The Price Effects of Innovative Security Design*

Claire Célérier†
University of Toronto

Gordon Liao‡
Federal Reserve Board

Boris Vallée§
Harvard Business School

April 5, 2021

*We are grateful to Dolly Yu for outstanding research assistance.

†Rotman School of Management, University of Toronto. E-mail: claire.celerier@rotman.utoronto.ca.

‡Federal Reserve Board. E-mail: gordon.y.liao@frb.gov.

§Finance Unit, Harvard Business School. E-mail: bvallee@hbs.edu.

Abstract

This paper investigates the effects of the issuance of retail structured products on option prices. For a given underlying asset, when the outstanding volume of products embedding a short-put position increases, implied volatility at the corresponding strike decreases. A similar pattern exists for the dividend term structure: larger outstanding volumes of retail structured products are associated with a flattened dividend term structured. A simple trading strategy exploiting this pattern leads to a Sharpe ratio above 2. These results are consistent with the existence of segmented markets and speak to the equilibrium effects of the demand for innovative securities with non-linear payoffs.

JEL Classification Codes: G12, G14, G15, G23

Keywords: Security Design, Volatility, Dividend, Options, Structured Products, Market Segmentation

1 Introduction

The outstanding volumes of securities with innovative payoff designs, from structured products to ETFs, have significantly increased in recent decades. Hundreds of billions of dollars of products targeting both retail and institutional investors are issued each year. A recent literature shows that such securities affect investment decisions by catering to the yield appetite of retail investors (Celerier and Vallee, 2017), to their demand for safe assets (Coval et al., 2009), or to their loss aversion or pessimistic beliefs (Calvet et al., 2020). While the rationale(s) for developing innovative security is actively studied, their effects on asset prices, as well as the implications on market efficiency are not well understood.

Under perfect markets, the introduction of a new security should *not* affect the price of other outstanding securities. Investors should be indifferent between holding this security or its replicating portfolio, which is already investable in the markets. This paper uses the development of retail structured products to study whether this principle holds empirically in a large and mature market. To do so, it investigates whether the issuance of structured products affect prices on related option and dividend swap markets, which play important informational roles for the broader equity markets (see for instance Pan and Poteshman (2006)). The paper explores what can be learnt from potential deviations from the perfect markets predictions in terms of the role innovative security design plays in moving prices towards or away from the efficient level, and whether it reveals important frictions at play even in mature capital markets. The effects of the development of structured products on asset prices also has implications for the cost of insurance against tail risk, and in turn might affect market participants risk-taking.

A large and growing fraction of structured retail products (thereafter SRP) take the form of a short-put position that mimics risky bond payoffs. Retail purchaser of SRP collect a fixed coupon over the duration of the SRP as long as the equity price of the underlying stock or index is between a pre-set range, most often included within 50% and 110% of the original underlying price at the time of issuance. When the equity price drops below the lower barrier, the SRP becomes equity-like, with the buyers exposed to the downside as if the "bond" is in default. When equity prices rise above the upper barrier, the SRP often knocks out with full return of principal. This design mimics the callable feature that often exists in corporate bonds.[1] Such market represents sizable volumes, with a particularly high penetration in Europe and Asia. Global outstanding volumes or retail structured products represents \$713 Billion in 2015. \$208 Billion of these products have embedded sales of put options, typically with deeply out of the money strikes.

When structuring SRPs, intermediaries hedge the underlying risks, most notably the exposure to the options embedded in these products. The typical hedge requires the intermediaries to short a portfolio of puts on the underlying asset and short the dividend exposure through dividend swaps.

This paper documents three main empirical facts that illustrate how the hedging activities associated with SRPs have a sizable and persistent price impact in the option and dividend markets. First, for a given underlying asset, when the outstanding volume of products embedding a short position in puts increases, implied volatility at the corresponding strike decreases relative to implied volatility at other moneyness. Second, a similar pattern exists for dividends: when the outstanding volume of structured product goes up, the term structure of dividends flattens. These patterns exist at a relatively long horizon, and therefore do not correspond to the microstructure concept of price impact. Third, a long-short trading strategy that using SRP issuance volumes on volatility markets yields attractive Sharpe ratios.

Our results suggest that the development of markets for innovative securities can generate supply and demand imbalances that affect asset prices through hedging strategies. This effect is consistent with a segmentation of option markets with downward slopping demand curve for any specific point of the volatility surface. Prices do not necessarily reflect fundamental value, but the (in-) balance between demand and supply for an option of a given moneyness and maturity. When effects on price are large, SRP issuances might result in moving option prices away from their efficient levels. On the other hand, by issuing securities that sell "expensive" points of the volatility surface, the retail market for structured products might bring prices closer to their efficient levels under certain contexts.

[1] The industry refers to such products as autocallable with reverse convertible or express certificates.

In terms of methodology, we leverage data offering a comprehensive coverage of retail structured products issued around the world, as well as detailed information on their payoff designs. Our empirical setting relies on regressing asset prices on the issuance volumes of structured products with a short-put exposure to these assets, while saturating with fixed effects to absorb fundamental price changes. In our preferred specification, we include option underlying asset - maturity - time fixed effects, therefore identifying price effects within individual volatility smiles at a given time.

This paper contributes to several streams of literature. First, our findings are consistent with models that emphasize funding constraints of financial intermediaries and limits to arbitrage as potential drivers of asset prices. Grleanu et al. (2009) develop a demand-based option pricing model and show that demand pressures from the put-call imbalance explain cross-sectional variations in volatility skewness across U.S. equity options. Vayanos and Vila (2009), Greenwood and Vayanos (2014) and Greenwood and Vissing-Jrgensen (2018) explain the term structure of riskless returns in a segmented supply and demand framework. Risk-averse intermediaries trade with end clients with strong preferences for specific-maturity bonds, hence driving price and return variations across different maturities.

This paper complements the literature on financial innovation and market efficiency (Allen and Gale, 1994, Duffie and Rahi, 1995). While financial innovation might reduce limits to arbitrage by completing markets, our study speaks to how by tapping specific demand it can generate supply-demand imbalances in segmented capital markets.

The paper also adds to the literature on the volatility risk premium (Bakshi et al., 2008, Bollerslev et al., 2009, Todorov, 2010, Han and Zhou, 2012, Cao and Han, 2013) and on spillovers between distinct but related capital markets, such as derivative markets and their underlying asset markets (Henderson et al., 2015).

Finally, this study speaks to the general equilibrium effects of the class of financial products studied in Celerier and Vallee (2017), Vokata (2020), Calvet et al. (2020), retail structured products, which have been shown to be effective at catering to, or mitigating, household behavioral biases.

2 Background

2.1 The Development of Retail Structured Products

Retail structured products include any investment products marketed to retail investors and possessing a payoff function that varies automatically and non-linearly with the performance of an underlying financial asset.[2] Typically designed with embedded options, these products leave no room for discretionary investment decisions during the life of the investment. These products are based mainly on equity indices and individual stocks but may also offer exposure to commodities, fixed income, or alternative indices.

The retail market for structured products emerged in Europe at the beginning of the 2000s and has subsequently experienced steady growth. In 2015, with several billion dollars of assets under management, the retail market for structured products represented 3 times the hedge fund industry. The European market is the largest market in the world, with more than half of the global volumes. The US and Asian markets, however, have been growing fast: retail structured product assets under management exceeded 400 billion US dollars in 2015 in the US.

2.2 Short-Put Payoff Design

Among retail structured products, products embedding a short sale of put options – "reverse convertible" – have been particularly popular. These products offer a payoff that somewhat imitates the one of a callable bond by presenting the following characteristics. The capital is protected on the downside as long as the underlying asset stays beyond a barrier. As soon as the underlying goes below the barrier, the investor participates in the performance of the underlying. The product pays a fixed coupon every period until maturity. These products also often offer an early redemption if the underlying asset price stays above a knock-out level, making them auto-callable.

[2] Exchange traded funds, which have payoffs that are a linear function of a given underlying financial index, are not retail structured products.

Figure 1 represents the pay-off diagram of a typical short-put product: an autocallable with reverse convertible, often labelled as “express certificate”.

INSERT FIG 1

The market for reverse convertible has been increasing over the years, from \$0.92 billion outstanding volumes in 2002 up to \$48 billion outstanding volumes in 2015. Europe, Asian and the US stand for respectively 50, 30 and 20% of the market share in 2015.

2.3 Associated Hedging Activity

2.3.1 Hedging Volatility

The issuing bank reduces the risk of paying large payoffs to the investors by buying and selling options that offset the payoffs of the structured product. For short-put products, the bank sells put options that mirror the exposure of the end user, or roll similar positions with a shorter maturity. Banks often rely on dynamic hedging as opposed to a static hedge at inception because the maturity of these products is often longer than the maturity of the options that can be traded efficiently to build the hedge. In addition, the hedging strategy could change over time, depending on the underlying asset price evolution, or changes in market conditions. The dynamic nature of the hedging activity suggests that while issuance volumes of retail structured products might have a price impact on option trading, outstanding volumes better capture the aggregate hedging needs from the banks. Eventually, banks are aiming to hedge the vega profile along moneyness and maturity of the outstanding products they have issued.

2.3.2 Hedging Dividends

End users of retail structured products typically enter in a short-put positions when buying reverse convertible products.[3] The performance of these instruments is given on a price return basis, which does not take into account dividends. Therefore, as banks usually hedge in a way

[3] The situation is similar with capital guarantee products.

that accounts for dividends – either through options or stocks–, they are long in dividend. Banks can offset this long exposure by entering into a short position in dividend futures.

3 Data

3.1 Retail Structured Products

The study exploits a dataset from a specialized private data provider that collects all information on retailed structured products issued globally since market inception. For each structured product, we observe the underlying asset, the maturity, the exact payoff design, the volumes and issuance date. While other papers have focused on specific geographic areas, this study is the first one to leverage the global coverage of the dataset, exploiting data from products issued in North America, Europe and Asia. This comprehensive coverage is key for our study as it offers a large cross-section to explore, but also because a large share of products are structured on foreign underlying assets. Therefore, the hedging needs associated with retail structured products result from global issuances, and not only from the domestic issuances.

3.2 Option and Dividend Prices

We obtain from a major investment bank a panel dataset of implied volatility surfaces for the stocks and indices most frequently used as underlying asset, and complement it with Bloomberg data when necessary. The volatility data represents a monthly panel from 2002 to 2019 at the underlying asset, moneyness, and maturity level. For any given stock at a time t, we observe 9 levels of implied volatility: at 80, 100, and 120 % moneyness, over 3, 12 and 24 months maturity. For any given index at a time t, the granularity is higher, with 33 levels of implied volatility: 50 to 150 % by 10% increments for moneyness, over 3, 12 and 24 months maturity as well.

3.3 Dividend term structure

We obtain a panel data of dividend term structures for the stocks used as underlying assets to retail structured products. The term structure spans 1 to 5 years.

3.4 Summary Statistics

In Figure 2, we plot the aggregate volume of short put products over time, broken down by continent. This figure evidences the fast penetration of such products in Europe relative to other geographic areas, and the subsequent rise in Asia.

Turning to the design of these instruments, Figure 3 displays the breakdown of cumulative issuance volumes by barrier level of the reverse convertible. The figure documents the mass of product design on round-number moneyness in the 60% to 80% range.

INSERT FIGURE 2 AND FIGURE 3

For each stock and index, we use the volumes of outstanding structured products, taking into account the early redemptions, as our central measures of hedging demand. We also use gross monthly issuances of short-put products and net monthly issuances for robustness purpose. Tables 1 provides summary statistics on these variables of interest from the combined dataset.

INSERT TABLE 1

4 Price Impact of Structured Products Issuance

4.1 On Volatility Surfaces

4.1.1 Identification Strategy

In the absence of exogenous variations in the outstanding volumes of short-put products, we exploit the granularity of our data to gain identification in assessing the price impact of short-put product hedging.

The panel structure of our volatility surface data allows us to absorb not only time-invariant characteristics using *underlying* × *moneyness* × *maturity* fixed effects, but also any shocks common to the whole volatility surface of a given underlying with *stock* × *time* fixed effects, or a common shock to a given part of all volatility surfaces with *time* × *moneyness* fixed effects. Our results are therefore identified within a given volatility surface or even volatility smile, which have been residualized on.

Saturating our main specification with this wide range of fixed effects mitigate concerns over unobserved variable bias. Unobservable characteristics will bias our results if they both correlate in the time series with short-put product outstanding volumes, and disproportionately impact the exact segment of the volatility surfaces that corresponds to the design of these products.

On the other hand, the literature suggests that banks are strategic in the way they choose the underlying asset for short-put products. For instance, banks might pick stocks with high implied volatility related to historical level to maximize the value of the put (Ammann et al., 2017). While this result from the literature is cross-sectional, it is possible that the same phenomenon might be at play in the time series and at a given point of the volatility surface. However, such behavior would bias our results downwards, as it would lead to an upward bias on implied volatility, therefore an attenuation of our prediction that implied volatility will be lower. In addition, our focus on outstanding volumes, as opposed to issuance volumes, also mitigates this concern given that such source of endogeneity should be more pronounced for issuances than for outstanding volumes.

4.1.2 Results

We estimate the following specification:

$$Implied\ Volatility_{i,m,T,t} = \alpha + \beta_1\, Outstanding\ Volume_{i,t} \times Moneyness + \lambda' Historical\ Volatility_{i,t} + \gamma + \varepsilon_{i,t},$$

where $Implied\ Volatility_{i,m,T,t}$ is the implied volatility of underlying asset i, moneyness m and maturity T, observed for the monthly period t, $Outstanding\ Volume_{i,t}$ is the outstanding volume of short put products with underlying asset i for the monthly period t, scaled by the underlying asset market capitalization, and γ are a given set of fixed effects. Moneyness are either 80,100 or 120% for stocks, and 50% to 150% by 10% increments for indices.

Table **??** presents the regression coefficients for this specification for the sample of single stock options, where we introduce increasingly precise sets of fixed effects. In our preferred specification, presented in column 6, we include *security* × *moneyness* × *maturity* fixed effects, *month* × *security* × *moneyness* fixed effects, and *month* × *moneyness* fixed effects. This saturated specification allows us to absorb time invariant characteristics for a given option specification, as well as possible common shocks to any individual volatility smiles (e.g. cut of volatility surface for a given maturity), as well as market wide variations in option smile shape.

The negative and significant coefficient of the double interaction $Moneyness = 80\% \times outstandingvolumes$ indicates that the outstanding volumes of short put products are significantly negatively correlated with the implied volatility at the 80% level, which corresponds to the strike level the closest to the most popular reverse convertible barrier, as shown in Figure 3.

Under the assumption that, for a given stock, there is no unobserved time-variant shocks specific to the 80% moneyness on the volatility surface that is correlated with outstanding volumes of short put products structured on this single stock, we can infer that there is a causal relationship between short-put product volumes and implied volatility.

INSERT TABLE 2

We now test whether the previously documented result is verified also for short-put products structured on indices. Table 3 shows the results. We find that the flattening of the volatility surface associated with outstanding volumes of short put products is particularly pronounced at the 60 and 70% moneyness, which again corresponds to the strike levels the most popular for short put products, as per Figure 3.

INSERT TABLE 3

4.2 On Dividend Term Structure

In addition to affecting implied volatility, issuances of retail structured products might affect the dividend term structure as banks typically hedge their long dividend exposure by taking a short position in dividend swaps.

We test this hypothesis by regressing the level of dividend swaps on the volume of outstanding retail structured products.

Table 4 indicates the results. We find a significant negative relationship between the outstanding volume of short put products and the overall level of the dividend term structure. When looking at the impact along the term structure, we find a magnitude increasing with maturity, i.e., a flattening of the term structure. Such pattern is consistent with the rigidity of the short end of the dividend term structure.

INSERT TABLE 4

5 Trading Strategy

To further quantify the impact of structured retail products on market prices, we consider a long-short trading strategy that exploits the supply and demand imbalances in the volatility market due to structured product issuance-related hedging. As previously documented, structured retail products dampen options implied volatility, particularly for moneyness that correspond to the strikes of short-put products. The following trading strategy exploits these price distortions by purchasing options (long on volatility or variance swaps) on stocks that have a relatively large amount of short-put product outstanding volumes and selling options (short on volatility or variance swaps) on stocks that have little or no associated short-put product issuance.

At each month, we form five volatility portfolios by sorting the underlying stocks based on the total outstanding volumes of short put products scaled by the market capitalization of each stock. We calculate the hold-to-maturity returns on one-year volatility ($r^{volswap}$) or variance ($r^{varswap}$) swaps for each individual stock by subtracting the implied fair strikes (K_{it}^{vol} and K_{it}^{var}) from the ex-post one-year realized volatility ($\sigma_{R,it}$) or variance ($\sigma_{R,it}^2$). The return on the volatility swap in units of dollar vega notional ($1 per volatility point) is

$$r_{it}^{volswap} = \sigma_{R,it} - K_{it}^{vol}, \tag{5.1}$$

and the returns on variance swap is

$$r_{it}^{varswap} = \frac{1}{2K_{it}^{var}} \left(\sigma_{R,it}^2 - K_{it}^{var} \right). \tag{5.2}$$

The term $\frac{1}{2K_{it}^{var}}$ is the variance notional or variance units that scales the variance swap similarly to volatility swap. If realized volatility is 1 point above the strike at maturity, the payoff will approximately be equal to this notional amount.

The variance swap fair strike, K_{it}^{var}, is calculated using the 80% moneyness and at-the-money implied volatility following the approximation from Demeterfi et al. (1999) assuming that the skew is linear in strike:

$$K_{it}^{var} \approx \sigma_{ATM,it} \sqrt{1 + 3T \times skew_{it}^2}, \tag{5.3}$$

where $skew_{it}$ is the slope of the implied volatility curve that we calculate to be $\sigma_{m=80,it} - \sigma_{ATM,it}$. Assuming a log-linear skew-to-strike relationship does not materially alter our results. Calculating $skew$ using the difference between 90% moneyness and ATM implied volatility also does not materially affect our results. The volatility swap fair strike is approximated as $K_{it}^{vol} \approx \frac{1}{2} \left(\sigma_{ATM,it} + K_{it}^{var} \right)$.[4]

[4] Volatility swap payoffs cannot be statically replicated as in the case of variance swaps. The approximation above is used commonly by market practitioners as the boundary for volatility swap fair strikes are determined by the ATM implied volatility and variance swap fair strikes, $\sigma_{ATM,it} < K_{it}^{vol} < K_{it}^{var}$.

Table 5 reports the summary statistics associated with the returns on volatility and variance swap portfolios sorted on the total outstanding volume of short put products, scaled by the market cap for each stock. The table shows that the portfolio returns increase monotonically with short put product exposure. While the portfolio with the lowest quintile exposure to short put products outstanding volume has negative return, the returns increases to positive for highly exposed portfolios. The high-minus-low long-short portfolio (last row) is constructed by taking a long position on volatility swaps/variance swaps on the stocks with the most short-put products outstanding and taking a short position on those with the least short-put products exposures.

INSERT TABLE 5

Figure 5 shows the time series of the cumulative P&L for the long-short volatility and variance swap portfolios constructed as the highest-quintile minus the lowest-quintile portfolio based on sorting by short put product exposures. This cumulative P&L assumes that the investor forms a long-short portfolio each month by sorting stocks into those most exposed to short-put products exposure and those with the least exposure, taking long (short) volatility or variance swap positions on the most (least) exposed stocks. Examining the time series, it appears that this particular strategy did not perform prior to 2008 and had the strongest performance from around 2008 to 2016. This pattern generally aligns with the pick up in the issuance of short-put products after the GFC and the eventual saturation of arbitrage capital in this market.

INSERT FIG 5

Table 6 reports the sharpe ratios associated with long-short portfolios formed based on sorting by alternative variables. These variables reflect either the stock or the flow of short put products. We find that the stock effect (outstanding volume) appears to be stronger than the flow effect (Net Issuance), particularly when scaled by the market capitalization of the underlying stock. Additionally, sorting on volume of issuance has the opposite effect than sorting on maturing volumes. This further support our general finding that structured retail products have a noticeable impact on the options volatility market.

INSERT TABLE 6

6 Conclusion

The paper documents the price effects of the demand for securities with innovative payoff designs.

References

Allen, Franklin and Douglas Gale, "Limited Market Participation and Volatility of Asset Prices," *The American Economic Review*, 1994, pp. 933–955.

Ammann, Manuel, Marc Arnold, and Simon Straumann, "Illuminating the Dark Side of Financial Innovation: The Role of Investor Information," *SoF-HSG*, 2017.

Bakshi, Gurdip, Peter Carr, and Liuren Wu, "Stochastic Risk Premiums, Stochastic Skewness in Currency Options, and Stochastic Discount Factors in International Economies," *Journal of Financial Economics*, January 2008, *87* (1), 132–156.

Bollerslev, Tim, George Tauchen, and Hao Zhou, "Expected Stock Returns and Variance Risk Premia," *Review of Financial Studies*, November 2009, *22* (11), 4463–4492.

Calvet, Laurent E, Claire Célérier, Paolo Sodini, and Boris Vallee, "Can Security Design Foster Household Risk-Taking?," *Working Paper*, 2020.

Cao, Jie and Bing Han, "Cross Section of Option Returns and Idiosyncratic Stock Volatility," *Journal of Financial Economics*, April 2013, *108* (1), 231–249.

Celerier, Claire and Boris Vallee, "Catering to Investors Through Security Design: Headline Rate and Complexity*," *The Quarterly Journal of Economics*, 02 2017, *132* (3), 1469–1508.

Coval, Joshua, Jakub Jurek, and Erik Stafford, "The Economics of Structured Finance," *Journal of Economic Perspectives*, 2009, *23* (1), 3–25.

Demeterfi, Kresimir, Emanuel Derman, Michael Kamal, and Joseph Zou, "A Guide to Volatility and Variance Swaps," *The Journal of Derivatives*, 1999, *6* (4), 9–32.

Duffie, Darrell and Rohit Rahi, "Financial Market Innovation and Security Design: An Introduction," *Journal of Economic Theory*, 1995, *65*, 1–42.

Greenwood, Robin and Annette Vissing-Jrgensen, "The Impact of Pensions and Insurance on Global Yield Curves," *Harvard Business School Working Paper*, June 2018, *18-109.*

___ **and Dimitri Vayanos**, "Bond Supply and Excess Bond Returns," *The Review of Financial Studies*, 2014, *27* (3), 663–713.

Grleanu, Nicolae, Lasse Heje Pedersen, and Allen M. Poteshman, "Demand-Based Option Pricing," *Review of Financial Studies*, October 2009, *22* (10), 4259–4299.

Han, Bing and Yi Zhou, "Variance Risk Premium and Cross-Section of Stock Returns," *unpublished paper, University of Texas at Austin*, 2012.

Henderson, Brian J, Neil D Pearson, and Li Wang, "New Evidence on the Financialization of Commodity Markets," *The Review of Financial Studies*, 2015, *28* (5), 1285–1311.

Pan, Jun and Allen M Poteshman, "The Information in Option Volume for Future Stock Prices," *The Review of Financial Studies*, 2006, *19* (3), 871–908.

Todorov, Viktor, "Variance Risk-Premium Dynamics: The Role of Jumps," *Review of Financial Studies*, January 2010, *23* (1), 345–383.

Vayanos, Dimitri and Jean-Luc Vila, "A Preferred-Habitat Model of the Term Structure of Interest Rates," Technical Report w15487, National Bureau of Economic Research, Cambridge, MA November 2009.

Vokata, Petra, "Engineering Lemons," *Working Paper*, 2020.

7 Figures

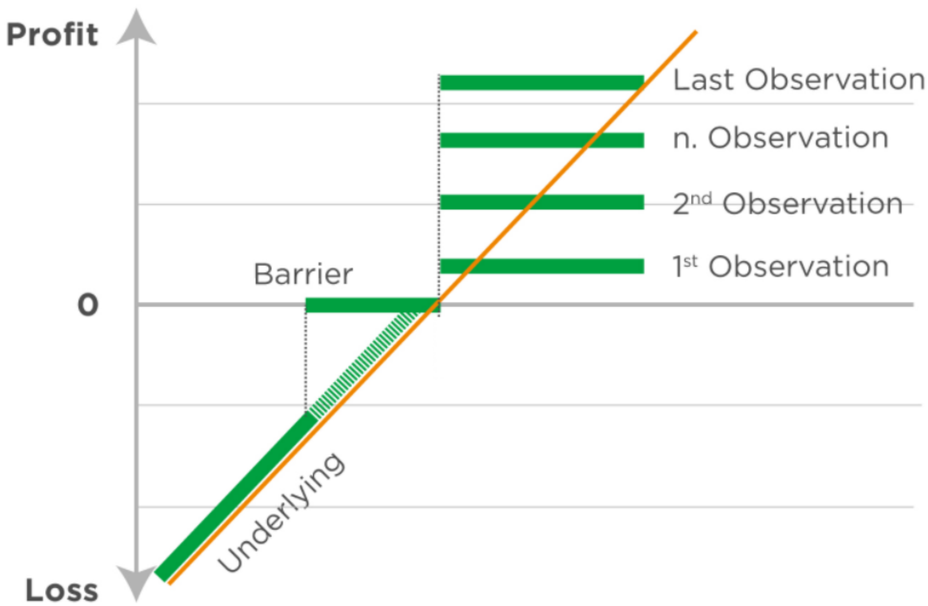

Figure 1: Example of a Product with Short-put Design

Notes: This figure represents the pay-off diagram of a typical short put product: autocallable with reverse convertible. The gain on the program depends on the time at which the product gets autocalled: "1st Observation" corresponds to the payoff if it gets called at first observation, "2nd Observation" corresponds to the payoff if the product was not called at first observation but is called at the second, and so on.

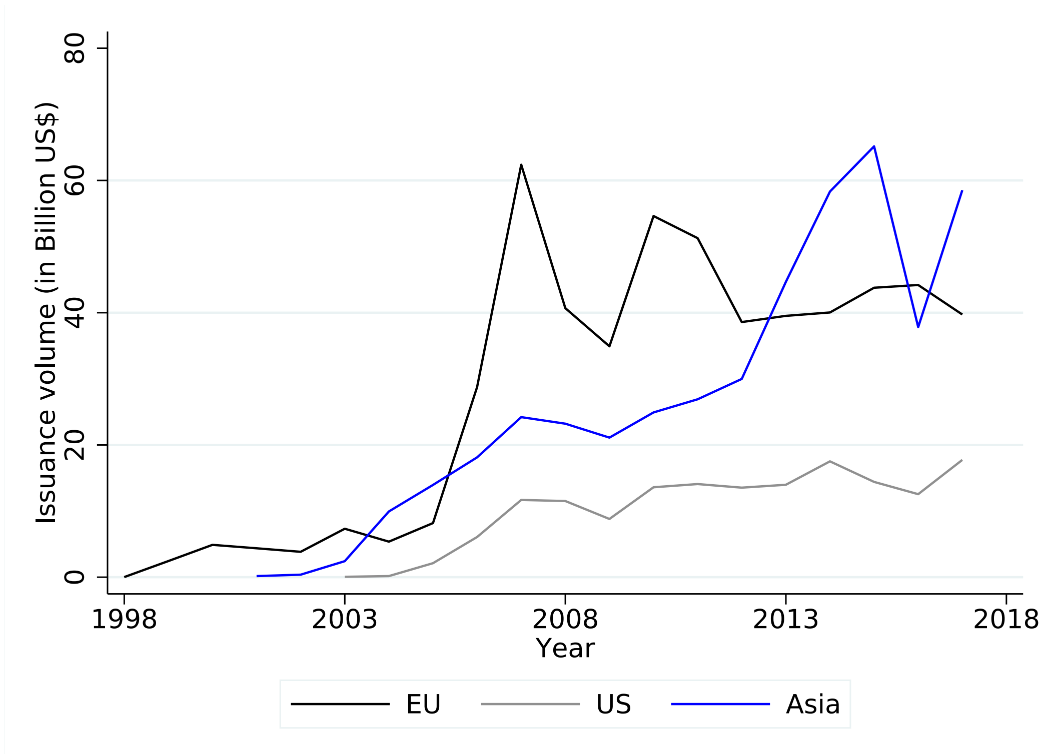

Figure 2: Issuance Volumes of Short-Put Products across Regions

Notes: This figure displays the yearly issuance volumes of short put products for Europe, the US and Asia.

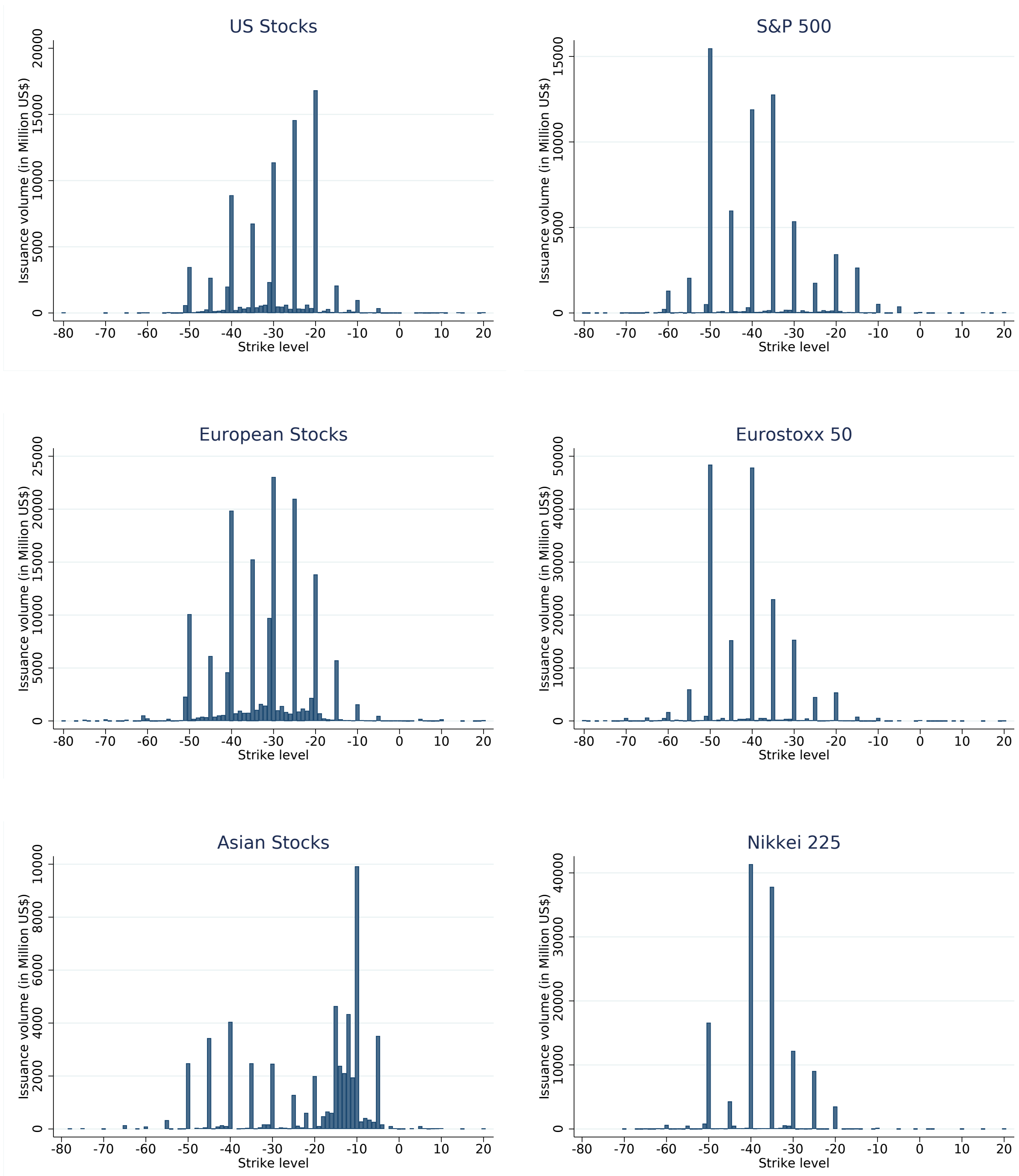

Figure 3: Issuance Volumes of Short-Put Products across Strike Levels

Notes: This figure displays the cumulative volume of short put products by strikes of their reverse convertible feature, broken down by types of underlying assets.

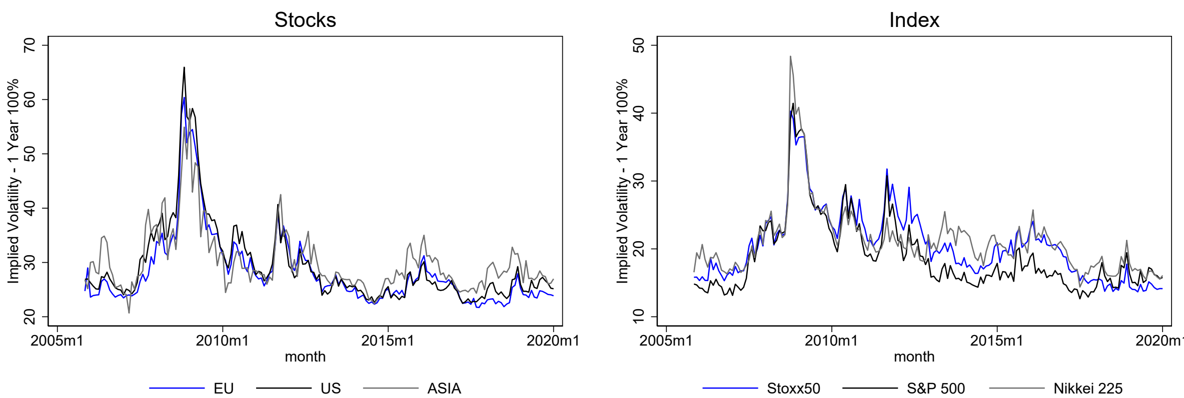

Figure 4: Implied Volatility over Time

Notes: This figure displays the time-series of the 1 year implied volatility, averaged across the stocks of each geographic zone, and for the three main equity indices.

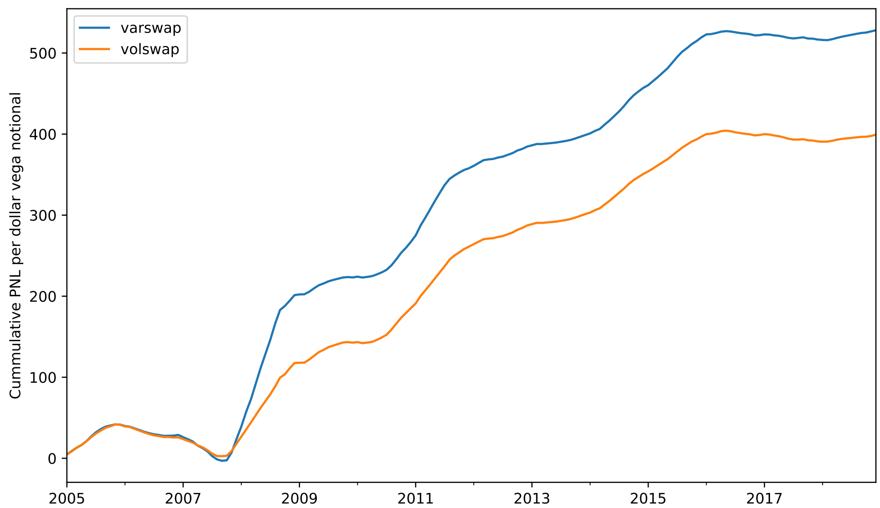

Figure 5: Cumulative P&L on long-short volatility and variance swaps portfolio

Notes: This figure the cumulative gains from implementing a monthly long-short trading strategy held to its 1 year maturity, based on sorting stocks on the amount of outstanding volume of short put products.

8 Tables

Table 1: Summary Statistics

	Panel A. SRP Volume				
	Obs	**Mean**	**Median**	**p10**	**p90**
Issuance Volume ($m) at the issuance level: Stocks					
Of which:					
North America	92,494	1.240	0.387	0.054	2.587
Europe	139,802	1.390	0.644	0.134	3.060
Asia	27,383	2.864	0.707	0.032	9.343
Issuance Volume ($m) at the issuance level: Indices					
Of which:					
North America	41,851	2.108	0.789	0.061	5.013
Europe	69,965	3.548	1	0.081	6.251
Asia	59,775	3.961	0.879	0.062	6.300
At the underlying-month level: Period = 2000-2019					
Issuance Volume ($m): Stocks	103,361	3.748	0	0	8.473
Issuance Volume ($m): Indices	2,285	250.868	32.507	0	864.201
Outstanding Volume ($m): Stocks	103,361	58.688	0.791	0	146.591
Outstanding Volume ($m): Indices	2,285	5884.431	1398.978	0	17433.150
Market Capitalization ($b): Stocks	103,074	79.515	36.312	9.737	166.449
Market Capitalization ($b): Indices	2,285	92872.990	3365.270	1232.340	418931
	Panel B. Volatility data: Stocks (N=515 stocks, Period=2000-2020)				
Historical Volatility (1 Year)	105,585	32.160	28.167	17.289	51.149
Implied Volatility (3 months, moneyness=80%)	72,717	35.254	32.088	23.701	50.190
Implied Volatility (3 months, moneyness=100%)	77,304	28.882	25.786	17.065	43.713
Implied Volatility (3 months, moneyness=120%)	72,717	27.763	24.862	16.402	41.887
Implied Volatility (1 Year, moneyness=80%)	63,671	31.956	29.322	21.646	44.983
Implied Volatility (1 Year, moneyness=100%)	67,624	28.402	25.877	18.065	41.237
Implied Volatility (1 Year, moneyness=120%)	63,671	27.046	24.573	16.689	40.028
Implied Volatility (2 Year, moneyness=80%)	51,623	30.284	28.069	20.979	41.884
Implied Volatility (2 Year, moneyness=100%)	54,616	27.349	25.171	18.115	38.711
Implied Volatility (2 Year, moneyness=120%)	51,623	26.377	24,220	16.890	38.0912

Table 1(continued)
Summary Statistics

	Panel C. Volatility data: Indices (N=9 indices, Period=2001-2019)				
	Obs	**Mean**	**Median**	**p10**	**p90**
Historical Volatility (1 Year)	7,458	20.247	18.792	11.262	29.005
Implied Volatility (3 months, moneyness=60%)	723	41.243	40.028	31.967	51.597
Implied Volatility (3 months, moneyness=70%)	723	35.646	34.164	27.716	44.770
Implied Volatility (3 months, moneyness=80%)	723	30.188	28.687	22.844	38.802
Implied Volatility (3 months, moneyness=90%)	723	25.008	23.487	18.041	33.170
Implied Volatility (3 months, moneyness=100%)	723	20.369	19.294	12.786	28.627
Implied Volatility (3 months, moneyness=120%)	723	17.110	16.086	10.873	24.200
Implied Volatility (1 Year, moneyness=60%)	723	32.025	31.324	25.496	39.122
Implied Volatility (1 Year, moneyness=70%)	723	28.720	28.000	22.876	35.378
Implied Volatility (1 Year, moneyness=80%)	723	25.686	24.832	20.016	32.020
Implied Volatility (1 Year, moneyness=90%)	723	22.961	22.160	17.472	29.000
Implied Volatility (1 Year, moneyness=100%)	723	20.573	20.142	14.812	26.613
Implied Volatility (1 Year, moneyness=120%)	723	17.469	17.273	11.072	23.078
Implied Volatility (2 Year, moneyness=60%)	723	28.807	28.216	23.410	35.035
Implied Volatility (2 Year, moneyness=70%)	723	26.418	25.551	21.116	32.413
Implied Volatility (2 Year, moneyness=80%)	723	24.297	23.316	19.320	30.117
Implied Volatility (2 Year, moneyness=90%)	723	22.444	21.689	17.682	28.177
Implied Volatility (2 Year, moneyness=100%)	723	20.847	20.255	16.062	26.279
Implied Volatility (2 Year, moneyness=120%)	723	18.512	18.284	13.138	23.627
	Panel D. Dividend data: Stocks (N=9 indices, Period=2004-2019)				
Historical Dividend(1 Year)	1,737	2.863	2.994	1.625	4.104
Implied dividend (1 year)	1,153	0.029	0.031	0.018	0.039
Implied dividend (2 year)	1,141	0.029	0.031	0.019	0.038
Implied dividend (3 year)	1,123	0.029	0.032	0.020	0.038
Implied dividend (4 year)	1,105	0.029	0.031	0.020	0.038
Implied dividend (5 year)	817	0.028	0.027	0.019	0.038

Notes: This table reports summary statistics for main variables used in the regressions. Panel A reports summary statistics of the volume of SRP that used top 200 stocks and indices in Asia, Europe and as underlyings. Panel B and C reports summary statistics of volatility data of these underlyings. Panel D presents the summary statistics of dividend data for the indices.

Table 2: Implied Volatility and Outstanding Volume of Short-Put Products: Single Stocks

	Implied volatility						Volatility Risk Premium	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Moneyness = 80 \times$ Outstanding SPP Volume	-20.386***	-20.308***	-30.340**	-16.836*	-16.849*	-16.942**	-15.682*	-15.639**
	(6.628)	(6.802)	(12.034)	(8.735)	(8.734)	(8.084)	(8.624)	(7.838)
Historical volatility-1 year	0.680***	0.519***	0.516***					
	(0.028)	(0.030)	(0.030)					
Outstanding Short Put Product Volume	-12.413	-10.163	-5.466					
	(11.709)	(13.041)	(12.378)					
$Moneyness = 80$	4.866***	4.852***	0.000					
	(0.110)	(0.111)	(0.000)					
Month FE	Y	Y	Y	N	N	N	N	N
Security FE	N	Y	N	N	N	N	N	N
Month X Security FE	N	N	N	Y	N	N	N	N
Security X Maturity X Moneyness FE	N	N	Y	Y	Y	Y	Y	Y
Month X Security X Maturity FE	N	N	N	N	Y	Y	Y	Y
Month X Moneyness FE	N	N	N	N	N	Y	N	Y
Observations	498,495	498,495	498,464	502,573	491,355	491,355	459,330	459,330
R^2	0.715	0.760	0.778	0.958	0.978	0.980	0.975	0.977
Within R^2	0.598	0.377	0.326					

Notes: This table displays the coefficients from regressing stock implied volatility on outstanding short put product volume scaled by the stock market capitalisation, interacted with an indicator variable for the implied volatility being measured at the 80% moneyness. Standard errors are double-clustered at the stock and month level. *, **, and *** represent statistical significance at the 10%, 5%, and 1% confidence levels, respectively.

Table 3: Implied Volatility and Outstanding Volume of Short-Put Products: Equity Indices

	Implied volatility		Volatility Risk Premium	
	(1)	(2)	(3)	(4)
Moneyness=50 × Outstanding Volume of SPP	-86.276***	-86.276***	-84.794***	-84.794***
	(25.811)	(25.811)	(25.906)	(25.906)
Moneyness=60 × Outstanding Volume of SPP	-81.888***	-81.888***	-81.294***	-81.294***
	(18.644)	(18.644)	(18.713)	(18.713)
Moneyness=70 × Outstanding Volume of SPP	-90.749***	-90.749***	-90.941***	-90.941***
	(13.672)	(13.672)	(13.696)	(13.696)
Moneyness=80 × Outstanding Volume of SPP	-77.949***	-77.949***	-78.520***	-78.520***
	(9.797)	(9.797)	(9.779)	(9.779)
Moneyness=90 × Outstanding Volume of SPP	-45.026***	-45.026***	-45.525***	-45.525***
	(5.601)	(5.601)	(5.571)	(5.571)
Moneyness=110 × Outstanding Volume of SPP	36.580***	36.580***	37.345***	37.345***
	(5.962)	(5.962)	(5.905)	(5.905)
Moneyness=120 × Outstanding Volume of SPP	46.771***	46.771***	47.668***	47.668***
	(9.897)	(9.897)	(9.868)	(9.868)
Moneyness=130 × Outstanding Volume of SPP	47.347***	47.347***	48.427***	48.427***
	(13.622)	(13.622)	(13.610)	(13.610)
Moneyness=140 × Outstanding Volume of SPP	45.273***	45.273***	46.840***	46.840***
	(17.396)	(17.396)	(17.371)	(17.371)
Moneyness=150 × Outstanding Volume of SPP	43.351**	43.351**	45.602**	45.602**
	(21.022)	(21.022)	(20.959)	(20.959)
Security X Maturity X Moneyness FE	Y	Y	Y	Y
Month X Security FE	Y	Y	Y	Y
Month X Security X Maturity FE	N	Y	N	Y
Month X Moneyness FE	Y	Y	Y	Y
Observations	52,206	52,206	52,206	52,206
R^2	0.962	0.981	0.963	0.981

Notes: This table displays the coefficients from regressing index implied volatility on outstanding short put product volume scaled by the index market capitalisation, interacted with indicator variables for the different moneyness levels. The reference point is a 100% moneyness and is therefore omitted. Standard errors are double-clustered at the index and month level. *, **, and *** represent statistical significance at the 10%, 5%, and 1% confidence levels, respectively.

Table 4: Dividend Term Structure and Outstanding Volume of Short-Put Products: Equity Indices

	Implied Dividend				
	(1)	(2)	(3)	(4)	(5)
Outstanding Volume Scaled by Market Cap	-0.524**	-0.545***	-0.524***	-0.417***	
	(0.195)	(0.122)	(0.126)	(0.097)	
Term=2y × Outstanding Volume Scaled by Market Cap				0.016	-0.097***
				(0.066)	(0.018)
Term=3y × Outstanding Volume Scaled by Market Cap				-0.111	-0.270***
				(0.092)	(0.038)
Term=4y × Outstanding Volume Scaled by Market Cap				-0.190	-0.408***
				(0.125)	(0.056)
Term=5y × Outstanding Volume Scaled by Market Cap				-0.273	-0.536***
				(0.163)	(0.066)
Historical Dividend		0.005***	0.005***	0.005***	
		(0.001)	(0.001)	(0.001)	
Month FE	Y	Y	N	N	N
Security × Maturity FE	Y	Y	Y	Y	N
Month × Maturity FE	N	N	Y	Y	N
Maturity FE	N	N	N	N	Y
Security × Month FE	N	N	N	N	Y
Observations	5,339	5,339	5,339	5,339	5,327
R^2	0.821	0.893	0.915	0.916	0.958

Notes: This table displays the coefficients from regressing future dividend yield on outstanding short put product volume scaled by the stock market capitalisation. Standard errors are double-clustered at the stock and month level. *, **, and *** represent statistical significance at the 10%, 5%, and 1% confidence levels, respectively.

Table 5: Volatility and variance swap portfolios sorted on outstanding structured retail products

SRP		2004-2018 VarSwap	2004-2018 VolSwap	2007-2018 VarSwap	2007-2018 VolSwap	2009-2018 VarSwap	2009-2018 VolSwap
Lo	Mean	-14.79	-18.46	-13.19	-17.71	-47.91	-47.53
	Sd	31.36	28.98	33.78	31.21	18.60	20.03
	Sharpe	-0.47	-0.64	-0.39	-0.57	-2.58	-2.37
2	Mean	-11.43	-17.10	-6.82	-13.58	-39.93	-41.43
	Sd	31.10	28.25	33.32	30.28	18.64	19.94
	Sharpe	-0.37	-0.61	-0.20	-0.45	-2.14	-2.08
3	Mean	-4.49	-11.26	0.83	-7.36	-29.64	-32.94
	Sd	30.85	27.94	33.01	29.96	21.08	21.61
	Sharpe	-0.15	-0.40	0.03	-0.25	-1.41	-1.52
4	Mean	3.28	-5.66	8.61	-2.31	-24.21	-28.44
	Sd	34.58	29.32	37.07	31.49	21.08	21.20
	Sharpe	0.09	-0.19	0.23	-0.07	-1.15	-1.34
Hi	Mean	22.93	10.06	28.41	13.42	-15.24	-19.36
	Sd	42.11	33.26	45.07	35.53	23.95	22.77
	Sharpe	0.54	0.30	0.63	0.38	-0.64	-0.85
Hi-Lo	Mean	37.72	28.52	41.60	31.12	32.67	28.17
	Sd	16.80	10.99	17.51	11.08	10.27	8.57
	Sharpe	2.25	2.59	2.38	2.81	3.18	3.29

Notes: This table presents return statistics associated with variance and volatility swap portfolios formed by sorting on the total outstanding of structured retail products scaled by the underlying stocks' market capitalization. At each month, stocks are sorted into five portfolios based on the total outstanding of structured retail products associated with each stock scaled by the market cap. Variance and volatility swaps with one year of maturity are formed for each stock and grouped into the sorted portfolios. The ex-post hold-to-maturity returns in units of vega notionals are reported for each portfolio group. The returns for each monthly portfolio groups are annualized (hold-to-maturity return means are multiplied by 12 and standard deviations are multiplied by square root of 12).

Table 6: Sharpe ratios for Long-short volatility and variance swap portfolios with alternative sorting variables

	2004-2018		2007-2018		2009-2018	
Type	VarSwap	VolSwap	VarSwap	VolSwap	VarSwap	VolSwap
Sort Variable						
Outstanding_MarketCapScaled	2.25	2.59	2.38	2.81	3.18	3.29
Outstanding	1.78	1.92	1.91	2.05	3.20	3.13
NetIssuance_MarketCapScaled	1.87	2.11	1.89	2.15	2.31	2.27
NetIssuance	1.28	1.28	1.40	1.45	1.92	1.73
Maturity	-1.24	-1.28	-1.30	-1.38	-1.85	-1.72
Issuance	0.86	0.74	0.96	0.84	0.83	0.65

This table presents the long-short portfolio sharpe ratio associated with variance and volatility swap portfolios formed by sorting on variables capturing the stock and flow of structure retail products. At each month, stocks are sorted into five portfolios based on the sorting variable. Variance and volatility swaps with one year of maturity are formed for each stock and grouped into the sorted portfolios. The ex-post hold-to-maturity returns are reported in units of vega notionals for each portfolio group. The sharpe ratio is based on annualized returns (each porfolio's hold-to-maturity mean return is multiplied by 12, and standard deviations are multiplied by square root of 12).