Currency Volatility and Global Technological Innovation

Po-Hsuan Hsu[1], Mark P.Taylor[2], Zigan Wang[3], Qi Xu[4]

National Tsing Hua University[1]
Washington University in St.Louis[2]
University of Hong Kong[3]
Zhejiang University[4]

ABFER 9th Annual Conference
May 26th 2022

Structure

Motivations

- Understanding the link between exchange rates and economic fundamentals is a central issue in international finance (James, Marsh, and Sarno, 2012; Rossi, 2013)
  - Strong empirical evidence of the exchange rate-fundamentals connection remains lacking in the literature(Meese and Rogoff, 1986; Mark, 1995; Cheung, Chinn, and Pascual, 2005 etc)
- Recent studies document the adverse impact of FX uncertainty on economic growth, production, and income at the aggregate level (Frankel and Rose, 2002; Aghion, Bacchetta, Rancière, and Rogoff, 2009).)
- At the firm level, excessive exchange rate volatility would increase uncertainty, which unavoidably impacts their operation and investment decisions

What's New

- We examine the real effects of FX volatility from an important yet hitherto unexplored perspective: *firm-level technological innovation*.
  - The importance of technological innovation in promoting economic growth (Solow (1957), Kydland and Prescott (1982), Romer (1986, 1990))
  - Innovation activities are long-term risky investments, which are highly subject to macroeconomic uncertainty (RBC model: Aghion, Angeletos, Banerjee, and Manova (2010); Real option models of Bloom and Van Reenen (2002) and Bloom, Bond, and Van Reenen (2007))
  - R&D: intangible long-term investment creates growth option, determines long term value, much risky, countercyclical, and recently grows much faster than traditional tangible investment
  - A lack of empirical evidence on the role of international finance on firm-level innovation activities.

What We Do and What We Find

- Firms with higher foreign exchange volatility hold more cash and produce fewer patents and patents with fewer citations
- We use a Bartik-style instrument and two major historical shocks to identify the effect of FX volatility
- The negative relation can be attributed to firms' precautionary savings needs and overall trade slowdown
- The negative relation is stronger for firms with financial constraints, with smaller size, with the use of foreign debt, and in more open economies
- The negative relation is weaker for firms with derivatives hedging, and in countries with better financial development

Contributions

- This paper adds new evidence to the literature on the real effects of FX volatility.
  - Existing studies on FX volatility mainly focus on the asset pricing implications
  - Arguably one of the first to analyze the impact of FX volatility on firm operations.
  - New insights into the exchange rate-fundamentals connection
- From a broader perspective, this work is related to the debate on the stability and regulation of foreign exchange rates
  - One reason for FX volatility to slow down economic growth is through reducing innovation activities and investments.
- Provides new evidence for the adverse effects of macroeconomic uncertainty on intangible investments
  - Supports the argument that government policies for reducing macroeconomic uncertainty is important for knowledge capital accumulation and application
  - Focus on a more specific and precisely measured uncertainty

Exchange Rate Data and Exchange Rate Volatility

- Exchange rate data: 48 daily USD-denominated spot exchange rates from January 1989 to December 2018 from Datastream (as in Menkhoff et al.,2012)
- Exchange rate change: $r_{m,t} = \Delta s_{m,t} = Ln(S_{m,t}) - Ln(S_{m,t-1})$
- Market-level exchange rate volatility : Realized volatility $Vol_{m,t} = \sqrt{\frac{1}{K}\sum_{k=1}^{K}(r_{m,t,k} - \overline{r_{m,t}})^2}$, for currency for market m, day k, year t.
- Firm-level weighted average exchange rate volatility for firm f: $Vol_{f,m,t} = \sum_{m=1}^{M} vol_{m,t} * Exposure_{f,m,t} = \frac{\sum_{m=1}^{M} vol_{m,t} Sales_{f,m,t}}{\sum_{m=1}^{M} Sales_{f,m,t}}$
  - It can be viewed as a general version of "Bartik (1991)-style "instrument. (Goldsmith-Pinkham, Sorkin, and Swift, 2020; Kelpacz, 2021)

Currency Derivatives Usage and Foreign Debt

- Currency derivatives usage
  Following Allayannis et al, (2012), We hand collect firm level currency derivatives usage information by searching for keywords such as "derivatives", "hedging", and "foreign exchange" or "exchange rate" or "currency" from SEC 20-F annual reports (for US listed international firms) and from Reuters Eikon (for non-US listed firms)
  We consider derivative usage firms and non-usage firms
- Foreign debt
  Following Kalemli-Ozcan, Liu, and Shim (2021), We construct a firm-level foreign debt measure based on the market-level foreign debt.
  i)construct a market-level foreign debt measure based on the non-financial sector debt share (from BIS), ii) firm-level foreign debt by assuming each firm's foreign debt share is equal to the aggregate market-level foreign debt share, iii)obtain firm-level foreign debt by multiplying firm-level total debt by foreign debt share

Firm-Level Innovation Measures

- We consider six prevalent measures of firm innovation activities
- R&D expenditure to total asset ratio (innovation inputs) from Computat-Global/Worldscope
- Patent (quantity of innovation outputs)
  Patents that are registered in home country (REGPAT) and in the US (Univ of Virginia, USPTO, NBER)
- Citation (quality of innovation outputs)
  Citation of patents registered in home country (REGPAT) and in the US (Univ of Virginia, USPTO, NBER)
- Propensity to file a patent in a year (extensive margin)

Other Innovation Characteristics

- We also go beyond the number and citation of patents (innovation intensity) and consider in depth four measures of patents' characteristics (direction of innovations)
- Originality and Generality follow Hall et al (2005)
  Originality (Generality): Patents that cite (being cited) a wider array of technology classes of patents
- Exploration and Exploitation follow Benner and Tushman (2002)
  Exploration (Exploitation): 80% or more of its citations are based on new knowledge outside (within) of a firm's existing expertise

Other Firm-Specific Control Variables and Sample Construction

- Conventional firm-specific control variables from Compustat-Global/Worldscope
  Tobin Q, EBITDA, earnings volatility, loss, leverage, pre-tax book income (PTBI), volatility of PTBI, sales change, size, and firm age
- Initial Sample from Compustat-Global/Worldscope with i) foreign sales information from FactSet Geographic Exposure, ii)available exchange rate data from Datastream, iii)merge with patent and citation data from REGPET and USPTO, iv)keep only firms with at least one patent granted
- Final Sample of 10,624 firm-year observations in 32 markets from 1989 to 2018

Summary Statistics

Dependent Variables	Obs	Mean	Std	Median
CASH_RATIO_AT	8,928	0.17	0.13	0.13
CITATION_DOM_LN	10,624	0.05	0.36	0.00
CITATION_US_LN	10,624	0.26	1.03	0.00
EXPLOIT_RATE	10,624	0.00	0.02	0.00
EXPLORE_RATE	10,624	0.03	0.15	0.00
FILE_PATENT_DUMMY	10,624	0.17	0.37	0.00
GENERALITY	10,624	0.00	0.02	0.00
ORIGINALITY	10,624	0.00	0.03	0.00
PATENT_DOM_LN	10,624	0.10	0.57	0.00
PATENT_US_LN	10,624	0.47	1.33	0.00
PREDICTED_EPS_DISPERSION	4,668	0.22	0.65	0.12
RD_RATIO_AT	10,624	0.02	0.07	0.01

Independent Variables	Obs	Mean	Std	Median
WEIGHTED_ERM_SHOCK	250	0.00	0.01	0.00
WEIGHTED_FIXED_TO_FLOAT	10,624	0.00	0.02	0.00
WEIGHTED_FLOAT_TO_FIXED	10,624	0.00	0.02	0.00
WEIGHTED_GARCH_VOL	10,421	0.04	0.06	0.02
WEIGHTED_NEWS_UNCERTAINTY	9,650	1.45	1.59	0.85
WEIGHTED_ROSSI_FORECAST_UNCERTAINTY	10,094	0.28	0.22	0.25
WEIGHTED_VOL	10,624	0.02	0.02	0.02

Interaction Variables	Obs	Mean	Std	Median
KZ_INDEX	9,462	-0.22	2.26	0.33
FINANCIAL_DEVT	9,500	141.42	38.35	160.36
FX_DEBT_RATIO_AT	965	0.01	0.01	0.01
FX_DERI	2,923	0.28	0.45	0.00
IMP_EXP_RATIO	9,607	47.25	31.37	35.60
SALES_LN	10,345	20.61	2.04	20.62

Control Variables	Obs	Mean	Std	Median
WEIGHTED_FX_RATE_CHANGE	10,624	0.00	0.02	0.00
EBIDTA	10,624	0.09	0.08	3.14
EBIDTA_VOL	10,624	0.05	0.05	0.10
FIRM_AGE	10,624	2.99	0.51	0.00
LEVERAGE	10,624	0.13	0.13	0.05
LOSS	10,624	0.13	0.34	0.03
PTBI	10,624	0.05	0.10	0.00
PTBI_VOL	10,624	0.05	0.06	1.07
SGA_DELTA	10,624	0.00	0.07	20.67
TOBINQ	10,624	1.38	0.97	1.07
TOTAL_ASSETS_LN	10,624	20.85	2.09	20.67

Baseline Results: Effects of firm-level FX vol on innovations

- $Innov_{f,m,t+k} = \alpha + \beta Vol_{f,m,t} + X_{f,m,t} + \Phi_f + \Phi_{m,m',t} + \epsilon_{f,m,t+k}$
  - $Innov_{f,m,t+k}$ is one of the six innovation measures of R&D (RD_RATIO_AT), patent (PATENT_DOM_LN, PATENT_US_LN), citation (CITATION_DOM_LN, CITATION_US_LN), and propensity to file a patent (FILE_PATENT_DUMMY), and a measure of firm cash holding (CASH_RATIO_AT)
  - $Vol_{f,m,t}$ is the firm-level weighted average foreign exchange volatility (WEIGHTED_VOL)
  - $X_{f,m,t}$ includes weighted exchange rate changes and other firm level control variables
  - We include *market-market-year* fixed effects $\Phi_{m,m',t}$(absorb not only market-level macro variables but also bilateral variables)
  - We also include firm fixed effects, cluster standard errors at market level

Baseline Results: Effects of firm-level FX vol on innovations

	(1) CASH_RATIO_AT	(2) RD_RATIO_AT	(3) PATENT_DOM_LN	(4) CITATION_DOM_LN	(5) PATENT_US_LN	(6) CITATION_US_LN	(7) FILE_PATENT_DUMMY
WEIGHTED_VOL	0.141**	-0.0871**	-1.046***	-0.157***	-4.095***	-3.528***	-1.794***
	(2.469)	(-2.249)	(-7.846)	(-4.581)	(-7.956)	(-4.249)	(-5.293)
WEIGHTED_FX_RATE_CHANGE	-0.0684**	0.0833	-0.0819	-0.000783	1.398***	1.045***	0.215*
	(-2.394)	(1.594)	(-1.014)	(-0.0135)	(4.525)	(5.205)	(1.768)
TOBINQ	0.0122**	2.92e-05	-0.00457	0.00409	-0.0233	-0.0129	-0.00621
	(2.426)	(0.0125)	(-0.413)	(0.811)	(-0.543)	(-0.545)	(-0.401)
EBIDTA	-0.00681	0.0340	-0.211**	-0.0653	1.394	0.528	0.167
	(-0.0452)	(1.280)	(-2.591)	(-0.422)	(1.404)	(1.039)	(1.092)
EBIDTA_VOL	0.171***	-0.0150	-0.0689	-0.117	0.680**	0.517	0.180*
	(4.599)	(-0.428)	(-0.430)	(-0.838)	(2.145)	(1.328)	(1.890)
PTBI	0.0981*	0.00988	0.0914	0.00926	-0.559***	-0.0240	-0.0737
	(1.772)	(0.458)	(0.798)	(0.426)	(-3.043)	(-0.146)	(-1.622)
PTBI_VOL	-0.0872	0.000831	0.211	0.146	0.664	-0.168	0.231
	(-1.690)	(0.0202)	(1.667)	(1.401)	(1.102)	(-0.556)	(1.390)
LEVERAGE	-0.0127	0.00676	0.0287	0.0183	0.162	-0.0356	0.00873
	(-0.719)	(1.249)	(1.007)	(1.558)	(0.795)	(-0.429)	(0.293)
LOSS	0.00354*	0.00122**	-0.00973	-0.00421	-0.00748	-0.0132	0.00322
	(1.774)	(2.109)	(-1.275)	(-1.077)	(-0.167)	(-0.321)	(0.253)
SGA_DELTA	-0.0226	-0.00838	0.0249	0.0389*	0.133*	0.0581	-0.0383*
	(-0.549)	(-0.560)	(0.707)	(1.734)	(1.722)	(0.406)	(-2.038)
TOTAL_ASSETS_LN	-0.0440***	-0.00457***	0.0258	0.0165	0.104***	0.0551	0.0330
	(-3.244)	(-3.562)	(0.534)	(0.247)	(3.233)	(1.402)	(1.394)
FIRM_AGE	0.0548***	-0.00505	0.0466	0.0403	2.091**	1.269***	0.485*
	(4.392)	(-0.601)	(0.435)	(1.615)	(2.433)	(3.372)	(1.917)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,928	10,624	10,624	10,624	10,624	10,624	10,624
R-squared	0.909	0.949	0.832	0.902	0.800	0.835	0.809

Baseline Results: Effects of firm-level FX vol on innovations

- The effects of FX volatility are negative and significant for innovation inputs, outputs, and propensity to innovate; positive and significant for cash holdings
- Not only statistically significant but also economically meaningful
- One standard deviation increase in the volatility results in 7.3% decrease in R&D ratio, 2% and 0.3% decreases in domestic patent and citations, and 7.8% and 6.8% decreases in US patent and citations, 21.4% decrease in propensity to file a patent, and 1.7% increase in cash holdings.

Innovation Characteristics

	(1) GENERALITY	(2) EXPLOIT_RATIO	(3) ORIGINALITY	(4) EXPLORE_RATIO
WEIGHTED_VOL	0.00275*	0.00708***	-0.0214**	-0.150***
	(1.870)	(3.037)	(-2.219)	(-3.669)
WEIGHTED_FX_RATE_CHANGE	-0.000869	-0.00241***	0.00397	-0.0232
	(-1.130)	(-3.046)	(1.182)	(-1.064)
TOBINQ	0.000542	-0.000157	-0.00125	-0.00287
	(1.579)	(-1.152)	(-1.337)	(-0.689)
EBIDTA	0.00107	0.00629*	-0.00260	-0.00950
	(1.211)	(1.942)	(-0.612)	(-0.269)
EBIDTA_VOL	-0.00341	0.0113	0.00281	0.0777
	(-0.700)	(1.096)	(0.210)	(1.120)
PTBI	-0.00158*	-7.14e-05	0.00243	0.0153
	(-1.879)	(-0.0759)	(1.280)	(0.823)
PTBI_VOL	0.00337	-0.00626	0.00167	-0.00259
	(1.312)	(-1.028)	(0.262)	(-0.0831)
LEVERAGE	-0.00168*	-0.000414***	-0.00375	0.00980
	(-1.700)	(-2.857)	(-1.063)	(1.101)
LOSS	6.47e-05	0.000503***	-5.43e-05	-0.00645*
	(0.418)	(4.339)	(-0.137)	(-1.987)
SGA_DELTA	0.00262	-0.00230	0.00283	0.0142
	(1.171)	(-0.918)	(1.022)	(0.883)
TOTAL_ASSETS_LN	-0.000972	-0.000108	0.000658	0.0202
	(-1.379)	(-0.669)	(0.388)	(1.013)
FIRM_AGE	0.00284***	0.000715	0.00130	-0.0498
	(2.917)	(0.826)	(0.249)	(-1.569)
Constant	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes
Observations	10,624	10,624	10,624	10,624
R-squared	0.930	0.932	0.867	0.872

Innovation Characteristics

- Higher FX volatility is positively associated with generality and exploitation ratio
- It is negatively associated with originality and exploration ratio
- FX volatility discourages long-term investment in innovation projects that are radical and different from firms' existing expertise
- The positive relation with patent generality and exploitation can be attributed to firms' resource-shifting

Robustness Checks

- Results hold for GARCH volatility
- Using two historical shocks in the FX markets: exchange rate regime changes (from float to fixed and from fixed to float) and 1992 European Exchange Rate Mechanism (ERM) Black Wednesday confirm our main findings and strengthen the identification

Mechanisms: Precautionary saving needs

- When FX volatility surges, firms are concerned about future profits and cash flows and may thus delay their investments and initiatives to enhance their precautionary savings
- It is difficult for firms to collateralize their innovation outputs that often take the form of intellectual property and such difficulty increases firms' needs for precautionary savings

Financial Constraint

	(1) CASH_RATIO_AT	(3) RD_RATIO_AT	(5) PATENT_DOM_LN	(6) CITATION_DOM_LN	(7) PATENT_US_LN	(8) CITATION_US_LN	(9) FILE_PATENT_DUMMY
WEIGHTED_VOL * KZ_INDEX	0.0963**	-0.0222**	-0.477***	-0.119**	-1.360***	-1.011***	-0.487***
	(2.645)	(-2.343)	(-4.601)	(-2.550)	(-6.843)	(-4.143)	(-4.505)
WEIGHTED_VOL	-0.0104	-0.0243	-1.425***	-0.343***	-5.075***	-4.238***	-1.901***
	(-0.228)	(-0.969)	(-7.671)	(-6.171)	(-21.10)	(-8.334)	(-9.974)
KZ_INDEX	-0.0154***	0.000545***	0.00945***	0.00277	0.00963	0.0229***	0.00634
	(-5.425)	(3.112)	(3.124)	(1.344)	(0.762)	(3.997)	(1.290)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,160	9,462	9,462	9,462	9,462	9,462	9,462
R-squared	0.922	0.955	0.868	0.949	0.816	0.857	0.827

Firm Sales

	(1) CASH_RATIO_AT	(3) RD_RATIO_AT	(5) PATENT_DOM_LN	(6) CITATION_DOM_LN	(7) PATENT_US_LN	(8) CITATION_US_LN	(9) FILE_PATENT_DUMMY
WEIGHTED_VOL * SALES_LN	-0.0745**	0.0307***	0.782***	0.376***	4.442***	1.820*	1.019***
	(-2.520)	(3.629)	(4.540)	(3.854)	(3.393)	(2.005)	(4.014)
WEIGHTED_VOL	1.632**	-0.688***	-16.04***	-7.412***	-91.73***	-38.37**	-21.87***
	(2.467)	(-3.667)	(-4.481)	(-3.601)	(-3.407)	(-2.091)	(-4.245)
SALES_LN	0.00575	0.00652*	0.0138	0.00757*	0.0368	0.0720**	-0.00205
	(1.302)	(1.945)	(1.265)	(1.761)	(1.001)	(2.380)	(-0.215)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,697	10,345	10,345	10,345	10,345	10,345	10,345
R-squared	0.915	0.965	0.864	0.927	0.803	0.851	0.816

Foreign Debt

	(1) CASH_RATIO_AT	(3) RD_RATIO_AT	(5) PATENT_DOM_LN	(6) CITATION_DOM_LN	(7) PATENT_US_LN	(8) CITATION_US_LN	(9) FILE_PATENT_DUMMY
WEIGHTED_VOL * FX_DEBT_RATIO_AT	55.35***	-41.39**	-110.6***	-28.27**	-61.32***	-9.493***	-80.91***
	(7.592)	(-3.272)	(-4.096)	(-3.833)	(-5.522)	(-4.863)	(-4.328)
WEIGHTED_VOL	-0.665***	0.593***	1.030**	0.202**	0.813***	-1.204***	0.858***
	(-50.78)	(4.429)	(3.934)	(3.181)	(6.588)	(-17.16)	(4.878)
FX_DEBT_RATIO_AT	-2.773**	-2.218***	4.052**	0.850**	0.476***	0.860**	1.295**
	(-2.782)	(-7.847)	(3.541)	(3.745)	(4.456)	(3.019)	(3.042)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	810	965	965	965	965	965	965
R-squared	0.876	0.659	0.960	0.995	0.978	0.981	0.939

Financial Development

	(1) CASH_RATIO_AT	(3) RD_RATIO_AT	(5) PATENT_DOM_LN	(6) CITATION_DOM_LN	(7) PATENT_US_LN	(8) CITATION_US_LN	(9) FILE_PATENT_DUMMY
WEIGHTED_VOL * FINANCIAL_DEVT	-0.0111***	0.00174**	0.0434***	0.0198**	0.155***	0.145**	0.0587***
	(-6.038)	(2.722)	(4.388)	(2.612)	(3.749)	(2.522)	(2.823)
WEIGHTED_VOL	1.710***	-0.333***	-6.265***	-2.836**	-22.07***	-22.15**	-9.420**
	(6.306)	(-2.882)	(-4.035)	(-2.390)	(-3.015)	(-2.422)	(-2.650)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,015	9,500	9,500	9,500	9,500	9,500	9,500
R-squared	0.917	0.912	0.852	0.902	0.818	0.847	0.819

Earnings Forecast Dispersions

	(1) PREDICTED_EPS_DISPERSION
WEIGHTED_VOL	3.808***
	(3.997)
Control	Yes
Constant	Yes
Market*Market*Year FE	Yes
Firm FE	Yes
Cluster at Market Level	Yes
Observations	4,668
R-squared	0.657

Mechanisms: Precautionary saving needs

- Firm may cut innovation investment to hold more cash in order to sustain day to day business (Cash holding as the dependent variable)
- The negative FX volatility-innovation relation is stronger for firms with tightened financial constraint (use the interaction term between FX uncertainty and Kaplan and Zingales (1997) KZ financial constraint index)
- The negative relation is weaker in firms with higher sales
- The negative relation is stronger in firms with foreign debts
- The negative relation is weaker for firms in countries with better developed financial markets
- FX volatility is followed by higher earning uncertainty (Analyst earnings forecast dispersions from IBES as the dependent variable)

Mechanisms: Trade slowdown

- Since high-tech or innovative firms rely on international trade and cross-border activities to a greater extent, they are also hurt the most by trade slowdowns due to FX volatility (Kenen and Rodrik, 1986)
- High FX volatility may therefore impede high-tech firms exporting their products and importing innovation input materials, which likely leads to lower patent outputs

The Use of Currency Derivatives

	(2) CASH_RATIO_AT	(3) RD_RATIO_AT	(5) PATENT_DOM_LN	(6) CITATION_DOM_LN	(7) PATENT_US_LN	(8) CITATION_US_LN	(9) FILE_PATENT_DUMMY
WEIGHTED_VOL * FX_DERI	-0.485***	0.300***	1.469***	0.637***	4.562***	3.716***	2.177***
	(-4.655)	(3.297)	(3.040)	(2.966)	(3.934)	(2.921)	(5.670)
WEIGHTED_VOL	-0.306	-0.249	-1.743***	-0.535	-9.738***	-9.455**	-5.747***
	(-0.443)	(-1.616)	(-2.793)	(-0.974)	(-4.402)	(-2.616)	(-10.40)
FX_DERI	0.0109	-0.00291	-0.0883*	-0.0434	0.00447	0.0251	-0.0289
	(1.588)	(-1.434)	(-1.787)	(-1.238)	(0.0926)	(0.567)	(-1.601)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,368	2,923	2,923	2,923	2,923	2,923	2,923
R-squared	0.955	0.957	0.928	0.930	0.953	0.960	0.940

Economic Openness

	(1) CASH_RATIO_AT	(2) RD_RATIO_AT	(3) PATENT_DOM_LN	(4) CITATION_DOM_LN	(5) PATENT_US_LN	(6) CITATION_US_LN	(7) FILE_PATENT_DUMMY
WEIGHTED_VOL * IMP_EXP_RATIO	0.00872***	-0.00447**	-0.117**	-0.0469**	-0.922**	-0.578**	-0.231**
	(2.990)	(-2.361)	(-2.569)	(-2.682)	(-2.052)	(-2.131)	(-2.264)
WEIGHTED_VOL	-0.326***	0.134**	3.556**	1.687***	30.24**	18.43**	6.555**
	(-2.859)	(2.272)	(2.442)	(3.138)	(2.221)	(2.179)	(2.046)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,712	9,607	9,607	9,607	9,607	9,607	9,607
R-squared	0.913	0.974	0.846	0.913	0.813	0.846	0.818

Mechanisms: Trade slowdown

- The negative FX volatility-innovation relation for firms to use currency derivatives to hedge their FX exposures
- The negative relation is stronger for countries with higher degrees of economic openness

Conclusion

- A cross-country firm-level empirical investigation about the real effect of foreign exchange volatility on technological innovations
- Construct a firm-level weighted average FX volatility (Bartik-style instrument) along with two historical FX shocks to enhance identification
- FX volatility negatively affects innovation inputs, innovation outputs, propensity to innovate, while positively affects cash holdings
- FX volatility positively affects innovation generality and exploitation ratio while negatively affects innovation original and exploration ratio
- Both precautionary saving and trade slowdown contribute to the negative relation

Thank You!

Appendix:GARCH Volaility

	(1) CASH_RATIO_AT	(2) RD_RATIO_AT	(3) PATENT_DOM_LN	(4) CITATION_DOM_LN	(5) PATENT_US_LN	(6) CITATION_US_LN	(7) FILE_PATENT_DUMMY	(8) GENERALITY	(9) EXPLOIT_RATIO	(10) ORIGINALITY	(11) EXPLORE_RATIO
WEIGHTED_GARCH_VOL	0.0369***	-0.00698***	-0.133***	-0.0503**	-1.086***	-0.583***	-0.395***	0.000535***	0.00126***	-0.00406***	-0.0251***
	(5.139)	(-3.257)	(-2.953)	(-2.335)	(-8.368)	(-3.716)	(-8.126)	(2.824)	(3.259)	(-2.932)	(-4.159)
WEIGHTED_FX_RATE_CHANGE	-0.0416*	0.0805	-0.177**	-0.0144	0.939***	0.749***	-0.0132	-0.00195***	-0.00461***	-0.00896*	-0.0503**
	(-1.924)	(1.588)	(-2.103)	(-0.264)	(4.042)	(5.950)	(-0.161)	(-3.686)	(-4.889)	(-1.922)	(-2.270)
TOBINQ	0.0115**	7.54e-05	-0.00829	0.000549	-0.0406	-0.0223	-0.0110	9.27e-05	-0.000199	-0.00135	-0.00445
	(2.070)	(0.0306)	(-0.772)	(0.174)	(-0.793)	(-0.801)	(-0.650)	(1.294)	(-1.565)	(-1.381)	(-1.199)
EBIDTA	0.0481	0.0258	-0.258***	-0.0906	1.218	0.411	0.148	-0.000299	0.00572	-0.00190	-0.0169
	(0.367)	(1.047)	(-2.811)	(-0.579)	(1.354)	(0.967)	(1.022)	(-0.454)	(1.638)	(-0.500)	(-0.567)
EBIDTA_VOL	0.139***	-0.00574	-0.0578	-0.0915	0.479	0.458	0.129	0.00179	0.0121	0.00648	0.0868
	(3.144)	(-0.146)	(-0.312)	(-0.700)	(1.579)	(1.137)	(1.085)	(0.691)	(1.045)	(0.516)	(1.196)
PTBI	0.0798	0.0129	0.145	0.0448	-0.393**	0.156	-0.0441	0.00107**	0.000736	0.00477*	0.0187
	(1.553)	(0.581)	(1.172)	(1.687)	(-2.385)	(0.857)	(-0.832)	(2.053)	(0.801)	(1.845)	(0.722)
PTBI_VOL	-0.0307	-0.00512	0.240*	0.144	0.765	-0.125	0.271	0.00271**	-0.00692	0.000183	-0.000159
	(-0.479)	(-0.111)	(1.748)	(1.434)	(1.147)	(-0.409)	(1.547)	(2.114)	(-1.012)	(0.0259)	(-0.00475)
LEVERAGE	0.000633	0.00798	0.0380	0.0170*	0.215	0.0424	0.0359	0.000609**	-0.000735**	-0.00145	0.00669
	(0.0349)	(1.534)	(1.560)	(1.836)	(1.017)	(0.400)	(1.198)	(2.384)	(-2.394)	(-0.566)	(0.798)
LOSS	0.00233	0.000857	-0.0102	-0.00186	-0.00752	-0.0144	0.00390	0.000176	0.000462***	0.000127	-0.00570**
	(1.256)	(1.578)	(-1.371)	(-0.563)	(-0.170)	(-0.378)	(0.282)	(1.097)	(4.497)	(0.389)	(-2.112)
SGA_DELTA	-0.000970	-0.0164	-0.00528	0.0162	0.0249	-0.0477	-0.0544**	0.000864	-0.00279	0.00157	0.0142
	(-0.0268)	(-1.039)	(-0.106)	(0.623)	(0.391)	(-0.327)	(-2.049)	(0.518)	(-1.036)	(0.385)	(0.569)
TOTAL_ASSETS_LN	-0.0518***	-0.00548***	0.0367	0.0268	0.0932**	0.0599	0.0258	-0.000355	8.93e-05	0.00135	0.0220
	(-4.042)	(-4.406)	(0.850)	(0.423)	(2.636)	(1.379)	(1.172)	(-1.193)	(1.061)	(1.065)	(1.176)
FIRM_AGE	0.0606***	-0.00522	0.0227	0.0264	2.122**	1.300***	0.495*	0.00170**	0.000787	0.000699	-0.0550
	(4.458)	(-0.604)	(0.197)	(0.983)	(2.343)	(3.130)	(1.940)	(2.510)	(1.439)	(0.126)	(-1.655)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,759	10,421	10,421	10,421	10,421	10,421	10,421	10,421	10,421	10,421	10,421
R-squared	0.912	0.951	0.846	0.913	0.804	0.842	0.813	0.946	0.939	0.890	0.885

Appendix:Exchange Rate Regime Changes

	(1) CASH_RATIO_AT	(3) RD_RATIO_AT	(5) PATENT_DOM_LN	(6) CITATION_DOM_LN	(7) PATENT_US_LN	(8) CITATION_US_LN	(9) FILE_PATENT_DUMMY
WEIGHTED_FIXED_TO_FLOAT	0.208***	-0.0453*	-0.716***	-0.261***	-7.174***	-2.787***	-1.779***
	(3.324)	(-2.031)	(-3.178)	(-3.481)	(-3.286)	(-4.764)	(-3.124)
WEIGHTED_FLOAT_TO_FIXED	-0.317***	0.0671**	1.708***	0.238***	6.556***	0.802***	1.437***
	(-2.953)	(2.051)	(5.860)	(6.315)	(4.290)	(4.298)	(2.981)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,928	10,624	10,624	10,624	10,624	10,624	10,624
R-squared	0.909	0.949	0.832	0.902	0.801	0.835	0.809

Appendix:European Exchange Rate Regime (ERM) Shock

	(1) CASH_RATIO_AT	(2) RD_RATIO_AT	(3) PATENT_DOM_LN	(4) CITATION_DOM_LN	(5) PATENT_US_LN	(6) CITATION_US_LN	(7) FILE_PATENT_DUMMY
WEIGHTED_ERM_SHOCK	2.979**	-0.862*	-30.90***	-36.77***	-2.009***	-33.68***	-33.02***
	(2.566)	(-1.893)	(-8.533)	(-7.887)	(-3.270)	(-3.118)	(-10.23)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Market*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster at Market Level	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	228	269	269	269	269	269	269
R-squared	0.928	0.940	0.965	0.936	0.975	0.945	0.875