - r_{0,T}^{f,\text{Tsy}}$ have considerably less unexplained variation, and are predicted mostly by their own past values
  - So some of each, but "convenience yield" does seem like a coherent, separate concept

Treasury Yields

Question 2: What's the right Treasury yield comparison?

- Authors calculate $r_{0,T}^{f,\text{Tsy}}$ using Gurkaynak, Sack, Wright (2007) zero-coupon yield estimates from parametric (Nelson-Siegel-Svensson) yield curve model
  - Estimation excludes front end, bills, on-the-run bonds
  - But these are the most "convenient" bonds to hold — more liquid, and trade at a big premium to rest of yield curve!
  - Should "convenience yield" be measured relative to bills rather than NSS curve? Note NSS curve's poor fit to front end (from GSW, 2007):

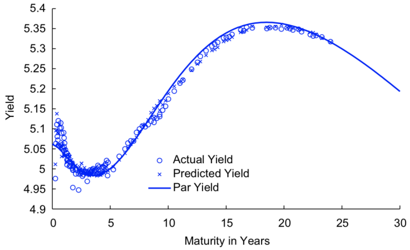

Fig. 1. Par-yield curve on May 9, 2006.

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  - Estimation excludes front end, bills, on-the-run bonds
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  - Should "convenience yield" be measured relative to bills rather than NSS curve?
- Seem to be underestimating convenience yields. . .snapshot shown in Figures IV–V, but would be interested in time variation as well

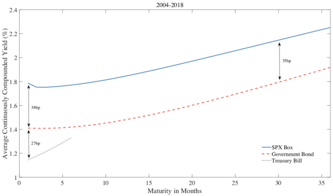

FIGURE IV

Average NSS yields curves fit to SPX box rates and treasury bond rates together with treasury bill rates, 2004-2018. All rates are continuously compounded

Extensions

Question 3: What else can be done?

- Lots of possible extensions — will just cover one
- Put-call parity:

$$p_{0,T,K} - c_{0,T,K} = \mathcal{P}_{0,T} - S_0 + \exp(-r^f_{0,T}T)K,$$

  where $\mathcal{P}_{0,T}$ is "convenience" of holding underlying
  [e.g., dividends: van Binsbergen, Brandt, Koijen (2012)]

- Authors run regression (using cross-section of strikes K):

$$p_{0,T,K} - c_{0,T,K} = \alpha_0 + \beta_0 K$$

  - They focus on β_0, but for any non-dividend-paying underlying, should also have $\alpha_0 = -S_0$, or else $\mathcal{P}_{0,T} \neq 0$
  - Is this the case? If not, how to interpret?
  - Can also re-run for, e.g., commodities, to back out risk-neutral cost of carry estimates — seems useful more generally [Koijen, Moskowitz, Pedersen, Vrugt (2018)]

Final Notes

- Very clever and well-done paper
- Provides forward-looking, model-free estimates of convenience yields at different horizons
- These seem to be important! Confirms intuition and mechanism underlying big post-crisis literature on safe assets
- Estimated series should be very useful for other researchers in lots of contexts