The Price Effects of Innovative Security Design*

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Abstract

This paper investigates the effects of the issuance of retail products with non-linear payoffs 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 retail demand for innovative securities.

JEL Classification Codes: G12, G14, G15, G23

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

1 Introduction

The volume 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). However, little is known about whether the development of these securities, which indirectly enlarge the derivatives participant pool to households, is having effects on asset prices. The burgeoning literature on segmented capital markets (Greenwood et al., 2018), and more broadly demand asset pricing (Koijen and Yogo, 2019) suggests that a change in the participant set of a capital market should materially affect both prices and their dynamics. Does the retail demand for innovative synthetic securities affect option prices, and if so how? What are potential spillovers of such changes in equilibria in the option market, for instance in terms of the cost of portfolio insurance, participants risk-taking or equity risk premium?

This paper uses the global development of retail financial products embedding sales of put options, thereafter *Short Put Products* or SPP, as a laboratory to address these questions. Households investing in SPPs collect a fixed coupon over the duration of the SPP 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. This coupon is financed by the implicit sale of put options. If the underlying asset price drops below the lower barrier, the put option is in the money and the household is exposed to the full capital loss. When equity prices rise above the upper barrier, the SPP typically knocks out with full return of principal.[1] Such market represents sizable volumes, with a particularly high penetration in Europe and Asia.[2]

When structuring short put products, intermediaries hedge the associated market risks, most notably the exposure to the options embedded in these products. The typical hedge for a SPP requires the intermediaries to short a portfolio of puts on the underlying asset and short the

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

[2] Global outstanding volumes for SPPs was around $208 Billion as of 2015, with respectively XX, YY and ZZ Billion for Europe, Asia and North America.

dividend exposure through dividend swaps. If competitive intermediaries can hedge perfectly – as in a Black-Scholes-Merton economy – then option prices are determined by no-arbitrage and the hedging should have no effect on option prices. In reality, however, even intermediaries cannot hedge options perfectly because of the impossibility of trading continuously, stochastic volatility, jumps in the underlying, and transaction costs (Figlewski 1989). In addition, intermediaries are sensitive to risk, for instance due to capital constraints and agency costs.

We exploit data offering a comprehensive coverage of all SPPs issued around the world from 2002 to 2015 to investigate how the hedging activities associated with SPPs have a sizable and persistent price impact in the option and dividend markets. For each SPP, we observe the underlying asset, the maturity, the volumes and issuance date and the exact payoff design. For each underlying asset, we collect data on the implied volatility at different levels of moneyness and on dividend yields. Our final dataset covers derivatives of more than 400 assets, over 15 years and across three continents: North America, Europe and Asia.

This paper documents three main findings. First, for a given asset, when the outstanding volumes of SPPs with an exposure to this asset increases, implied volatility at the corresponding strike decreases relative to implied volatility at other moneyness. Our empirical setting relies on regressing asset volatility prices on the outstanding volumes of SPPs with exposure to these assets, interacted with moneyness, while saturating with fixed effects to absorb any fundamental price changes. In our preferred specification, we include option underlying asset $\times$ maturity $\times$ moneyness fixed effects, as well as moneyness $\times$ time fixed effects. This result holds for both stocks and indices. As a robustness check, we show that the issuance of SPPs with a put option at a given moneyness affects the implied volatility at the same moneyness. Therefore, we identify price effects within individual volatility smiles at a given time.

Second, a similar pattern exists for dividends: when the outstanding volume of SPPs goes up, the term structure of dividends flattens. These patterns exist at a relatively long horizon, and therefore do not correspond to the micro-structure concept of price impact.

Third, a long-short trading strategy in volatility markets that sort stocks by their associated SPP issuance volumes yields attractive Sharpe ratios, which further speaks to the significance and persistence of the equilibrium effects we document.

Our results suggest that the development of markets for innovative securities can affect the supply and demand equilibrium for derivatives by channeling household demand through intermediaries 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. As option markets prices are key inputs for financial institutions risk management models, the effects we document can potentially affect their risk-taking. More broadly, our results speak to the equilibrium effects of a change in the set of participants for a given financial market.

This paper contributes to several streams of the literature. First, our findings are consistent with models that emphasize supply and demand factors, such as funding constraints of financial intermediaries or limits to arbitrage, as key drivers of asset prices. Gârleanu 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-Jørgensen (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. Our contribution is to document how innovative securities can affect the supply and demand equilibrium of derivative markets by introducing retail demand.

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 Short Put Products

SPPs is a highly popular type of retail structured products, which include any investment products marketed to retail investors possessing a payoff function that varies automatically and non-linearly with the performance of an underlying financial asset.[3] Typically designed with embedded options, these products leave no room for discretionary investment decisions during the life of the investment. Retail structured 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 772.4 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 (414 billion US dollars in 2015) of the global volumes. The US and Asian markets, however, have been growing fast: retail structured product assets under management exceeded 85.5 billion US dollars in 2015 in the US.

Among retail structured products, SPPs 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.

[3] 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 SPP with an auto-callable feature, often labelled as “express certificate”.

INSERT FIG 1

The market for SPPs 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.

2.2 Bank Hedging

2.2.1 Hedging Volatility

When issuing structured products, the issuing bank reduces the risk of paying large payoffs to the investors by buying and selling options that offset these payoffs. More specifically for SPPs, 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.

2.2.2 Hedging Dividends

When investing in SPPs, retail investors get a return that does not take into account dividends. Therefore, as banks usually hedge in a way 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 Short Put 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, including SPPs. For each SPP, 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 Sample Construction

We build our sample by merging the data on SPPs with the volatility and dividend data for the top 200 stocks in the US, Europe and Asia and the following 9 indices: the Eurostoxx 50, S&P 500, Nikkei 225, Hang Seng, Hang Seng China Enterprises, CAC 40, Swiss Market, Tokyo Stock Exchange, FTSE 100. Our final sample hence covers 600 stocks and 9 indices over the 2002-2015 period.

For each stock and index, we measure the hedging demand using the volumes of outstanding SPPs that use them as underlying, taking into account the early redemptions. We build a panel at the month and underlying level. For each month-underlying observation, the panel includes the corresponding outstanding volumes of SPPs, volatility data at three maturity and different moneyness, as well as dividend data.

For each index, we also use the monthly issuances of SPPs in a panel at the month-underlying-moneyness level. More precisely, we collect the issuance volumes of SPPs using the index as underlying at different level of moneyness.

3.5 Summary Statistics

In Figure 2, we plot the yearly volumes of SPP issuance across the US, Europe and Asia. This figure evidences the fast penetration of such products in Europe relative to other geographic areas, and the more recent rise in Europe and the US.

INSERT FIGURE 2

Turning to the design of SPPs, Figure 3 shows that issuance volumes are higher for products with round-number moneyness in the 40% to 90% range. The figure displays the aggregate volumes of issuance over the 2002-2015 period of SPPs across moneyness, as indicated by the strike level of the embedded put option.

INSERT FIGURE 3

Tables 1 provides summary statistics on the main variables of our analysis. Our final sample includes more than 180,000 SPP products, with an average maturity of 1.5 years. The moneyness of the embedded put option ranges from 0.5 (10^{th} percentile) to 0.8 (90^{th} percentile). 23% of the SPPs have an index as an underlying.

INSERT TABLE 1

4 The Price Impact of Short Put Products

4.1 On Volatility Surfaces

4.1.1 Identification Strategy

We identify the price impact of SPP hedging using the heterogeneity of SPP outstanding volumes within a given volatility surface or even a given volatility smile for a given asset. To do so, we absorb not only time-invariant characteristics using *underlying* $\times$ *moneyness* $\times$ *maturity* fixed effects, but also any shocks common to the whole volatility surface of a given underlying with *stock* $\times$ *time* fixed effects, or a common shock to a given part of all volatility surfaces with *time* $\times$ *moneyness* fixed effects.

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 first 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 0.8, 1 or 1.2 for stocks, and 0.5 to 1.5 by 0.1 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 $Moneyness = 0.8\% \times outstandingvolumes$ indicates that the outstanding volumes of short put products are significantly negatively correlated with the implied volatility at the 0.8 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 0.8 moneyness on the volatility surface that is correlated with outstanding volumes of SPPs structured on this single stock, we can infer that there is a causal relationship between SPP volumes and implied volatility.

INSERT TABLE 2

We now show that the previously documented result is verified also for SPPs 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

Finally, we investigate whether issuances of SPPs at a given moneyness affect the implied volatility of the corresponding indexes. To do so, we test the following specification:

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

INSERT TABLE 4

Table 4 provides the results. Issuance volumes affect both the corresponding implied volatility and volatility premium, after controlling for *security* $\times$ *moneyness* $\times$ *maturity* fixed effects, *month* $\times$ *security* $\times$ *moneyness* fixed effects, and *month* $\times$ *moneyness* fixed effects.

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 5 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 5

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]

Table 6 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 6

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

[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, $\sigma_{ATM,it} < K_{it}^{vol} < K_{it}^{var}$.

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 7 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 7

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-Jørgensen, "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.

___ **, Samuel G Hanson, and Gordon Y Liao**, "Asset Price Dynamics in Partially Segmented Markets," *The Review of Financial Studies*, 2018, *31* (9), 3307–3343.

Gârleanu, 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.

Koijen, Ralph SJ and Motohiro Yogo, "A demand system approach to asset pricing," *Journal of Political Economy*, 2019, *127* (4), 1475–1515.

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

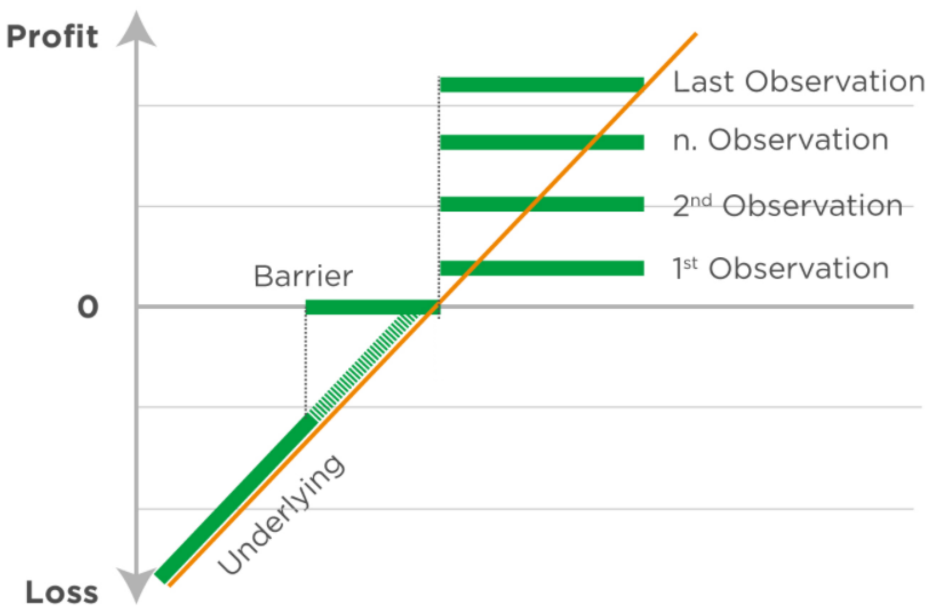

Figure 1: Example of a Short Put Product

Notes: This figure shows the pay-off diagram of a typical Short Put Product with an autocallable feature. The final return depends on the date 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.

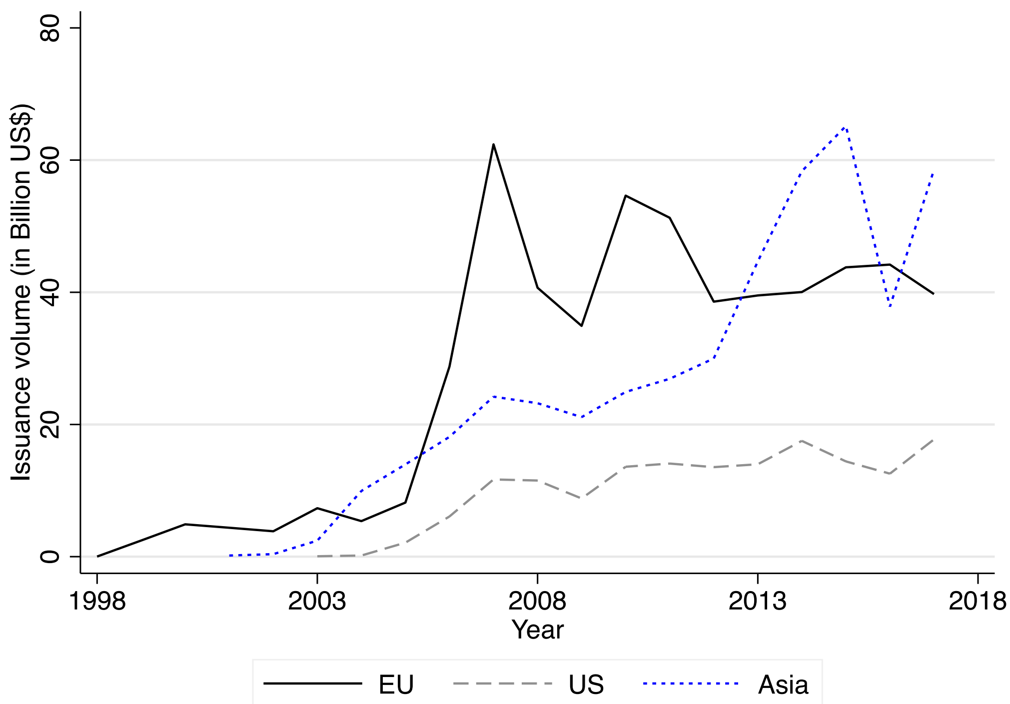

Figure 2: Issuance Volumes of Short Put Products across Regions

Notes: This figure displays the yearly issuance volumes of short put products in Europe, the US and Asia from 1998 to 2018.

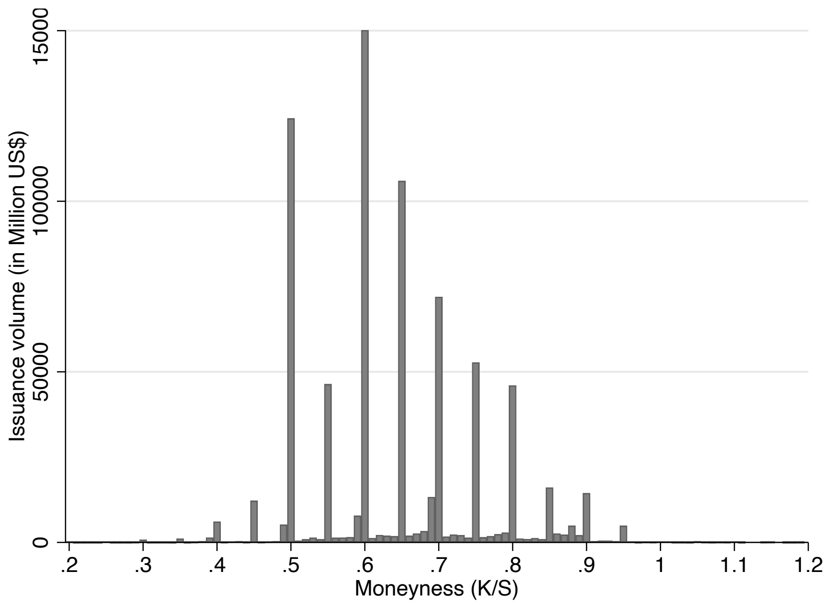

Figure 3: Issuance Volumes of Short Put Products across Moneyness

Notes: This figure displays the cumulative issuance volumes of short put products by moneyness over the 2002-2015 period.

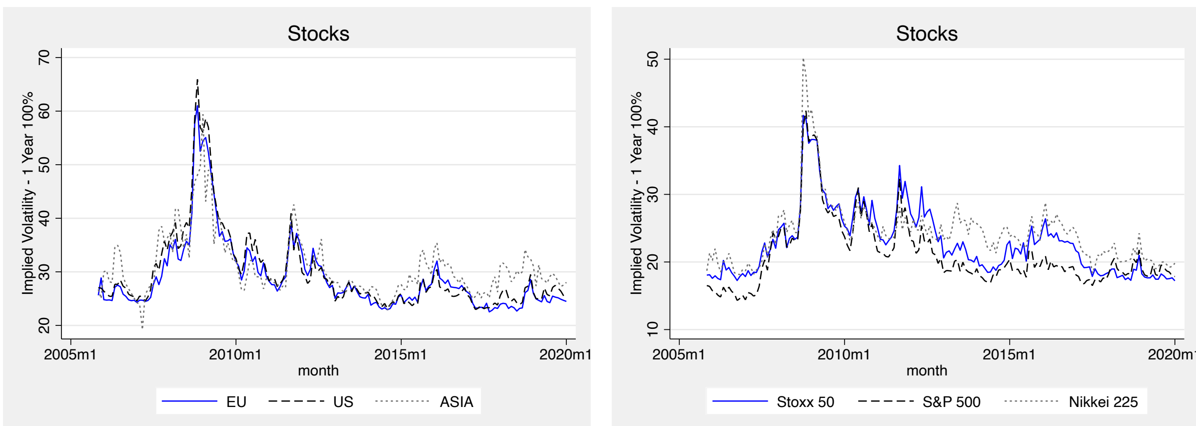

Figure 4: Implied Volatility over Time

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.

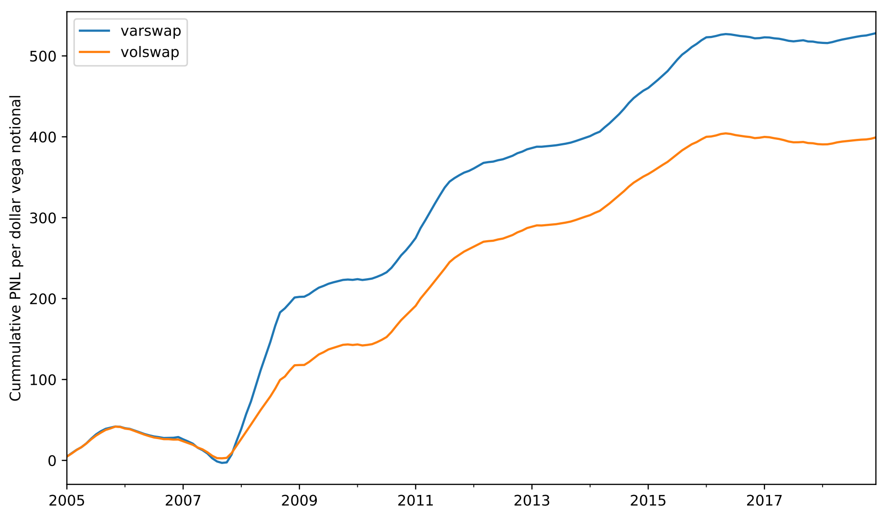

Figure 5: Cumulative P&L on long-short volatility and variance swaps portfolio

Notes: This figure plots 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 volumes of short put products.

8 Tables

Table 1: Summary Statistics on Short Put Products (2002-2015)

	Obs	Mean	Median	p10	p90
At the product level					
Maturity	180762	1.50	1.02	0.27	3.02
Moneyness	143913	0.67	0.66	0.50	0.80
Issuance Volumes (in m$)	180807	3.68	1.28	0.10	8.63
Year	180807	2015.5	2017	2010	2019
% Index	180807	23	-	-	-
At the underlying-month level					
Issuance Volume ($m):	103,361	3.748	0	0	8.473
Outstanding Volume ($m)	103,361	58.688	0.791	0	146.591
Market Capitalization ($b)	103,074	79.515	36.312	9.737	166.449

Notes: This table reports summary statistics on the volume and design of SPPs that use top 200 stocks and indices as underlying asset.

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)
Outstanding SPP Volume × $Moneyness = 0.8$	-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 SPP Volume	-12.413	-10.163	-5.466					
	(11.709)	(13.041)	(12.378)					
$Moneyness = 0.8$	4.866***	4.852***	0.000					
	(0.110)	(0.111)	(0.000)					
Fixed Effects								
Month	Yes	Yes	Yes					
Security		Yes						
Month × Security				Yes				
Security × Maturity × Moneyness			Yes	Yes	Yes	Yes	Yes	Yes
Month × Security × Maturity					Yes	Yes	Yes	Yes
Month × Moneyness						Yes		Yes
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 implied volatility data 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. The sample includes monthly implied volatility data across three moneyness – 0.8, 1 and 1.2 – and three maturities – 3 months, 1 year and 2 years – for all the top 200 stocks across the US, Europe and Asia. The sample covers the 2002-2015 period. 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)
Outstanding Volume of SPP × Moneyness=0.5	-86.276***	-86.276***	-84.794***	-84.794***
	(25.811)	(25.811)	(25.906)	(25.906)
Outstanding Volume of SPP × Moneyness=0.6	-81.888***	-81.888***	-81.294***	-81.294***
	(18.644)	(18.644)	(18.713)	(18.713)
Outstanding Volume of SPP × Moneyness=0.7	-90.749***	-90.749***	-90.941***	-90.941***
	(13.672)	(13.672)	(13.696)	(13.696)
Outstanding Volume of SPP × Moneyness=0.8	-77.949***	-77.949***	-78.520***	-78.520***
	(9.797)	(9.797)	(9.779)	(9.779)
Outstanding Volume of SPP × Moneyness=0.9	-45.026***	-45.026***	-45.525***	-45.525***
	(5.601)	(5.601)	(5.571)	(5.571)
Outstanding Volume of SPP × Moneyness=1.1	36.580***	36.580***	37.345***	37.345***
	(5.962)	(5.962)	(5.905)	(5.905)
Outstanding Volume of SPP × Moneyness=1.2	46.771***	46.771***	47.668***	47.668***
	(9.897)	(9.897)	(9.868)	(9.868)
Outstanding Volume of SPP × Moneyness=1.3	47.347***	47.347***	48.427***	48.427***
	(13.622)	(13.622)	(13.610)	(13.610)
Outstanding Volume of SPP × Moneyness=1.4	45.273***	45.273***	46.840***	46.840***
	(17.396)	(17.396)	(17.371)	(17.371)
Outstanding Volume of SPP × Moneyness=1.5	43.351**	43.351**	45.602**	45.602**
	(21.022)	(21.022)	(20.959)	(20.959)
Fixed Effects				
Security × Maturity × Moneyness	Yes	Yes	Yes	Yes
Month × Security	Yes	Yes	Yes	Yes
Month × Security × Maturity		Yes		Yes
Month × Moneyness	Yes	Yes	Yes	Yes
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 monthly 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. The sample includes monthly implied volatility data across eleven moneyness and three maturities – 3 months, 1 year and 2 years – for the nine main indices of the US, Europe and Asia. 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: Implied Volatility and Issuance of Short-Put Products: Equity Indices

	Implied volatility		Volatility Risk Premium	
	(1)	(2)	(3)	(4)
Issuance by Moneyness Scaled by Market Cap	-8.443***	-8.443***	-8.466***	-8.466***
	(0.912)	(0.912)	(0.915)	(0.915)
Fixed Effects				
Security × Maturity × Moneyness	Y	Y	Y	Y
Month × Security	Y	Y	Y	Y
Month × Moneyness	N	Y	N	Y
Month × Security × Maturity	Y	Y	Y	Y
Observations	52,437	52,437	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 the issuance volumes of short put products by moneyness scaled by the index market capitalisation. The sample includes monthly implied volatility data across eleven moneyness and three maturities – 3 months, 1 year and 2 years – for the nine main indices of the US, Europe and Asia. 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 5: 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)	
Fixed Effects					
Month	Yes	Yes			
Security × Maturity	Yes	Yes	Yes	Yes	
Month × Maturity			Yes	Yes	
Maturity					Yes
Security × Month					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 volumes scaled by the stock market capitalization. Standard errors are double-clustered at the stock and month levels. *, **, and *** represent statistical significance at the 10%, 5%, and 1% confidence levels, respectively.

Table 6: Volatility and variance swap portfolios sorted on outstanding short put 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 short put 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 7: 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 short put 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).