Global Monetary Policy Shocks and Export Prices*

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Abstract

This paper examines how global monetary policies impact the export pricing behaviors of Chinese firms using unexpected exogenous monetary shocks and disaggregated customs export data. Our findings show that the unexpected tightening of the US monetary policy will lead to an increase in China's export prices. This effect is attributed to a borrowing cost channel, which is related to firms' trade credit and liquidity conditions. Moreover, the impact of US monetary policy shocks on export prices is more profound for firms that face higher borrowing costs, lower trade credit acquisitions, and tighter liquidity conditions. To further explain our empirical findings, we develop a heterogeneous firm trade model that incorporates financial frictions and external monetary shocks.

Keywords: Monetary policy, Export prices, Trade credit, Liquidity, Borrowing costs, Credit constraints.

JEL Codes: E52, F14, F33, F42.

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1 Introduction

How external shocks affect global exports is an essential question in international economics. Many papers have studied the effect of exchange rate shock, technology shock, trade liberalization shock, etc., while the role of international monetary policy shock is less well understood. The impact of international monetary shocks should be of at least equal significance, as they can substantially affect the real economy and financial markets, which in turn will shape the dynamics of international trade. This question is especially important for the US shock because it is a key driver of the global financial cycle (see Miranda-Agrippino and Rey (2020)), and the US dollar is the dominant currency in global transactions (see Gopinath et al. (2020)). Previous literature, especially theoretical works, usually focused on the exchange rate channel and highlighted the demand side impact. In this paper, using highly disaggregated micro-level data, we find that due to the existence of financial frictions, the US monetary shocks can affect Chinese exporters' pricing behaviors through a borrowing cost channel, where the impact is transmitted from the supply side. Our findings on export price responses to monetary policy shocks are closely related to the implementation of Fed monetary policy and will help us better understand its potential impact on inflation. One of the main goals of Fed policy is to curb inflation. Relevant to the purpose, this paper suggests that the tightening of US monetary policy may induce a rise in US import prices from China. This adverse effect could pose new challenges to the realization of policy objectives, given the large proportion of US imports from China. What is more, our findings reveal a new channel on how the US monetary policy could spill over to other countries through the trade linkage with China.

In our baseline empirical results, it is found that one unit of unexpected contractionary US monetary policy shock (100 basis increase in 2-year US treasury yield) could uplift China's export prices by around 15%. Here, the monetary shock is obtained from Bu, Rogers and Wu (2021), which is a composite measurement including the shifts of both conventional and unconventional monetary policy stances. It is largely unpredictable by any available information and less suffered from criticism of the central bank information effect.[1] Consequently, this shock serves as an ideal tool for us to study the monetary spillover effect on export prices with less concern for endogeneity, which is a long-lasting plague in the study of export price determinants.[2] Nevertheless, our

[1]Regarding the discussion on information effect of monetary policy, see Nakamura and Steinsson (2018), Jarociński and Karadi (2020), etc.

[2]Zhang (2022) indicates that many exchange rate pass-through studies usually directly regress export

findings are not exclusive for the shock of Bu, Rogers and Wu (2021). We also verified the results employing other commonly used high-frequency measurements (e.g., the 30-minute change of federal fund rate around the FOMC announcement, the shock of Guraynak, Sack and Swanson (2005), Nakamura and Steinsson (2018), Jarociński and Karadi (2020), etc.) and yielded a consistent conclusion. What's more, our finding is also robust to 1) different ways of aggregation in export price data, 2) sub-sample of single-product firms, 3) firms with different ownership, 4) different exporting destinations, 4) different exchange rate regimes, 5) alternative fixed effects and standard error cluster levels, 6) different currencies of price, 7) controlling more macroeconomic variables, 8) computing price change with approximate time match, and 9) adopting announcement date adjusted shocks, etc.

After the illustration of baseline empirical findings, we dive into the mechanisms under which the monetary policy transmission works. In summary, we propose a borrowing cost channel. More specifically, an unexpected US monetary tightening will induce the trade credit shrink and liquidity shortage for Chinese exporters, which consequently forces firms to rely more on external financing (e.g. bank loans, usually more expensive than internal financing), thus driving up the average borrowing cost and export prices. To verify this channel, we first reveal that a tightening US monetary shock will exacerbate the firms' trade credit and liquidity conditions. Then, we illustrate that monetary tightening caused trade credit and liquidity aggravation would force firms to borrow more from external financial institutions, thus yielding a higher borrowing cost. Moreover, consistent with the cost channel, it is found that the impact of the US monetary policy on export prices depends on firms' credit conditions: it is more prominent conditional on higher borrowing cost, lower trade credit acquisition, and tighter liquidity.

In addition, we conducted several additional analyses to help us acquire a deeper understanding of the proposed cost channel. To start with, we decompose the firm-level export price change into markup and marginal cost change following the method proposed by De Loecker and Warzynski (2012) and investigate their responses, respectively. The results show that only the marginal cost responds significantly to the US monetary policy shock, and the reaction of markup is relatively silent on average, which suggests that the US monetary policy shock mainly serves as a cost-push shock. In addition, the level of markup plays little role in explaining the cross-sectional difference in price

price changes on exchange rate shifts, which may generate biased estimation since some omitted global factor can simultaneously affect the export price and bilateral exchange rate. Also, traditional papers usually use annual or monthly federal fund rate change as a US monetary policy shock to study its spillover effect. However, only the unexpected component of this change can be treated as exogenous.

in response to external monetary shocks. Moreover, we explicitly demonstrate that the marginal cost shifts are mainly driven by financial costs rather than other input costs, like materials, wages, imported goods, etc. Finally, regarding the movement of borrowing costs, there might be another possible channel: the US tightening increases China's interest rate. However, we find that China's market interest rate responds quite mildly to the US monetary shock, which may be due to China's rigorous capital control and relatively independent monetary authority.

To strengthen the mechanism proposed above, we also provide several additional evidence. First, we reveal that FDI firms are less affected by the tightening US monetary shock due to their relatively stable trade credit and liquidity conditions. Second, we compare the responses of exporters participating in ordinary trade with those of processing trade and find that the impact on the former is much larger than the latter, which is consistent with our story. That is because processing traders usually face a more fixed production contract than ordinary traders and are less reliant on external financing. In addition, we also discuss and exclude two alternative explanations for the average price reactions to monetary policy shocks, namely the global demand shift and exchange rate pass-through channels.

For further discussion, we first explore the interaction of external monetary shocks and domestic monetary stances and find that the impact of US shocks is more powerful in impacting China's export price when the domestic monetary environment is more contractionary. Moreover, the tightening of domestic monetary policy will drive up the export price as well. Second, recent literature (e.g., Miranda-Agrippino and Nenova (2022), etc.) finds that the monetary shock from the European Central Bank (ECB) also has a substantial spillover effect, although it is less powerful than the influence of the Fed. We also test the impact of the ECB shock, but the results are not significant both economically and statistically, which indicates that US monetary policy, as an important driver of the global financial cycle, has a special role in shaping the dynamics of export behaviors throughout the world. Finally, it is argued in some papers (e.g. Manova and Zhang (2012), Manova (2013), Manova, Wei and Zhang (2015)) that firms' pricing behaviors are affected by their credit constraints. Those firms with binding credit constraints may behave differently from those non-binding firms. Consistent with their arguments, we explain that the US monetary tightening will also drive up the prices for those binding firms. Intuitively, the US monetary tightening will worsen firms' trade credit and liquidity conditions. Thus, firms need to borrow more from external financial institutions. To satisfy the rising credit needs, those firms should improve their credit access by increasing export prices and getting more cash flows as collateral.

To illustrate our proposed channel more clearly, we also build a partial equilibrium model. We follow the workhorse trade model (e.g., Melitz (2003) and Manova (2013)) and augment it with financial frictions, including credit constraint and working capital constraint, and global monetary policy shocks. Our model discusses the responses of export prices in two separate cases: binding versus non-binding credit constraint. In the former case, the US monetary tightening will deteriorate firms' credit conditions and they would be forced to increase prices to alleviate the credit restrictions. As for the latter, the US tightening-induced worsening of trade credit and liquidity conditions would motivate firms to borrow more from the financial market and undertake a higher borrowing cost. In the benchmark model, the optimization problem is static, the price setting is assumed to be flexible, and we don't explicitly consider currency invoicing and fixed entry costs. However, the conclusion is also robust to these extensions, the results of which are shown in Appendix D.

Our paper is mainly related to four strands of literature. To start with, many papers have revealed how financial frictions or credit restrictions affect international trade. For example, Manova (2013) identifies and quantifies three mechanisms through which credit constraints affect trade. Manova, Wei and Zhang (2015) show that foreign affiliates and joint ventures in China have better export performance than domestic private companies in financially more vulnerable sectors. Amberg, Jacobson and von Schedvin (2021) studies the role of trade credit in affecting firms' export prices. Nevertheless, the sources of the variation in credit conditions of an exporter are less explored. In light of this, our paper illustrates that the US monetary shock, as one of the main drivers of the global financial cycle, is an important force in shaping exporters' credit conditions. We also show that exporters' credit conditions could be affected through trade credit and liquidity. Moreover, to prove the credit mechanism, previous papers mainly rely on cross-sectional differences among firms. Our paper additionally provides supporting evidence to the credit channels through the time dimension differences, namely, the variation of credit conditions in reaction to time-varying global monetary policy shocks. This article is most closely related to the research by Lin and Ye (2018*b*), which shows that tightening US monetary policy has a significant effect on the sectoral composition of developing countries' exports, and financially more vulnerable sectors suffer a more negative impact. They focus on the impact on aggregate trade value using an annual cross-country sector-level bilateral trade dataset. However, our main interest lies in the pricing behavior of exporters. Furthermore, using firm-product-level data could help us identify a new borrowing cost channel through which the US monetary shocks would impact international trade. To our knowledge, this is the first paper to empirically investigate exporters' pricing behaviors in response to external monetary policy shocks using detailed micro-level data.

Second, our paper is part of a large body of literature on the domestic and international transmission of monetary policy (e.g., Miranda-Agrippino and Rey (2020)), especially those on price puzzles and the cost channel of monetary policy.[3] Some empirical papers find that monetary easing will cause a decrease in domestic prices, which is contrary to the prediction of canonical macroeconomic models, and this phenomenon is called a "price puzzle". A branch of literature (e.g., Sims (1992), Christiano, Eichenbaum and Evans (1994), Bernanke and Mihov (1998)) thinks that this is due to the misspecification of empirical design and the inclusion of commodity price can solve this puzzle. Another branch argues that this is evidence of the cost channel of monetary policy, namely, monetary easing can improve the financing conditions of firms and thus decrease their borrowing cost, which will motivate firms to decrease prices (e.g., Barth III and Ramey (2002), Ravenna and Walsh (2006), Gaiotti and Secchi (2006), Boehl, Goy and Strobel (2022)). These papers explore how domestic monetary policy could affect price levels through the cost channel. By comparison, our paper studies the supply-side channel of monetary policy in an international context, and we especially highlight the role of trade credit and liquidity instead of interest rate in the transmission of cost channel. Furthermore, we also explore the interaction of foreign monetary shocks with domestic monetary policy stances.

Third, the relationship between monetary policy and international trade has been widely studied in international macroeconomic papers, usually in a small open economy model or a two-country model. For example, Lombardo and Ravenna (2014) investigates how trade openness affects monetary transmission. Bergin and Corsetti (2020) find that monetary stabilization contributes to a country's competitiveness in international trade. Cacciatore and Ghironi (2021) explore the implication of trade cost on monetary policy trade-off. In addition to these theoretical papers, we provide new evidence on how exporter pricing responds to international monetary policy shocks using detailed micro-data, which may help to better understand the transmission of monetary policy through trade. This may also shed light on the design of optimal monetary policy considering exporter responses to external shocks.

Finally, this paper contributes to the broad literature on the determinants of export prices. For example, the exchange rate pass-through literature studies how trade prices

[3] For more details, please refer to the survey paper of Bhattarai and Neely (2022).

respond to exchange rate shocks,[4] and some other articles investigate the impact of firm or country characteristics and trade liberalization on export prices (e.g., Manova and Zhang (2012), Fan, Lai and Li (2015), Harrigan, Ma and Shlychkov (2015), Fan, Li and Yeaple (2015), etc.). Compared with these papers, this article shows that the US monetary policy shock, one of the main drivers of the global financial cycle, constitutes an important additional force in influencing international export prices.

The remainder of this paper is organized as follows. Section 2 describes the data and measurements. Section 3 presents our main empirical results. Section 4 demonstrates the mechanism under which a monetary policy shock affects export prices. Section 5 provides more discussion. Section 6 introduces a partial equilibrium model to further explain the mechanism. Finally, Section 7 concludes.

2 Data and Measurement

To investigate how exporters adjust their export prices in response to foreign monetary policy shocks, we conduct our empirical tests using various data sources: (1) surprise shocks from US Fed (or European Central Bank) monetary policy; (2) customs trade data from China's General Administration of Customs; (3) the Annual Survey of Industrial Enterprise (ASIE) from the National Bureau of Statistics of China (NBSC). This section will introduce the basic information about these datasets and briefly describe the sample construction process.

2.1 Monetary policy shocks

We use the shock developed by Bu, Rogers and Wu (2021) as our baseline measure of the US monetary policy shock. This measure uses Fama and MacBeth (1973) two-step regressions: it first estimates the sensitivity of interest rates at different maturities to FOMC announcements and then regresses all outcome variables onto the corresponding estimated sensitivity index from step one. This measure has several attractive advantages: (1) it is largely unpredictable from the available information in the past so that we can regard it as exogenous for the US and even more exogenous for other countries; [5]

[4] See Obstfeld and Rogoff (2000), Amiti, Itskhoki and Konings (2014), and Li, Ma and Xu (2015), among others.

[5] Past literature usually directly uses the federal rate change as exogenous US monetary policy shock to study its spillover effect. The justification is that the economic condition of foreign countries,

(2) its information effect is not significant such that we can treat it as pure policy shock and avoid the confounding effect of the private information of the fed revealed through its policy actions; (3) this unified measure can make the effect of US monetary policy more comparable across conventional and unconventional monetary policy regimes. A unit of positive BRW shock will increase the daily 2-year US treasury rate by 100 basis points.[6] The monthly series can be seen in Figure 1. To match our monthly trade data, we mainly focus on the seven-year period from 2000-2006, which is marked with vertical red lines. Typically, there are eight scheduled FOMC meetings each year, and each meeting has a corresponding policy shock. If there is no FOMC announcement in a month, then the shock in this month is zero.[7]

It is worth noting that our results are not exclusive to this identification. We also use some other popular measurements, such as the 30-minute high-frequency changes in expected federal fund rate around the FOMC announcements, and Nakamura and Steinsson (2018) shock, which uses three eurodollar futures and two federal fund rate futures to extract the first principal component of these price changes. The underlying assumption of these shocks is that, in such a tight window around the FOMC statements, most of the asset price changes are driven by monetary policy instead of other factors. Also, if the financial market is efficient, the asset prices before the announcement have already absorbed all the available information; thus, the price changes capture the unexpected component of monetary policy shock. We also try Guraynak, Sack and Swanson (2005) shock, which also uses high-frequency approaches but decomposes the aggregate shock into two parts, the target, and the path, representing conventional monetary policy and forward guidance, respectively. Moreover, to further alleviate the concern about the information effect of the monetary policy, we also employ the pure monetary policy shock of Jarociński and Karadi (2020), which is identified through the movement directions of interest rates and stock prices. Regarding the monetary policy shock of the European area, we use the series of Miranda-Agrippino and Nenova (2022) who decompose the EU shock into three components: the “target”, “path”, and “lsap” shocks,

especially small economies, will not affect US monetary policy; thus, there is less concern for reverse causality. However, China is the largest exporting country and the second largest economy in the world, so it is unlikely that US monetary policy does not consider the impact originating from China. Even worse, there are still some common global shocks that can affect both the US monetary policy and China’s exports simultaneously. Thus, using this measure can substantially alleviate endogeneity concerns.

[6]By our measure, the average absolute value of monthly unexpected monetary policy shocks is 0.046, or a 4.6 basis point change in the interest rate, a scale much smaller than a one-unit shock.

[7]This procedure is widely used in the literature, such as Chari, Dilts Stedman and Lundblad (2021).

which represent policy rate change, forward guidance, and large-scale asset purchase, respectively. What's more, we also tried the pure policy shock constructed by Jarociński and Karadi (2020), the approach of which is similar to the US counterpart.

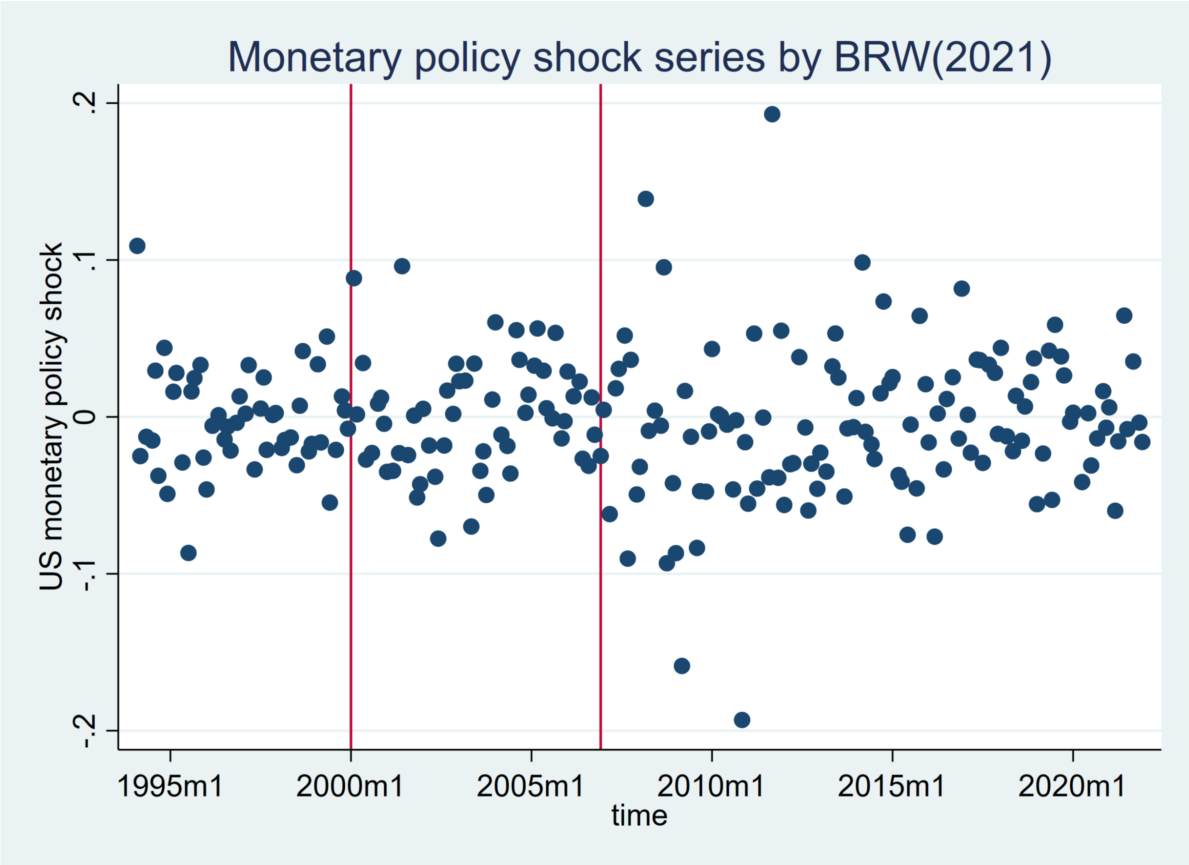

Figure 1: US monetary policy shock: Bu, Rogers and Wu (2021)

Note: The whole period of Bu, Rogers and Wu (2021) shocks series is from 1994 to 2021. One unit of positive shock means an increase in the daily 2-year US treasury rate by 100 basis points. This paper will focus on the 84 months from 2000 to 2006, which is marked with vertical red lines. We drop all months without any FOMC announcement, which means $brw = 0$.

2.2 Customs trade data

To investigate how exporters adjust their export prices in response to foreign monetary policy shocks, we first use the monthly transaction records from the General Administration of Customs of China (GACC) from 2000 to 2006.[8] This dataset includes the

[8]Because of data matching issues, we used the time period of 2000 to 2006 for the monthly data and 2000 to 2007 for the annual data.

most comprehensive information on all Chinese trade transactions, including each firm's import or export value denominated in US dollars, quantity, unit, product name and code, source or destination country, and the type of enterprises (e.g., state-owned, private, foreign-invested, and joint ventures), etc. In the raw data, each unique transaction refers to a firm-product-country-year/month entry. Of all customs information, each transaction's export value and quantity are of special interest because we can calculate the unit value by dividing the value by the quantity as an approximate measure of the export price, referring to the method of De Loecker and Warzynski (2012).

The categories of products in China's customs trade data are coded according to the Harmonized Coding and Description System (HS) of the World Customs Organization (WCO). The original data are subject to HS 8-digit classification. Since there were two major revisions of the HS system in 2002 and 2007, we aggregated HS8 product-level information to the HS6 level and then used conversion tables from the United Nations Trade Statistics to convert all codes into the older version of HS1996. We exclude unwanted observations referring to the standard of Li, Ma and Xu (2015): (1) products with inconsistent missing information of unit or quantity; (2) special product categories such as arms (HS2=93), antiques (HS2=97), and special categories (HS2=98 and 99); (3) transactions existing for only one year without any change over time.

Since we focus on the short-term price response of Chinese exporters, we will use disaggregated monthly-level records to match high-frequency monetary policy shocks. This is one of the main differences between this article and previous articles that used Chinese customs data, which mainly used annual value, quantities, and unit prices because we would like to observe more high-frequency price changes. To avoid including too much noise variation, we sum the price data to the firm level in the baseline regressions; meanwhile, we also exploit product and market differences using more disaggregated data.

2.3 Chinese firm-level data

The source of Chinese firm-level production and financial information is the Annual Surveys of Industrial Enterprises in China (ASIE) conducted by the National Bureau of Statistics of China (NBSC). This database includes all state-owned enterprises and above-scale firms with more than 5 million RMB in annual sales. Between 2000 and 2006, the dataset records 160,000 in 2000 to 300,000. Previous studies of the Chinese economy have widely used this database since it contains details about firms' identification codes, ownership, industry type, and about 80 other accounting variables on the three major accounting statements (i.e., balance sheets, profit & loss accounts, and cash flow statements). Among all that information, our research will focus on the variables related to two aspects: (1) firms' production costs and sales, including total wage payment, total operation inputs, and sales income, etc., (2) firms' financial costs, including interest payment and total financial expenses, and (3) liquidity conditions in balance sheets, such as accounts receivable and payable, net liquid assets, cash holding, and debts.

Manufacturing firms participating in international trade in the matched sample are uniquely identified by each observation's FRDM (legal entity) code and the survey year. To deal with reporting errors in the ASIE, we remove unsatisfactory observations referring to the criteria of Fan, Lai and Li (2015) and Brooks, Kaboski and Li (2021). We only keep firms that satisfy the following conditions: (1) the firm identification number cannot be missing and must be unique; (2) the key financial variables (such as total assets and sales income) cannot be missing; (3) the total assets must be greater than the liquid assets and total fixed assets; (4) the sales income cannot be negative; (5) the total liability cannot be negative; (6) the number of employees hired by a firm must not be less than 10.

We follow the standard procedure to match the identification codes based on the firms' contact information as in Fan, Li and Yeaple (2015) to merge these firm-level survey data with customs trade data. In Table 1, we provide summary statistics for firm information and their export patterns in our matched sample. One notable point is that the distribution of firms' export value is skewed to the right long-tail shape, with a few large exporters accounting for most of the trade value.

Table 1: Summary statistics

	Mean	SD	p50	p25	p75
ΔP	0.03	0.42	0.01	-0.11	0.17
# HS6 Products	6.29	10.31	3.00	2.00	7.00
Export Value (*1000 USD)	76024	8585801	2437	459	10335
Sales (*1000 RMB)	160148	1201262	34910	15350	90852
Employment	449	1210	197	96	418
Debt	0.55	0.26	0.56	0.37	0.74
IE/L	0.02	0.04	0.01	0.00	0.03
Liquid	0.10	0.29	0.10	-0.07	0.28
ϕ^{exp} (Export/Sales)	0.46	0.38	0.36	0.07	0.89
ϕ^{imp} (Import/Inputs)	0.18	0.30	0.01	0.00	0.25
Firm-year observations			270271		

Notes: This table shows the summary statistics of firms in the matched sample. The first row ΔP indicates monthly price changes, while all other rows describe annual-level firm variables. # HS6 Products denotes the number of HS6 product types exported by a company in a given year. *Debt* denotes the ratio of total liability over total assets, IE/L denotes the ratio of interest expense over total liability, and *Liquid* denotes the ratio of net liquid assets over total assets. ϕ^{exp} represents the export intensity, which is the firm-level ratio of exports to total sales. ϕ^{imp} represents the import intensity, which is the firm-level ratio of imports to total material inputs.

2.4 Export price index

The customs dataset contains disaggregated trade values denominated by US dollars and quantities for each HS6 product h, each firm i, to each country c, at time t, V_{ihct}, and Q_{ihct}. We compute the unit values as the proxy of export prices:

$$P_{ihct} = \frac{V_{ihct}}{Q_{ihct}}$$

Because product categories are highly subdivided, we believe that the unit value is an ideal proxy for the transaction-level price. [9]

[9] In robustness checks, we also use the exchange rate between the US dollar and Chinese RMB to convert all trade values into RMB denominations, that is, we compute $P_{ihct}^{RMB} = \frac{V_{ihct} \cdot NER_{US,t}}{Q_{ihct}}$ where

Using the above unit value price, we construct a firm-level Tornqvist price index using detailed information about the price of each product in each destination market following Smeets and Warzynski (2013). First, we aggregate the unit value to the firm-product level, which is the average price of product h produced by firm i weighted by the relative sales to each market c at time t, $P_{iht} = \sum_c s_{c,iht} P_{ihct}$, where the market-specific value share is $s_{c,ihct} = V_{ihct}/V_{iht}$.

Second, we calculate the weighted average of the firm-product level price growth rate $\Delta_n \ln P_{iht} = \ln P_{iht} - \ln P_{ih(t-n)}$, for all product categories across n periods:

$$\Delta_n \ln P_{it} = \sum_h \frac{s_{h,i(t-n)} + s_{h,it}}{2} \Delta_n \ln P_{iht}$$

where the product-specific value share is $s_{h,it} = V_{iht}/V_{it}$, and the effective weight is the average value of product weights at time t and $t-n$. In the monthly price baseline regression, we set the time gap n as 12 months. This firm-level price growth rate $\Delta_{12m} P_{it}$ describes year-over-year changes for the average export price of a certain exporter, considering all adjustments to both product and market scopes. We will exclude observations with the year-over-year growth rate of firm-level unit value in the top or bottom one percentile to avoid results being affected by extreme idiosyncratic factors other than monetary policy shocks. [10]

3 Empirical Results

This section describes our empirical specifications and shows how Chinese export prices adjust in response to unexpected US monetary policy shocks. We start from the baseline estimations of the firm-level price response and then conduct robustness tests.

3.1 Baseline specification

Similar to the literature in monetary economics (e.g. Nakamura and Steinsson (2018), Chari, Dilts Stedman and Lundblad (2021), and Gürkaynak, Karasoy-Can and Lee (2022), etc.), we directly regress the price change on the monetary shocks. In our

$NER_{US,t}$ is the bilateral nominal exchange rate of US dollars in terms of RMB in month t.

[10] The way we calculate annual price changes is similar to calculating monthly price changes. The difference is that we first sum all the value amounts and quantities to the annual total, then get the annual unit value, and finally calculate the change in adjacent years.

empirical analysis, we aggregate Chinese export prices at the firm level and treat this as our starting point. Although export unit values are at the firm-product-country level (namely, the transaction level), aggregation to firm-level price could avoid noise originating from too many dimensions. Specifically, the regression is:

$$\Delta \ln P_{it} = \alpha + \beta \cdot m_t + \Gamma \cdot \mathbf{Z}_{it-n} + \eta \cdot \Delta \ln P_{it-1} + \Psi \cdot \Omega_t + \xi_i + \varepsilon_{it} \tag{1}$$

where $\Delta \ln P_{it}$ represents the monthly year-over-year export price change of firm i at time t (compared with the same month in last year), m_t represents the unexpected monetary policy shock at time t.[11] In the baseline regression, we use the measure by Bu, Rogers and Wu (2021) as our monetary policy shocks m_t, while alternative measures will also be employed in robustness checks. Our variable of interest, β, represents the average response of the price to concurrent monetary policy surprises. One advantage of using our exogenous monetary policy shock measure and micro-level price is to deliver causality directly. $\mathbf{Z}_{it-n}$ denotes lagged controls of firm-level time-variant variables, including price changes in the previous month (controlling for price adjustment autocorrelation, n=1) and real sales income in the previous year (controlling for firm size, n=12). Ω_t represents time-variant variables. In the benchmark regression, we add the nominal USD/RMB exchange rate to account for the exchange rate pass-through, and in the robustness part, we also include more macroeconomic variables such as China's industrial production growth rate, China and US inflation rate, VIX index, commodity prices, etc. To control for unobserved firm heterogeneity, we include ξ_i, the firm-level fixed effects that capture any time-invariant factors for a given firm. As a comparison, we will also display the annual results. In this case, following Gürkaynak, Karasoy-Can and Lee (2022) and Di Giovanni and Rogers (2023), monetary shocks will be aggregated to an annual frequency. Also, the corresponding dependent variable is an annual price change, $\mathbf{Z}_{it-n}$ denotes price changes and real sales income in the previous year, and Ω_t represents the annual USD/RMB exchange rate change.

3.2 Export price responses to monetary policy shocks

The baseline results are shown in Table 2: Chinese exporters will increase (decrease) their average export prices in the short run, facing an unexpected contractionary (ex-

[11]The reason we use monthly year-over-year price change is to make the prices across periods more comparable without the noises originating from the seasonal variation of export prices. The results of month-on-month price changes are overall consistent and are available upon request.

pansionary) monetary policy shock from the US. That said, when the Federal Reserve unexpectedly raises the policy rate or cuts it less than expected, China's export prices would rise significantly that month.

In column (1) of Table 2, we only include the monthly shock and the monthly nominal USD/RMB change rate change. We find that one unit of US monetary policy shock (100 basis point unexpected increase in the 2-year US treasury yield rate) will induce an 18 % monthly increase in China's export prices on average. From columns (2)-(3), we observe that controlling other firm-level factors slightly reduces the magnitude of the price response to around 15 %, but the results are still significant. Columns (4)-(6) show the results where we aggregate the monthly sample to the annual level. In the annual sample, The dependent variable becomes annual price changes, and the monetary shock represents the sum of all the monthly shocks in that year. It turns out that the impact of the monetary shock is largely consistent with that of monthly regression.[12] Visually, we show the scattered plot of US monetary policy shock and China's monthly average export price change in Figure 2, which suggests that our results are not driven by some outliers.

[12]As for the controlled variables, the coefficients of lagged price change are opposite in the two versions: price changes display inertia in the short term and show a pattern of mean reverting in a relatively longer run, which is consistent with our intuition.

Table 2: Export price responses to US monetary policy shocks

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}			Annual ΔlnP_{it}		
brw_t	0.180***	0.182***	0.150***	0.177***	0.189***	0.244***
	(0.011)	(0.011)	(0.010)	(0.007)	(0.007)	(0.010)
$Sales_{it-n}$		-0.004**	-0.005***		-0.017***	-0.015***
		(0.002)	(0.001)		(0.002)	(0.003)
ΔlnP_{it-1}			0.299***			-0.303***
			(0.003)			(0.005)
ΔNER_t^{USD}	-0.777***	-0.815***	-0.654***	-0.717***	-0.925***	-1.119***
	(0.048)	(0.051)	(0.039)	(0.046)	(0.052)	(0.066)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1100400	1072227	917419	151542	147471	96296

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1)-(3) are changes in monthly prices, while columns (4)-(6) are changes in annual prices. All regressions include firm fixed effects.

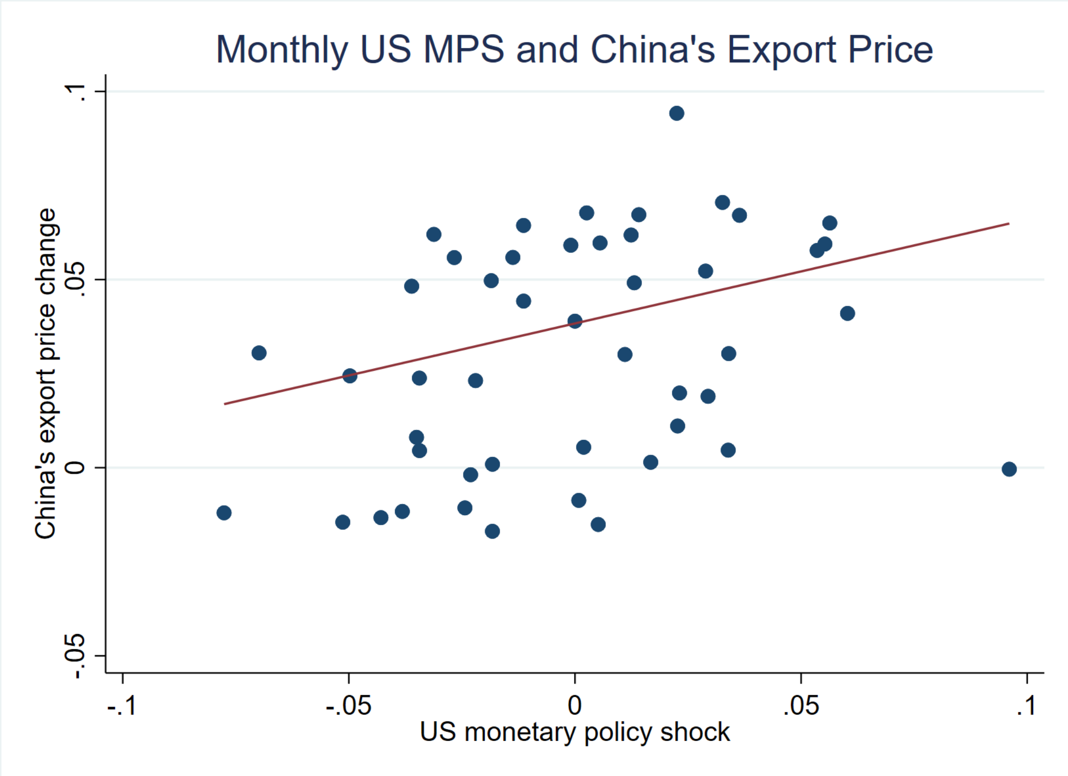

Figure 2: Monthly US monetary policy shocks and China's average export price

There are three noteworthy aspects of the interpretations for these baseline results: (1) The coefficients only describe the average price response of an exporter to a common shock and do not contain information on the differences among firms. Some firms may adjust more than others and some firms may don't respond at all. We will explore this difference in the later mechanism part. (2) We display that the average impact in the current period is significant, which does not mean that prices are not sticky; instead, it only implies that at least part of the product price changes immediately, and it is possible that less sticky firms may adjust more.[13] (3) Here we only display the concurrent reaction for the ease of illustration. Regarding dynamic responses, we find

[13]The price stickiness doesn't mean that the price will not respond to current shocks, instead it indicates that only a proportion of firms could adjust prices freely, which is supported by two popular theories: 1) only firms with a low menu cost could reset price immediately (e.g. Golosov and Lucas Jr (2007)); 2) each firm has a probability to change the price in a given period (e.g. Calvo (1983)). Nakamura and Steinsson (2008) show that the US firms have a probability of around 20% to change the price in a month on average and this frequency could range from 7% to 87% across different products. Moreover, according to Zhang (2022), homogeneous goods are usually more flexible in price adjustment than differentiated goods. As is displayed in Table 10, we find that the former group will increase the prices by a larger magnitude facing a tightening US monetary shock.

that most of the adjustment takes place in the first six months, and the impact will gradually fade out within 12 months, indicating a short-term effect. The detailed results are shown in Figure A1 and Table A1.

This finding is interesting as it is inconsistent with the prediction of the standard textbook open economy macroeconomic models, where a tightening monetary shock should decrease global import demand and hence reduce export prices. Also, traditional macroeconomic models usually highlight the exchange rate channel of monetary policy transmission to international trade. However, we find that the US monetary policy shocks still have a significant impact on China's export prices even when we control the contemporary exchange rate changes. This suggests that there may be some additional mechanisms of global monetary transmission, which will be discussed later.

In addition to the export price responses, in Table A2, we also analyze the impact on the export values and quantities. In the annual regression, a tightening shock will significantly decrease export quantity, and this effect dominates the impact of export price increases so that we can observe a reduction of export value. This is consistent with Lin and Ye (2018*b*), who find that US tightening will reduce global trade volumes using cross-country industry-level data. A new finding of this paper is that in the short run, the quantity responses are insignificant, and export price increases mainly drive the value reaction. This is plausible, as quantity adjustment might be sticky due to some reasons, such as capital adjustment costs.

3.3 Robustness checks

Our benchmark results are robust to many additional checks. To start with, we try *alternative monetary policy shocks* in Table 3. We first use the 30-minute high-frequency federal fund rate changes around the FOMC announcements to study the impact of conventional monetary policy shock, and then use the composite shock of Nakamura and Steinsson (2018), which is also a 30-minute high-frequency shock derived from the price changes of 2 federal fund rate futures and 3 Eurodollar futures around the FOMC announcement. This shock captures both the conventional monetary policy shock and the forward guidance. Moreover, we also employ the shock derived by Guraynak, Sack and Swanson (2005), who explicitly decompose an aggregate shock into the target and path part to represent the conventional monetary policy shock and forward guidance, respectively. These data are obtained from Acosta (2022). The shocks mentioned above may have the concern of information effect (see the literature like Nakamura and Steinsson (2018), Jarociński and Karadi (2020), Acosta (2022), etc.). Namely, the policy action of the Fed may signal its private information about current and future economic fundamentals. Therefore, we also test the impact of the pure monetary policy shock of Jarociński and Karadi (2020), which excludes the information effect and is identified through the co-movement of treasury yield and stock prices. To facilitate comparison, we rescale all the other shocks so that one unit of shock will increase the daily 2-year US treasury yield by 100 basis points. All of these measures suggest that a tightening shock will move export prices upward.[14]

[14]The correlation of *brw* shock with the federal fund rate shock, target shock, path shock, NS shock, and MP shock are 0.28, 0.28, 0.47, 0.53, and 0.49, respectively.

Table 3: Alternative monetary policy shocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var	Monthly ΔlnP_{it}							
	Δ FFR		NS		Acosta		JK	
ΔFFR_t	0.063***	0.056***						
	(0.017)	(0.016)						
NS_t			0.128***	0.121***				
			(0.008)	(0.008)				
$Target_t^{US}$					0.125***	0.118***		
					(0.018)	(0.018)		
$Path_t^{US}$					0.122***	0.117***		
					(0.007)	(0.007)		
MP_t							0.097***	0.124***
							(0.010)	(0.013)
CBI_t							0.652***	0.414***
							(0.039)	(0.042)
$Sales_{it-1}$		-0.004***		-0.005***		-0.005***		-0.005***
		(0.001)		(0.001)		(0.001)		(0.001)
ΔlnP_{it-1}		0.299***		0.299***		0.299***		0.299***
		(0.003)		(0.003)		(0.003)		(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1100400	917419	1100400	917419	1100400	917419	1100400	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in all columns are changes in monthly price. The monetary policy shock measures in columns (1)-(2), (3)-(4), (5)-(6), and (7)-(8) are from changes in the Fed fund rate, Nakamura and Steinsson (2018), Acosta (2022), and Jarociński and Karadi (2020), respectively. For ease of comparison, we re-scale all the other shocks so that one unit of shock will increase the daily 2-year US treasury yield by 100 basis. All regressions include firm fixed effects.

Besides the robustness of the alternative shocks, we have several additional robustness tests. First, we adopt ***alternative aggregation levels of price index*** as in Table

A3. Firm-level price index adjustments give us an initial idea about price elasticity regarding monetary policy shocks. Here, we further use more disaggregated firm-product level prices and firm-product-country level prices as supplements. In the firm-product-country level regression, each transaction-level price is narrowly defined as the unit value of a certain product produced by a certain firm selling to a certain market. In this regression, we add some additional controls: the change of annual bilateral real exchange rate between Chinese RMB and currency in the country c (the RMB price of a foreign currency, RER_{ct}), and $RGDP_{ct}$, the real GDP of the destination country deflated to the constant price level, which proxies for market demand. In the firm-product level regression, we aggregate the price change across destinations. All the results at those aggregation levels are consistent.

Second, we limit our regression to ***different firms***. To start with, in Table A4, we repeat our baseline regressions on firms exporting only a single HS6 product within a given month. This test excludes any product-switching effect on the firm-level price index. Although the sample size for single-product firms is much smaller, we observe similar price responses to monetary policy shocks. What's more, we show that our results are common for firms with 4 different ownerships: state-owned enterprises (SOE), domestic private enterprises (DPE), multinational enterprises (MNE), and joint venture enterprises (JV) (see Table A5).

Third, with respect to ***destinations***, we begin with the same regression for each country of China's top 20 trading partners each time and plot the coefficients in Figure A2. We find that most of the countries (18 out of 20) experienced a price rise in response to a US unexpected tightening shock. In addition, we regress the price change in the interaction term of monetary shock and destination-specific exposure. The exposure is defined as ratios of the export value to a certain market over the total export value of each firm within the same year. We find that firms exporting more to emerging markets would increase prices by a larger magnitude. By contrast, firms exposed more to the US market would increase less. Detailed results are displayed in Table A6.

Fourth, we conduct the benchmark regression separately over ***two periods***: the fixed regime (from January 2000 to June 2005) and the floating regime (from July 2005 to December 2006). The results are displayed in Table A7. We can see that the impacts are significant in both regimes.[15]

[15] The effect in the floating regimes is smaller, which indicates that the floating exchange rate serves as a buffer to external monetary shocks. This is consistent with the conclusions in the literature, such as Shambaugh (2004), Klein and Shambaugh (2012), Georgiadis (2016), Dedola, Rivolta and Stracca

Fifth, we use ***alternative fixed effects and standard error cluster levels***. In addition to the monthly regression with only firm-level fixed effects, we also include additional year- or month-fixed effects and use a firm-time-level (time-level or sector-level) cluster of standard errors. All the results are robust as in Table A8.

Sixth, we convert all export prices to the ***RMB price***. Due to data limitations, we do not have specific information on the invoice currency used by each exporting company, but we know through anecdotal evidence that during the period studied in this article (2000-2006), the vast majority of China's exports were denominated in US or RMB dollars. The results using RMB dollar prices show that export price adjustments in response to monetary policy shocks are not sensitive to the invoicing currency (see Table A9).

Seventh, although our monetary policy shocks are unexpected and largely unpredictable from previous information, which to some degrees alleviates the endogeneity problem originating from omitted variables, we still add more ***macroeconomic indicators*** of China, the US, and the world, such as China's industrial production growth rate, China and US inflation rate, VIX, commodity prices, etc., to control the impact of time-varying factors on export prices. The results with more controls are robust and are shown in Table A10.

Eighth, we will use an ***approximate time match*** approach to calculate year-on-year price changes in Table A11. In our baseline specification, we compute the price change as the growth of this month relative to the same month in the last year. However, some exporters may not export every month, so this method can sometimes generate missing values if a firm does not export in the same month of the last year. In this test, we will allow our sample to include those transactions for which we find no previous record in exactly 12 months before but do find adjunct records in the last 11 to 13 months (or more loosely in the last 10 to 14 months). Namely, we use the nearby record as a proxy for the value in the same month of the last year in case there is no export. It turns out that the results are consistent with the benchmark findings.

Finally, one may think that the FOMC announcement (unexpected monetary policy shocks) by the Fed in the earlier days of a month might have a bigger impact on the current month's price compared with that in the latter days. In light of this, similar to Ottonello and Winberry (2020), we construct a ***date weighted shock*** according

(2017), etc. The policy implication is that a more flexible and floating exchange rate regime can be adopted to mitigate the adverse impact of foreign monetary policy shocks.

to the number of remaining days in the current month after the announcement date.[16] Similarly, we can also calculate the weighted shock in annual frequency. Specifically, for each original monthly shock, we first calculate its effective and remaining parts according to the number of remaining days in this year. Then, the shock in a given year is constructed as the sum of all the shock components assigned to this year, namely, all the effective parts of the shocks in this year plus the remaining parts of the shocks in the last year. The robust results are shown in Table A12.

4 Mechanism

In this section, we will explore the mechanism behind our benchmark findings. According to the classical open economy macroeconomic models, a tightening US monetary policy will push up global interest rates and lead households to consume less and deposit more, thus driving the shrinking of the global demand and decreasing product prices, which is contrary to our empirical findings. Apart from the demand-side story, the US monetary policy will also exert its influence on China's export prices through the supply side. More specifically, we propose a "**Borrowing Cost Channel**": the US monetary tightening would induce the worsening of trade credit and liquidity conditions of Chinese exporters, which will motivate firms to rely more on external financing (e.g. bank loans, more expensive than internal financing), thus causing a higher average borrowing cost. Therefore, firms will raise their export prices to compensate for the cost increases.

To test this mechanism, we will do the following tasks: (1) we first show that the US contractionary monetary shock would deteriorate the trade credit and liquidity conditions of Chinese exporters; (2) we then show that the average borrowing costs and borrowing proportions increase in response to a tightening shock; (3) moreover, to strengthen this channel, we illustrate that firms with higher borrowing costs, lower trade credit acquisitions, and tighter liquidity conditions would increase their prices by a larger magnitude.

Additionally, we will also demonstrate that the price increases are not owing to the role of markup but marginal cost. Among all the costs, it is found that only the borrowing cost movements are consistent with the responses of export prices. Finally,

[16] For example, if an announcement was made on March 20 2001 and the magnitude of the monetary shock was 1, then we will attribute $(31 - 20)/31$ of this shock to the current month and the remaining part to the next month. Therefore, the adjusted weighted shock in a given month should be equal to the remaining part of the shock in the last month plus the effective part in this month.

the borrowing cost reaction is mainly due to the increase in borrowing proportion instead of the interest rate itself.

4.1 Trade credit and liquidity responses

As is widely documented in the literature, the US monetary policy is a main driver of the global financial cycle, and a tightening shock would cause the decline of asset prices and shrinking of financial loans (see Miranda-Agrippino and Rey (2020)). Consequently, global firms would decrease trade credit provisions to their trade partners to mitigate financial pressure. As a result, even those firms that are not directly exposed to US monetary shocks due to rigorous capital control (e.g., China) would be indirectly affected through the international supply chain. To verify this conjecture, we check how trade credits of Chinese exporters respond to the US monetary shocks through the following regression equation:

$$\Delta Tr_{it} = \alpha + \beta \cdot m_t + \Gamma \cdot \mathbf{Z}_{it-1} + \xi_i + \varepsilon_{it} \tag{2}$$

where Tr represents trade credit measures, and Z_{it-1} is firm-specific one-year lagged control variables, including log real sales income (a proxy for firm size) and the ratio of total debt to total assets. ξ_i is firm fixed effect. Similar to Fisman and Love (2003), trade credit is measured by the ratio of accounts payable to total assets ($APay$) and the ratio of accounts receivable to total assets ($ARec$).[17]

The results are displayed in Table 4 that one unit of unexpected tightening shock would decrease the ratio of accounts payable by 0.025, which means that an exporter in China will get fewer trade credits from its trade partners (see column (1)).[18] Consistently, it is found in column (2) that this exporter will also cut down its trade credit to other firms, although the magnitude is smaller. This is plausible as exporters may partially absorb the adverse impacts so the pass-through to other trade partners is not

[17] All the balance sheet variables are obtained from the Annual Surveys of Industrial Enterprises in China (ASIE). The data ranges of accounts payable and accounts receivable are 2004-2006 and 2000-2006, respectively. It is worth noting that the data scope of accounts receivable is not completely consistent across years. In some years, it refers to accounts receivable, while in other years, it means accounts receivable minus bad debt reserves. In most cases, the proportions of bad debt reserves are not too big, so we can generally perceive this variable as a proxy for accounts receivable. If without special notice, the period of all other variables in this database is from 2000 to 2006.

[18] Due to data limitation, we can only observe the overall impacts but not the detailed sources of trade credits.

one-to-one.

Table 4: Firm-level trade credit change

	(1)	(2)
Dependent Var	Trade credit measures	
	$\Delta APay$	$\Delta ARec$
brw_t	-0.025***	-0.012***
	(0.006)	(0.004)
$Sales_{it-1}$	-0.016***	-0.018***
	(0.002)	(0.001)
$Debt_{it-1}$	-0.310***	-0.066***
	(0.008)	(0.004)
Firm FE	Yes	Yes
Observations	88076	155699

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1)+(3) and (2)+(4) are accounts payable over total assets and accounts receivable over total assets, respectively. All regressions include firm fixed effects.

Similarly, we show that the unexpected tightening of US monetary policy will also deteriorate firms' liquidity conditions. To measure a firm's liquidity conditions, we use three variables: the net liquid asset ratio $Liquid$ (liquid asset minus current liability over total assets), the cash ratio $Cash$ (cash holding over total assets), and the first principle component of these two variables FPC. Lower values correspond to tighter liquidity. The specification is directly regressing annual liquidity change on monetary shock with the control of one-year lagged firm size and total debt ratio (similar to Equation 2). From Table 5, we find that an unexpected US tightening shock will significantly worsen the liquidity of firms. One possible explanation is that the tightening shock will shrink global demand and thus reduce the firm's operational cash flow from exporting. This is consistent with our previous finding that the US contractionary shock will reduce the firm's annual export quantities and values (see Table A2).

Table 5: Liquidity changes of exporters

	(1)	(2)	(3)
Dependent Var		Liquidity conditions	
	ΔFPC	$\Delta Cash$	$\Delta Liquid$
brw_t	-0.084***	-0.018***	-0.012**
	(0.021)	(0.004)	(0.005)
$Sales_{it-1}$	-0.033***	-0.003***	-0.011***
	(0.005)	(0.001)	(0.001)
$Debt_{it-1}$	1.221***	-0.014***	0.630***
	(0.023)	(0.005)	(0.007)
Firm FE	Yes	Yes	Yes
Observations	155699	155699	155699

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. All firms are exporters. The dependent variables in columns (1)-(3) are changes in the first principal component of cash over total asset ratio and net liquidity asset over total asset ratio and those two individually. All regressions include firm fixed effects.

4.2 Borrowing cost and export price

After confirmation of the responses of trade credit and liquidity conditions, we now check how borrowing costs react to US monetary shock. We argue that due to the worsening of trade credit and liquidity conditions, firms are forced to borrow more from outside institutions, thus yielding a higher average borrowing cost. To verify this hypothesis, we use a specification similar to Equation 2, and the dependent variables are changes in the borrowing cost or debt ratio. To measure the average borrowing cost, we use four variables: the ratio of interest rate expenditure over total debt IE/L, the ratio of interest rate expenditure over current debt IE/CL, the ratio of financial expenses over total debt FN/L, and the ratio of financial expenses over current debt FN/CL.[19] The total debt may contain funding borrowed from financial markets, payroll payable,

[19]The financial expenses include both the interest rate expenditures and some other financing related costs, for example accounting and auditing fees, etc.

trade account payable, etc.[20] Only the debt of financial institutions requires an explicit interest expenditure. So, an increase in the average borrowing cost may originate from the rise of the borrowing rate itself or the lifting up of borrowing proportion from the financial markets.[21]

Table 6: Borrowing cost changes of exporters

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var		Borrowing costs			Liability	
	$\Delta\frac{IE}{L}$	$\Delta\frac{IE}{CL}$	$\Delta\frac{FN}{L}$	$\Delta\frac{FN}{CL}$	$\Delta Debt$	$\Delta CDebt$
brw_t	0.005***	0.007***	0.014***	0.015***	0.039**	0.038**
	(0.001)	(0.001)	(0.002)	(0.003)	(0.017)	(0.019)
$Sales_{it-1}$	-0.000*	-0.001	-0.001*	-0.002**	-0.144***	-0.147***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.005)	(0.006)
$Debt_{it-1}$	0.033***	0.038***	0.069***	0.077***	-2.318***	-2.208***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.024)	(0.025)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	155008	153219	155008	153219	154908	153086

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. All firms are exporters. The dependent variables in columns (1)-(4) are changes in interest expense over the total liability ratio, interest expense over the current liability ratio, total financial expense over the total liability ratio, and total financial expense over the current liability ratio, respectively. The dependent variables *Debt* and *CDebt* in columns (5)-(6) are changes in total and current liability over total asset ratios. All regressions include firm fixed effects.

As shown in Table 6, we find that the firm's borrowing cost increases significantly in response to a US contractionary shock, which is consistent with our previous conjecture. Additionally, both firms' total debt ratio (total debt over total assets) and current debt ratio (current debt over total assets) increased after a tightening shock, suggesting that firms are relying more on external financing.[22] Furthermore, we also demonstrate that

[20]Due to data limitation, we don't have a clear measurement for each type of debt, but only aggregate variables.

[21]The average borrowing cost $BC = \frac{Interest}{Debt_T} = \frac{Interest}{Debt_F} \cdot \frac{Debt_F}{Debt_T} \equiv BR \cdot BP$, where $Interest$ means interest expenditures or financial expenses, $Debt_F$ ($Debt_T$) is the financial (total) debt, BR denotes borrowing interest rate, and BP represents the borrowing portion from financial markets.

[22]Although we don't have a direct measure of financial debt, we know that the trade credits decrease

the price impact is bigger if a firm faces higher borrowing costs (see Table 7). The specification is:

$$\Delta \ln P_{it} = \alpha + \beta \cdot m_t \cdot X_{st-12} + \Gamma \cdot \mathbf{Z} + \xi_i + \Xi_t + \varepsilon_{it} \tag{3}$$

where the dependent variable is the monthly year-on-year price changes and X_{st-12} is the one-year lagged sector-level average borrowing cost. $\mathbf{Z}$ is firm-specific controls, including one-year lagged log real sales income and one-month lagged price changes. ξ_i and Ξ_t are firm and time-fixed effects respectively.[23] Besides, it is found that firms with ex-ante bigger borrowing costs would get a larger rise in the borrowing costs, which reconciles with the bigger movement of prices. These results are displayed in Table B1.

in facing a tightening shock, which indicates that the increase of total debt is very likely contributed by the rise of financial debt.

[23]To alleviate endogeneity concerns, we aggregate the variables at the sector level and use the value of last year. Also, to control some time-specific common factors that can affect borrowing cost and price simultaneously, we add the time-fixed effect.

Table 7: Interactions with borrowing cost

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var				Monthly ΔlnP_{it}				
$brw_t \times \frac{IE}{L}_{st-12}$	7.645***	6.959***						
	(2.259)	(2.141)						
$brw_t \times \frac{IE}{CL}_{st-12}$			6.269***	5.614***				
			(1.902)	(1.803)				
$brw_t \times \frac{FN}{L}_{st-12}$					6.288***	3.694*		
					(2.387)	(2.245)		
$brw_t \times \frac{FN}{CL}_{st-12}$							5.153***	3.069*
							(1.953)	(1.841)
$Sales_{it-12}$		-0.017***		-0.017***		-0.017***		-0.017***
		(0.001)		(0.001)		(0.001)		(0.001)
ΔlnP_{it-1}		0.296***		0.296***		0.296***		0.296***
		(0.003)		(0.003)		(0.003)		(0.003)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1072227	917419	1072227	917419	1072227	917419	1072227	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The interaction terms in columns (1)-(2), (3)-(4), (5)-(6), and (7)-(8) are changes in interest expense over the total liability ratio, interest expense over the current liability ratio, total financial expense over the total liability ratio and total financial expense over the current liability ratio, respectively. All regressions include firm and time-fixed (year-month pair) effects.

Similarly, consistent with the borrowing cost channel, if the borrowing cost increase is due to the worsening of trade credit acquisition and liquidity conditions, we would expect that the price change should be related to these factors, and firms with distinct trade credit acquisition and liquidity conditions may react differently in response to the same tightening shock. This conjecture is validated in Table B2 and Table B3, respectively. The specification is similar to Equation 3, and the only difference is replacing the borrowing cost measurements with the trade credit and liquidity variables. It is found that firms with lower trade credit acquisition and tighter liquidity conditions would conduct a bigger increase in export prices.[24]

4.3 More about cost channel

To further validate the cost-driven channel, we also decompose the export price changes into markup adjustments and marginal cost changes using the structural assumptions of De Loecker and Warzynski (2012) and the GMM estimation method as in Brooks, Kaboski and Li (2021).[25] It is found that only marginal cost responds significantly to the US monetary shock, and the reaction of mark-up change is quite weak both economically and statistically. The results are displayed in Table B4. In addition, we test how the firm heterogeneity in markup matters. Specifically, we check whether a firm's relative markup within a sector (within-sector markup) and the median markup of the sector (across-sector markup) affect its response price to monetary policy shocks in Table B5. We find that all interaction terms are insignificant, implying that the export prices of firms with different markups do not exhibit significant differences in response to monetary policy shocks. Moreover, we also test that among all the costs, only the borrowing cost responds substantially, while the material input cost, the labor cost, and the cost associated with imported goods don't matter too much. These results are shown in Table B6.

Finally, regarding why borrowing costs increase after a tightening shock, there may be another possible explanation: the US tightening increases China's interest rates. To verify this possibility, we regress the overnight return of Chinese treasury bonds and corporate bonds price index on the US monetary policy shock, and the results turned out to be relatively weak and insignificant, although the reaction direction is consistent (see Table B7). This implies that the average borrowing cost movement is mainly driven by the higher reliance on more expensive external financing rather than the increases in the

[24] The results for trade credit provision, namely accounts receivable, are not significant. This makes sense because trade credit provision is less directly related to firms' borrowing decisions than trade credit acquisition and firms with lower trade credit acquisition may not necessarily have lower trade credit provision. The fact that accounts receivable equals accounts payable only holds at the aggregate level, not at the firm level.

[25] We derive the firm-specific markup as the ratio of an input factor's output elasticity to its firm-specific factor payment share $\mu_t = \theta_t^X \left(\alpha_t^X\right)^{-1}$, where α_t^X is the share of expenditures on input X in total sales and θ_t^X denotes the output elasticity on input X. We apply the methodology of Ackerberg, Caves and Frazer (2015) to address the endogeneity of inputs, assuming a third-order translog gross output production function. The marginal cost, therefore, could be written as $MC_{it} = P_{it}/\mu_{it}$ and $\Delta ln(MC)_{it} = \Delta \ln P_{it} - \Delta \ln \mu_{it}$.

borrowing rate itself. This is plausible as China has quite tight capital control and highly independent monetary authority; thus, China's financial market is not tightly exposed to US monetary policy adjustments. Similar results are also documented in previous papers such as Hausman and Wongswan (2011) and Ho, Zhang and Zhou (2018), etc. This result is interesting because it suggests that exporter's financing conditions are affected by external monetary shock even though the Chinese financial market itself responds quite mildly.

4.4 Further verification

To verify the borrowing cost channel proposed above, we also conducted several additional tests. To begin with, we display that FDI firms are less affected due to their relatively more stable trade credit and liquidity conditions. Second, we compare the responses of ordinary exporters with those of processing trade exporters. Processing trade responses should be smaller, as their operation is less dependent on external financing. Third, we rule out the possibility of a global demand shift by comparing the reaction of differentiated goods response to that of homogeneous goods. We show that homogeneous goods also significantly respond to the US shock, which suggests that the price increases after a tightening shock are not due to a global demand shift from other countries to China. Finally, we argue that our channel is an additional way to affect export prices beyond the exchange rate pass-through channel.

4.4.1 FDI VS non-FDI firms

We provide indirect evidence to validate the borrowing cost channel through the comparison of FDI and non-FDI (domestic) firms. It is generally believed that foreign direct investment (FDI) firms have better supply chain management capabilities and relative advantages in global risk hedging compared to purely domestic firms in China; therefore, their trade credit and liquidity conditions should be less affected by external adverse shocks. Accordingly, it is expected that their export prices will also be less influenced. This is verified in Table 8. It is revealed that the coefficients in columns (3)-(4) are much smaller than those in columns (1)-(2). Additionally, if we interact monetary shock with the dummy of FDI, we can observe that this term is significantly negative (see columns (5)-(6)).

Table 8: FDI VS non-FDI firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var			Monthly ΔlnP_{it}			
	Domestic		FDI		Comparison	
brw_t	0.215***	0.216***	0.161***	0.116***		
	(0.024)	(0.025)	(0.012)	(0.011)		
$brw_t \times FDI_{it-12}$					-0.113***	-0.107***
					(0.027)	(0.027)
$Sales_{it-12}$		0.010***		0.000		-0.017***
		(0.003)		(0.001)		(0.001)
ΔlnP_{it-1}		0.185***		0.337***		0.296***
		(0.005)		(0.003)		(0.003)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	No	No	No	No	Yes	Yes
Observations	269743	210467	830657	706952	1072227	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The samples in columns (1)-(2) and (3)-(4) include domestic firms and FDI firms, respectively. The interaction term in columns (5)-(6) is the lagged FDI dummy variable, which takes a value of 1 for multinational firms or joint ventures and 0 for domestic Chinese firms, identified 1 year ago. All regressions include firm fixed effects. Columns (5)-(6) additionally incorporate time-fixed (year-month pair) effects.

4.4.2 Ordinary VS processing trade

Some exporters may be registered as **processing trade**. That is, a processing trader imports raw materials and intermediate inputs from a foreign firm for domestic processing and re-exports to the same firm as its customer. Processing trade contracts is more fixed than that of ordinary trade. Firms that participate in more processing trade usually have less borrowing needs and are less affected by credit conditions (Manova and Yu (2016)). So, suppose the borrowing cost channel holds, we expect that facing the same monetary policy shock, the price responses for processing traders should be smaller than those of ordinary traders.

The results are shown in Table 9. Columns (1)-(2) only include the sample of ordinary trade transactions. In columns (3)-(4), we instead show the results using only processing trade transactions. In columns (5)-(6), we use the intensity of the processing trade as the interaction term to study the difference between processing and ordinary trade. In practice, in the firm-product level sample, we create a processing trade dummy, which takes the value of 1 when a transaction belongs to processing trade and 0 when it belongs to ordinary trade. When aggregating to a firm-level sample, we compute the processing trade intensity as the proportion of processing trade in total export value. We find that the coefficients in columns (1)-(2) are much bigger than in columns (3)-(4), and the interaction terms in columns (5)-(6) are significantly negative, which verifies our conjecture and further reinforces our proposed mechanisms. In fact, ordinary trade firms account for more than 2/3 of the total observations in our sample. Therefore, the pricing patterns based on ordinary trade should dominate the overall Chinese trade.

Table 9: Ordinary trade vs processing trade

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}					
	Only ordinary trade		Only ordinary trade		Comparison	
brw_t	0.194***	0.181***	0.100***	0.071***	0.223***	0.190***
	(0.018)	(0.019)	(0.019)	(0.016)	(0.016)	(0.016)
$brw_t \times process_{it}$					-0.101***	-0.088***
					(0.024)	(0.023)
$Sales_{it-12}$		-0.001		-0.011***		-0.005***
		(0.002)		(0.002)		(0.001)
ΔlnP_{it-1}		0.189***		0.473***		0.299***
		(0.003)		(0.005)		(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	499448	391356	283934	242572	1100400	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. In columns (1)-(2), we limit our sample to firms doing only ordinary trade. In columns (3)-(4), we limit our sample to firms doing only processing trade. In columns (5)-(6), we use the whole sample but additionally include the interaction term of monetary shock and the processing trade intensity. A higher value of *process* means a firm is more involved in processing trade. All regressions include firm fixed effects.

4.4.3 Global demand shift

In addition to the cost channel, there might be another potential explanation for the export price increase after a tightening US monetary shock. A tightening global monetary shock will induce a recession in a business cycle, which might make Chinese exports more competitive because some Chinese products are cheaper and of lower quality than similar ones from other developed countries. The idea is similar to the concept of Giffen goods: the prices of inferior goods increase when people's incomes drop.

Therefore, we check whether there is a significant difference in price response patterns between different products. We divide all export products into homogeneous goods, which are traded in standard exchange (denoted as ToE) or at least with referenced prices (denoted as Ref), and differentiated goods (for which firms have full autonomy to set prices) by HS6 codes. In practice, we construct a firm-level value-weighted index for ToE and Ref using two classification standards (conservative and liberal) as in Rauch (1999).

In Table 10, we find that the prices of homogeneous goods also increase.[26] These goods have little differences in quality across producers and can't be treated as Giffen goods. Thus, it is less likely that people will buy more of these goods from China than from other countries during a recession. So, the mechanism shouldn't be attributed to a global demand shift.

[26]The reason why homogeneous goods increase prices more might be that those goods have more flexible prices, as argued by Zhang (2022).

Table 10: Homogeneous good vs differentiated good

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var	Monthly ΔlnP_{it}							
	Conservative classification				Liberal classification			
brw_t	0.177***	0.149***	0.156***	0.137***	0.175***	0.147***	0.155***	0.139***
	(0.011)	(0.011)	(0.012)	(0.012)	(0.011)	(0.011)	(0.013)	(0.012)
$brw_t \times ToE_{it}$	0.154	0.117			0.265***	0.243***		
	(0.129)	(0.126)			(0.086)	(0.082)		
$brw_t \times Ref_{it}$			0.209***	0.125***			0.167***	0.083***
			(0.033)	(0.032)			(0.031)	(0.030)
$Sales_{it-12}$		-0.005***		-0.005***		-0.005***		-0.005***
		(0.001)		(0.001)		(0.001)		(0.001)
ΔlnP_{it-1}		0.298***		0.298***		0.298***		0.298***
		(0.003)		(0.003)		(0.003)		(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1014106	850165	1014106	850165	1014106	850165	1014106	850165

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The variables ToE and Ref represent the value share of goods traded on an organized exchange and the value share of reference-priced goods of firm i. Columns (1)-(4) use the "conservative" classification, while columns (5)-(8) use the "liberal" classification, both referring to Rauch (1999). All regressions include firm fixed effects.

4.4.4 Exchange rate pass-through

Many papers on exchange rate pass-through have revealed that domestic exchange rate depreciation will increase export prices denominated in domestic currency in most cases. Furthermore, monetary policy surprises can also drive exchange rate fluctuations, which gives us another possible explanation for our finding. However, this explanation is not likely to be the main reason for the price response. In most of our sample period (from January 2000 to June 2005), China's exchange rate regime is fixed to the US dollar; A US tightening shock will cause the RMB to appreciate against other currencies, so this story means the RMB-denominated price will fall, which is contrary to our finding in

Table A9. In addition, we have controlled the change of bilateral real exchange rate in the firm-product-country level regression (columns (4)-(6) of Table A3). All results are robust and significant, which implies that exchange rate pass-through can not fully explain the impact of monetary policy shocks on export prices.

5 More Discussion

5.1 Domestic monetary tightness

In this part, we will illustrate how global monetary policy shocks interact with the Chinese monetary environment. In our sample period, the implementation of monetary policy in China is mainly based on the quantity instrument (such as the growth of money) rather than the price tool (such as the interbank interest rate). Consequently, similar to Lin and Ye (2018*a*), we use the normalized minus M2 growth rate as a measure of China's domestic monetary tightness, and a bigger value means tighter conditions.[27] In Table 11, the coefficients of *tightness* are positive in all columns, which implies that domestic tightening also causes exporters to raise prices. This is plausible as both domestic monetary policy and external monetary shocks could potentially affect exporters through trade credit, liquidity, and borrowing interest rate. Moreover, it is worth noting that all interaction coefficients are positive as well, indicating that a global contractionary shock would have a larger impact conditional on a tighter domestic monetary environment. This is consistent with Lin and Ye (2018*a*) who find that the impacts of foreign liquidity shock on trade credits of Chinese firms are more profound in tighter domestic monetary conditions. This is also coherent with our previous empirical evidence that the effect of the US tightening shock should be bigger when firms have higher average borrowing costs.

[27] In practice, we construct two measures, year-on-year tightness index, $tightness_{YoY} = -(M2_t - M2_{t-12})/M2_{t-12}$, and month-on-month tightness index, $tightness_{MoM} = -(M2_t - M2_{t-1})/M2_{t-1}$, where t is an index of month.

Table 11: Domestic monetary tightness in China

	(1)	(2)	(3)	(4)
Dependent Var	Monthly ΔlnP_{it}			
	Year-on-year tightness		Month-on-month tightness	
brw_t	1.186***	0.747***	0.375***	0.293***
	(0.079)	(0.077)	(0.022)	(0.019)
$brw_t \times tightness_t^{YoY}$	6.173***	3.680***		
	(0.453)	(0.443)		
$brw_t \times tightness_t^{MoM}$			9.226***	6.894***
			(0.895)	(0.836)
$tightness_t^{YoY}$	0.275***	0.169***		
	(0.025)	(0.020)		
$tightness_t^{MoM}$			0.100***	0.040
			(0.028)	(0.030)
$Sales_{it-12}$		-0.006***		-0.005***
		(0.001)		(0.001)
ΔlnP_{it-1}		0.298***		0.299***
		(0.003)		(0.003)
NER Control	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	1100400	917419	1100400	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The monetary tightness in columns (1)-(2) is measured by the minus year-on-year growth rate of M2, while in columns (3)-(4) is the minus month-on-month growth rate of M2. All regressions include firm fixed effects.

5.2 EU monetary policy shocks

In addition to the spillover effect of the US monetary policy shock, recent literature (see Ca'Zorzi et al. (2020), Corsetti et al. (2021), and Miranda-Agrippino and Nenova (2022), etc.) indicates that the monetary policy of the European Central Bank (ECB) also has a substantial effect on global financial conditions and real economic activities. Using the same specification as our benchmark regression, we explore how China's export prices respond to ECB monetary shocks in Table 12. For ease of comparison, we also report the result of the US BRW shock in the first column.[28]. In column (2)-(4), we use the shocks from Miranda-Agrippino and Nenova (2022)[29]. To avoid the confounding effect resulting from the central bank information effect, we also use the pure monetary policy shock and information shock by Jarociński and Karadi (2020) in columns (5)-(7). It is seen that, unlike the reaction to the US shock, Chinese export prices barely move in response to the European monetary policy shocks. One unit of tightening target shock will decrease China's export prices by only 0.1% (see column (4), for the US shock, this magnitude is around 0.7%). In addition, the impact of the ECB shock seems to be dominated by the demand side effect, so a tightening shock would induce export prices to decline. However, these effects are not quite robust. When we use the pure monetary policy shock and information shock of Jarociński and Karadi (2020), it is found that both are insignificant (in columns (5)-(7)).

Our finding is consistent with the conclusion in the literature (like Ca'Zorzi et al. (2020), Corsetti et al. (2021) and Miranda-Agrippino and Nenova (2022), etc.) that the spillover effect of ECB shock is less powerful than that of the Fed. This is easy to understand because the dominant role of the US dollar, along with the intensive integration of the global financial market, confers on US monetary policy a special role in driving the global financial cycle (GFC) (Miranda-Agrippino and Rey (2020)). Another possible explanation is that, in most of our sample period, China's exchange rate is fixed to the US dollar, and a substantial proportion of the transactions may be invoiced in the US dollar, which may augment the impact of US shock on China's export prices.

[28]Here, the shock is standardized so that one unit of shock indicates one standard deviation of the shock itself. A similar procedure is also applied to other ECB shocks

[29]Using the approach of Swanson (2021), Miranda-Agrippino and Nenova (2022) decompose the ECB monetary shock into three components: the "target", "path" and "lsap" part, which reflects unexpected policy rate change, forward guidance, and large-scale asset purchasing, respectively. In our baseline period from 2000 to 2006, there was almost no large-scale asset purchase. Therefore, we only use the target shock and the path shock here.

Table 12: Export price responses to EU monetary policy shocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Var	Monthly ΔlnP_{it}						
	BRW	Miranda-Agrippino & Nenova			Jarocinski & Karadi		
$\tilde{brw}_t$	0.0068***						
	(0.0005)						
$target_t$		-0.0010**		-0.0010**			
		(0.0004)		(0.0004)			
$path_t$			-0.0000	-0.0001			
			(0.0004)	(0.0004)			
mp_t					0.0002		0.0002
					(0.0005)		(0.0004)
cbi_t						-0.0003	-0.0003
						(0.0004)	(0.0004)
$Sales_{it-12}$	-0.0047***	-0.0040***	-0.0039***	-0.0040***	-0.0039***	-0.0039***	-0.0039***
	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0014)
ΔlnP_{it-1}	0.2989***	0.2991***	0.2991***	0.2991***	0.2991***	0.2991***	0.2991***
	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)	(0.0027)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	917419	917419	917419	917419	917419	917419	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. Apart from the first column, all the monetary policy shocks are from the European Central Bank. The shock in columns (2)-(4) is obtained from Miranda-Agrippino and Nenova (2022), while columns (5)-(7) are from Jarociński and Karadi (2020). For ease of comparison, all shocks are standardized so that one unit of shock indicates one standard deviation of the shock. All regressions include firm fixed effects.

5.3 Discussion about credit constraints

As is documented in the literature (see Manova and Zhang (2012), Manova (2013), Manova, Wei and Zhang (2015)), the choice of export prices depends on firms' credit constraints.[30] For those firms with unbinding credit constraints, export prices are equal to the marginal cost times markup, and the responses of prices are determined by these two components, which is what we have analyzed before. Then, how about the reactions of those binding firms? Actually, the worsening of credit conditions induced by the tightening of the US monetary shock would also cause an increase in export prices, and this is consistent with the efficiency sorting theory (regarding efficiency sorting, see Manova and Zhang (2012) for more details). More specifically, a tightening US monetary policy shock would reduce an exporter's trade credit and liquidity conditions (as is proved in the previous section 4.1), which will accordingly increase firms' credit demand. To satisfy the requirement from credit needs, the exporters are forced to increase prices and obtain more cash flow so as to improve credit access. That's because firms with more fluent cash flow are less likely to default and thus could obtain more credit access from the financial markets.

It is worth noting that empirically identifying which firms have binding credit constraints is quite hard, and the constraints may be even occasionally binding to a firm. We will further explain how these channels work in an illustrative model in Section 6, where we study the binding versus non-binding cases separately.[31]

[30] Manova and Zhang (2012) finds that many exporters are constrained by credit limits. This is even more prominent than for non-exporters as exporting activities are usually more demanding than domestic business.

[31] In this paper, we will only qualitatively explore how the binding credit constraint would affect firms' pricing decisions and leave the quantitative analysis for future study.

6 Model

In this section, we construct an illustrative partial equilibrium model to show how exporting firms' behaviors respond to a global monetary contraction, where the mechanism is related to exporters' trade credits and liquidity conditions.[32] The model is based on the heterogeneous firm trade model of Melitz (2003) and Manova (2013), and we further incorporate global monetary shocks. The main difference between the existing literature on firm credit constraints and trade is that, in this paper, we include a working capital constraint in addition to the credit constraint, and the constraints are affected by global monetary shocks.[33] The big picture is that if the credit constraint is binding, the contractionary shock will worsen the firm's trade credits and liquidity conditions, motivating it to increase prices to alleviate credit restrictions. Moreover, if the credit constraint is unbinding, a tightening global monetary shock could increase the borrowing cost and incentivize the firm to uplift its export price.

6.1 Setting

Preferences and demand

We introduce a more general setting for the model to explain empirical evidence on the price responses of Chinese exporters and the underlying mechanism. Source and destination countries are denoted by i and j, respectively. In this paper, i is China, and j denotes the rest of the world. Consumers in country j can access a set of goods X_j, potentially different across countries. It is assumed that a representative consumer in country j has a constant-elasticity-of-substitution (CES) utility function given by

$$U_j = (\int_{\omega \in \Omega_j} [\chi_{ij}(\omega)]^{\frac{\sigma-1}{\sigma}} d\omega\ )^{\frac{\sigma}{\sigma-1}} \tag{4}$$

where χ_{ij} is country j's consumed quantity of variety ω originated from country i, and $\sigma > 1$ is the elasticity of substitution between varieties. Therefore, consumer optimization yields the following demand function for variety ω:

[32]We use the partial equilibrium setting to make the model more concise. A general equilibrium model will not alter the direction of the impact of global monetary policy shocks.

[33]Regarding the working capital constraint, here we follow the literature on the cost channel of monetary transmissions, such as Ravenna and Walsh (2006), etc.

$$\chi_{ij}(\omega) = \frac{p_{ij}(\omega)^{-\sigma}}{P_j^{-\sigma}} Y_j \tag{5}$$

where $p_{ij}(\omega)$ is the price of the variety ω, $P_j = (\int_{\omega \in \Omega_j} [p_{ij}(\omega)]^{1-\sigma} d\omega)^{\frac{1}{1-\sigma}}$ is an aggregate price index in the country j, and Y_j represents the total expenditure of country j. We assume that it is affected by global monetary shocks m (e.g., the US monetary shock): $Y_j = \bar{Y}_j + \rho_Y^j m + \epsilon_Y^j$, where $\bar{Y}_j$ is a trend component of Y_j, $\rho_Y^j < 0$, ϵ_Y^j is a random error, and a positive m means a tightening shock.[34]

Exporting firm

In each source country i, there is a continuum of firms that ex-ante differ in their productivity level ϕ_i. We assume that there is only one input (e.g., materials or labor) for production and that the production function is $y_i = \phi_i L_i$, where ϕ_i is productivity and L_i is input. The firm in country i minimizes its cost to satisfy the demand in the country j, $\chi_{ij}(\omega) = \frac{p_{ij}(\omega)^{-\sigma}}{P_j^{-\sigma}} Y_j$. This yields a total cost function $C_{ij} = \frac{w_i}{\phi_i} \frac{p_{ij}(\omega)^{-\sigma}}{P_j^{-\sigma}} Y_j$, where w_i is the price of input. To capture the demand side effect, we allow the input price to fluctuate in response to global monetary shocks: $w_i = \bar{w}_i + \rho_w^i m + \epsilon_w^i$, where $\bar{w}_i$ is a trend component of w_i, $\rho_w^i < 0$ and ϵ_w^i is a random error.[35]

We further assume a working capital constraint that a fraction δ_i of the input costs should be borrowed from outside financial institutions (e.g., bank loans or issuing bonds) and paid in advance.[36] Here $\delta_i \in [0, 1]$ is a decreasing function of the firm's liquidity condition and trade credit: $\delta_i \equiv 1 - c_i^\gamma - \zeta_i$, where $c_i \in [0, 1]$ is the liquidity condition (a higher value means better situation), γ is a positive constant and reflects the elasticity of borrowing fraction with respect to liquidity condition, ζ_i is the fraction of input costs that are supported by trade credit (i.e. accounts payable). The intuition is that a firm with better liquidity conditions and trade credit has fewer external financing needs. Here, c_i is assumed to be impacted by monetary policy shock exogenously: $c_i = \bar{c}_i + \rho_c^i m + \epsilon_c^i$, where $\bar{c}_i$ is a trend component of c_i, $\rho_c^i < 0$ and ϵ_c^i is a random error.[37] Trade credit is

[34] Past literature has documented that US monetary policy tightening has a negative spillover effect on the GDP of other countries (e.g., Kim (2001), Georgiadis (2016), and Iacoviello and Navarro (2019)).

[35] According to the demand side story, a contractionary global monetary shock may depress domestic total demand, and hence decrease the demand of inputs and also their prices.

[36] Compared with domestic sales or purchasing, the cross-border exporting or importing is riskier and more demanding, and relying more on additional external capital (Manova (2013)).

[37] The cash flow from sales income and the balance sheet may be adversely affected after a contractionary shock. In the empirical part, we verify that firms' liquidity conditions will be worse after a tightening shock. For simplicity, here, the liquidity conditions are assumed to be exogenous, and the endogenization of cash holding will not alter our main mechanisms.

also assumed to be affected by global monetary shocks: $\zeta_i = \bar{\zeta}_i + \rho^i_\zeta m + \epsilon^i_\zeta$, where $\bar{\zeta}_i$ is a trend component of ζ_i, $\rho^i_\zeta < 0$ and ϵ^i_ζ is a random error.[38]

Thus the cost function becomes $C_{ij} = \frac{w_i(1-\delta_i+\delta_i R_i)}{\phi_i}\frac{p_{ij}(\omega)^{-\sigma}}{P_j^{-\sigma}}Y_j$, where $R_i > 1$ is the gross borrowing interest rate in country i. We explicitly assume $R_i = \bar{R}_i + \rho^i_R m + \epsilon^i_R$ where $\bar{R}_i$ is a trend component of R_i, $\rho^i_R > 0$ and ϵ^i_R is a random error.[39] Also, to allow the non-linear elasticity of cost with respect to interest rate (which can be generated by other financial costs associated with borrowing), we replace R_i with R_i^α, where α is a constant and represents the elasticity of financial costs with respect to the interest rate. Following the convention, we also add an iceberg trade cost such that $\tau_{ij} \geq 1$ units of good must be shipped from country i for one unit to arrive at j. For simplicity of notation, the subscripts for source and destination and the index for variety are omitted. Thus, the new cost function is:

$$C = \frac{\tau w(1-\delta+\delta R^\alpha)}{\phi}\frac{p^{-\sigma}}{P^{-\sigma}}Y \tag{6}$$

We also assume that firms cannot borrow more than a fraction θ of the expected cash flow from exporting, and it is smaller when R is higher. The intuition is that higher interest rates imply higher risks and access to credit should be lower. Without loss of generality, we can assume $\theta = R^{-\nu}$, where ν is bigger than 0 and reflects the elasticity of financial credit access with respect to the interest rate. The optimization problem of the firm is:

$$\max_p \ (p - \frac{\tau w(1-\delta+\delta R^\alpha)}{\phi})\frac{p^{-\sigma}}{P^{-\sigma}}Y$$

$$\text{s.t. } \theta[(p-\zeta\frac{\tau w}{\phi})\frac{p^{-\sigma}}{P^{-\sigma}}Y] \geq (1-c^\gamma-\zeta)\frac{\tau w}{\phi}\frac{p^{-\sigma}}{P^{-\sigma}}Y \tag{7}$$

Case 1: borrowing constraint is binding:

If $\theta <= \bar{\theta}$, where $\bar{\theta}$ is a threshold, the borrowing constraint is binding and we can rewrite the borrowing constraint as

[38] Lin and Ye (2018*a*) revealed that global liquidity shocks may deteriorate domestic trade credit. We also verified this assumption in the empirical part.

[39] The literature (like Georgiadis (2016) and Miranda-Agrippino and Rey (2020), etc.) have reached an agreement that the borrowing interest rate of foreign firms will increase after a contractionary US monetary policy shock. Here, we assume that it is exogenous, and the firm takes it as given. The endogenization of interest rate will not change our main results.

$$p = [(1 - R^{\nu})\zeta + (1 - c^{\gamma})R^{\nu}]\frac{\tau w}{\phi} \tag{8}$$

Case 2: borrowing constraint is not binding

If $\theta > \bar{\theta}$, the borrowing constraint is not binding. Solving the unconstrained optimization problem will give us :

$$p = \frac{\sigma}{\sigma - 1}\frac{\tau w[c^{\gamma} + \zeta + (1 - c^{\gamma} - \zeta)R^{\alpha}]}{\phi} \tag{9}$$

This becomes $p = \frac{\sigma}{\sigma-1}\frac{\tau w}{\phi}$ if external financing is assumed to be as expensive as internal financing (that is, $R = 1$), which is similar to Melitz (2003).

6.2 Propositions

In the partial equilibrium model, the firm-level optimal export prices are affected by trade credit, liquidity conditions, and borrowing interest rate, which in turn are affected by monetary policy shocks. With the expressions of export prices in hand, we could derive three propositions:

Proposition 1. *The export price decreases with trade credit and liquidity conditions and increases with the borrowing interest rate:* $\frac{\partial p}{\partial \zeta} < 0$, $\frac{\partial p}{\partial c} < 0$, $\frac{\partial p}{\partial R} > 0$.

This proposition represents the relationship between export prices and the characteristics of the firms. Consequently, the impact of global monetary policy on export pricing is determined by how the shock could affect these intermediate variables. When the credit constraint is binding, it is consistent with the efficiency sorting theory, which predicts that more stringent credit conditions (here, smaller ζ and c, and higher R) would raise optimal prices.[40] When the credit constraint is unbinding, tighter trade credit and liquidity conditions and a higher borrowing rate would cause a larger average borrowing cost, thus implying a higher price.

Proposition 2. *The export price would increase in response to a tightening US monetary policy shock (that is,* $\frac{\partial p}{\partial m} > 0$*) if the supply side effect dominates.*

This is what we have revealed in the benchmark findings in Section 3. Theoretically, a tightening global monetary shock would deteriorate firms' trade credits and liquidity

[40] For more details about efficiency sorting, please refer to Manova and Zhang (2012).

conditions and increase the borrowing rate. Therefore, according to Proposition 1, it is straightforward to understand why the export price would increase following a tightening monetary policy shock.[41] On the demand side, a tightening shock would depress aggregate demand and decrease input prices, which would contribute to a negative effect on export prices. However, as long as this force is less powerful than that of the supply side, the net impact will be positive, which is consistent with our empirical finding. It is worth noting that although we emphasize the finding of a cost channel, we don't deny the existence of the demand side impact. It is very likely that sometimes the demand side effect will be dominant.[42]

Proposition 3. *The impact of the US monetary shock on export price (i.e., $\frac{\partial p}{\partial m}$) depends on the credit conditions of the firms. If supply-side factors dominate, it is greater when the firms' trade credits ζ and liquidity conditions c are worse, and their average borrowing costs (δR) are higher.*

This proposition sheds light on the role of firms' credit conditions in the transmission of global monetary shocks to firms' export prices. Our model shows that the impact of monetary shocks is heterogeneous at the firm level: firms with tighter trade credit and liquidity conditions and higher average borrowing costs experience greater price increases in response to tightening shocks. The empirical supporting evidence is displayed in Section 4.[43]

The proof of the above proposition is shown in the Appendix C. Our conclusion in the benchmark model is robust to dynamic and sticky price settings, different currency invoicing choices, and the inclusion of fixed costs. All extensions are displayed in the Appendix D.

[41] Empirically, in Section 4, we show that trade credit and liquidity worsen significantly in reaction to a tightening shock. However, the interest rate responses to global monetary shocks are not significant in China. However, this impact is theoretically possible, especially for countries with less rigorous capital control.

[42] The determinants of the relative importance of demand-side versus supply-side impact is beyond the scope of this paper, which is left for future investigation.

[43] We don't have a direct measure of the borrowing rate R in the data and our measurements of average borrowing cost are proxies for δR.

7 Conclusion

In this paper, we explore the response of export prices to external shocks, which is a fundamental aspect of international economics. Different from the existing literature, our focus is specifically on monetary policy shocks originating from the United States, which behaves as a pivotal force driving the global financial cycle and an important factor contributing to world output fluctuations. Using high-frequency exogenous monetary shocks, monthly custom transaction records, and comprehensive firm-level balance sheet data, we provide a fresh perspective on this subject. This paper documents a counter-intuitive finding that exporters do not lower their export prices in response to a contraction in total demand following a tightening of US monetary policy. Moreover, we show that the exchange rate movement, usually perceived as a key factor in global trade, is not the main reason accounting for the export price adjustments to the US monetary shocks. Instead, the monetary contraction mainly affects export prices through a "borrowing cost channel", which is related to firms' trade credit and liquidity conditions.

Specifically, we reveal that tightening US monetary policy shock will deteriorate firms' trade credit and liquidity conditions, which will force firms to rely more on external financing and induce a higher average borrowing cost. What's more, it is illustrated that the transmission of US monetary policy shock on export prices depends on firms' financing conditions, and the impact is more pronounced for firms with higher average borrowing costs, less favorable trade credit acquisitions, and tighter liquidity conditions.

In an era characterized by the increasing integration of global trade and finance, understanding how export prices adapt to global monetary policy shocks in the presence of financial frictions is crucial for both market players and policymakers. Our paper casts new light on the special role of US monetary policy shocks in shaping international trade through its influence on exporters' trade credits, liquidity conditions, and financing costs. We use China, the largest exporter in the world, as an example, which has general implications for all economies.

Moreover, the response of exporters' pricing behaviors also provides new evidence on how the Fed monetary policy could affect US and global inflation through the trade connection with China. It also reveals the role of China in transmitting the US monetary policy impact to other countries. Our findings may provide enlightenment for some other research, such as the global monetary policy spillover on the real economy and asset prices through trade channels and the optimal domestic policy and international coordination in response to adverse global shocks in the presence of financial frictions, etc. Many interesting and important questions remain in this area, and we hope that our paper will serve as a stepping stone for future research.

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A More results on baseline regression

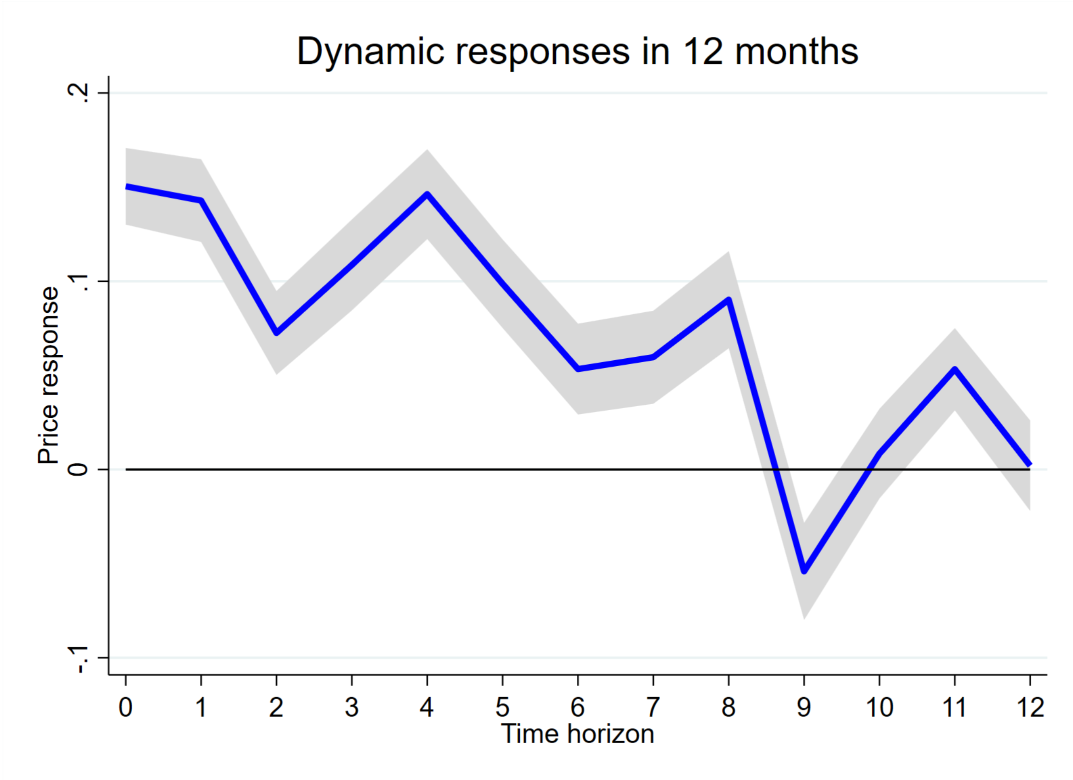

Figure A1: Dynamic price responses to monetary policy shocks

Note: The specification is $\Delta_{12} \ln P_{it+n} = \alpha + \beta \cdot m_t + \Gamma \cdot \mathbf{Z} + \Omega_t + \xi_i + \varepsilon_{it}$. The dependent variables in columns (1)-(12) are the changes in monthly price in the future 1 to 12 months after the monetary policy shocks. The regression coefficients are reported in A1.

Table A1: Dynamic response of export prices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent Var	Monthly $\Delta lnP_{it+\tau}$											
	1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
brw_t	0.143***	0.073***	0.109***	0.146***	0.099***	0.053***	0.060***	0.090***	-0.054***	0.008	0.053***	0.002
	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.013)	(0.012)	(0.011)	(0.012)
$Sales_{it-n}$	-0.006***	-0.007***	-0.007***	-0.006***	-0.003*	-0.004*	-0.003	-0.003	-0.002	-0.001	-0.003	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
ΔlnP_{it-1}	0.235***	0.179***	0.138***	0.103***	0.069***	0.040***	0.007***	-0.017***	-0.049***	-0.083***	-0.345***	-0.103***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	834640	798607	763134	730964	699857	669829	640174	612189	585815	564448	575010	566639

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The specification is $\Delta_{12} \ln P_{it+n} = \alpha + \beta \cdot m_t + \Gamma \cdot \mathbf{Z} + \Omega_t + \xi_i + \varepsilon_{it}$. The dependent variables in columns (1)-(12) are the changes in monthly price in the future 1 to 12 months after the monetary policy shocks. All regressions include firm fixed effects.

Table A2: Export value and quantity responses to US monetary policy shocks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var	Firm level value ΔlnV_{it}				Firm-product level quantity ΔlnQ_{iht}			
	Monthly		Annual		Monthly		Annual	
brw_t	0.133***	0.211***	-0.628***	-0.184***	-0.018	0.036	-1.930***	-2.011***
	(0.040)	(0.038)	(0.036)	(0.049)	(0.037)	(0.038)	(0.030)	(0.041)
$Sales_{it-n}$		-0.254***		-0.245***		-0.264***		-0.059***
		(0.005)		(0.015)		(0.005)		(0.012)
ΔlnP_{it-1}		0.210***		-0.456***		0.203***		-0.387***
		(0.002)		(0.012)		(0.001)		(0.003)
NER Control	Yes	Yes	Yes	Yes	No	No	No	No
Firm FE	Yes	Yes	Yes	Yes	No	No	No	No
Firm-product FE	No	No	No	No	Yes	Yes	Yes	Yes
Observations	1140624	986757	154732	99751	2359502	1751828	571830	314287

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. Columns (1)-(4) show results of firm-level value, while columns (5)-(8) show results of firm-product-level quantity. All regressions include firm fixed effects.

Table A3: Alternative aggregation levels of export prices

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Firm-product level ΔlnP_{iht}			Transaction level ΔlnP_{ihct}		
brw_t	0.140***	0.147***	0.127***	0.099***	0.104***	0.091***
	(0.011)	(0.011)	(0.011)	(0.009)	(0.009)	(0.010)
$Sales_{it-n}$		-0.009***	-0.009***		-0.010***	-0.010***
		(0.002)	(0.002)		(0.001)	(0.001)
ΔlnP_{ihct-1}			0.273***			0.274***
			(0.002)			(0.002)
$\Delta lnNER_{ct}$				0.118***	0.118***	0.101***
				(0.008)	(0.008)	(0.008)
$\Delta lnCPI_{ct}$				0.146***	0.155***	0.151***
				(0.032)	(0.032)	(0.036)
$\Delta lnGDP_{ct}$				0.445***	0.477***	0.336***
				(0.030)	(0.030)	(0.028)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm-product FE	Yes	Yes	Yes	No	No	No
Firm-product-country FE	No	No	No	Yes	Yes	Yes
Observations	2420018	2360154	1758341	3478000	3478000	2140247

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1)-(3) are changes in firm-product level price, while in columns (4)-(6) are changes in firm-product-country (transaction) level price. For the latter columns, we control changes in bilateral nominal exchange rates and the CPI inflation for the destination countries. All regressions include firm fixed effects.

Table A4: Alternative sample: only single-product firms

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var		Monthly ΔlnP_{it}			Annual ΔlnP_{it}	
brw_t	0.233***	0.219***	0.177***	0.210***	0.212***	0.312***
	(0.021)	(0.024)	(0.024)	(0.022)	(0.028)	(0.036)
$Sales_{it-n}$		-0.003	-0.006*		-0.019**	-0.025**
		(0.004)	(0.004)		(0.007)	(0.010)
ΔlnP_{it-1}			0.272***			-0.344***
			(0.006)			(0.018)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	359864	265249	187491	21567	14675	8690

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1)-(3) are changes in monthly prices, while columns (4)-(6) are changes in annual prices. All regressions include firm fixed effects.

Table A5: Different ownership

	(1)	(2)	(3)	(4)
Dependent Var		Monthly ΔlnP_{it}		
	SOE	DPE	MNE	JV
brw_t	0.215***	0.222***	0.136***	0.129***
	(0.078)	(0.026)	(0.015)	(0.017)
$Sales_{it-n}$	0.015	0.008**	-0.012***	0.001
	(0.011)	(0.003)	(0.002)	(0.002)
ΔlnP_{it-1}	0.167***	0.186***	0.378***	0.286***
	(0.022)	(0.005)	(0.004)	(0.005)
NER Control	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	13429	197037	390138	316814

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables are changes in monthly price. The ownership types of firms in columns (1)-(4) are state-owned enterprises, domestic private enterprises, multinational enterprises, and joint ventures, respectively. All regressions include firm fixed effects.

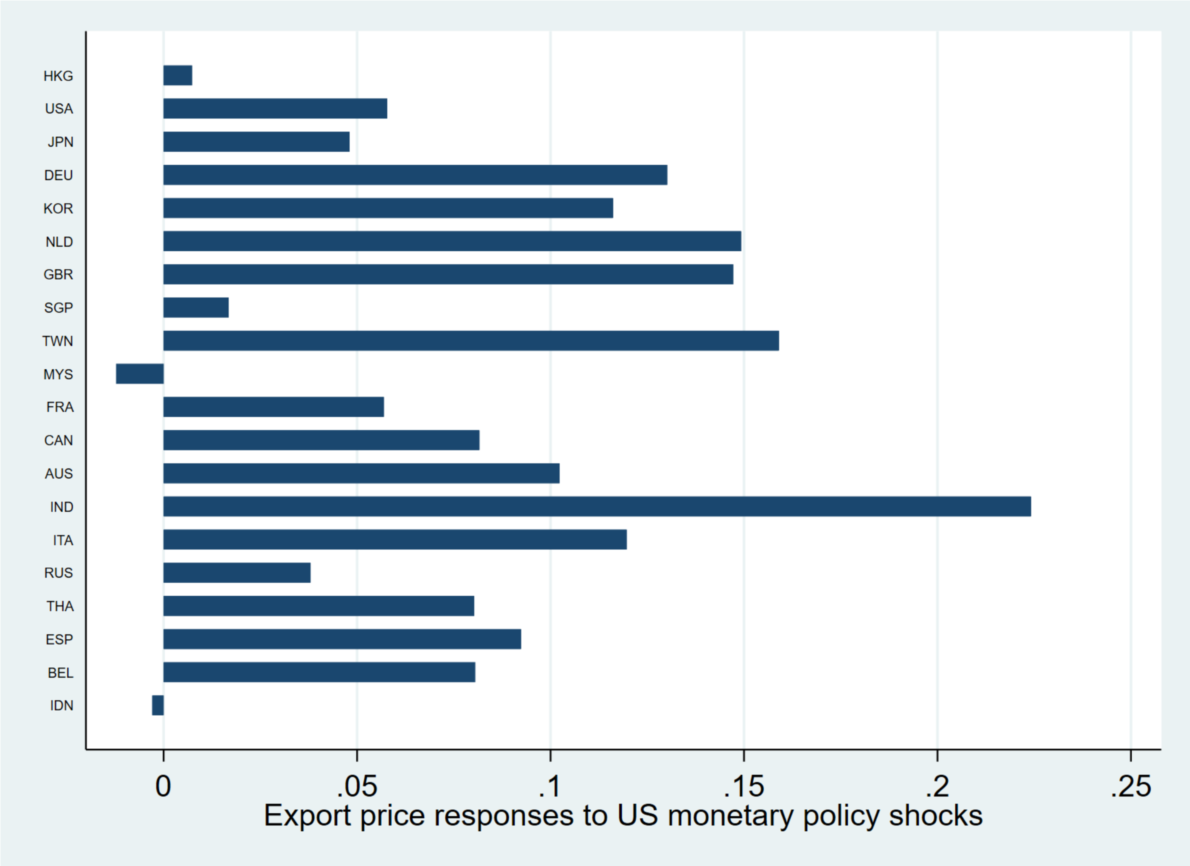

Figure A2: Price responses to top 20 trading partners

Note: The estimation specification for transaction level price response is the same as in columns (4)-(6) in Table A3. The horizontal coordinates represent the regression coefficients for the sub-sample containing only exports to each country.

Table A6: Market-specific export exposure

	(1)	(2)	(3)	(4)	(5)
Dependent Var			Monthly ΔlnP_{it}		
	US	EU	OECD	Emerging	All
brw_t	0.148***	0.133***	0.104***	0.122***	0.084***
	(0.012)	(0.012)	(0.020)	(0.012)	(0.021)
$brw_t \times \phi_{it}^{US}$	-0.065**				-0.098***
	(0.033)				(0.037)
$brw_t \times \phi_{it}^{EU}$		0.025			-0.022
		(0.054)			(0.056)
$brw_t \times \phi_{it}^{OECD}$			0.048*		0.093***
			(0.026)		(0.029)
$brw_t \times \phi_{it}^{EME}$				0.079**	0.077*
				(0.040)	(0.041)
$Sales_{it-12}$	0.002	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ΔlnP_{it-1}	0.300***	0.300***	0.300***	0.300***	0.300***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	917166	917166	917166	917166	917166

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The interaction terms in columns (1)-(4) are firm-specific export exposures to the US, EU, OECD, and emerging markets. The exposure to a certain market is defined as ratios of the export value to a certain market over the total export value of each firm within the same year. All regressions include firm fixed effects.

Table A7: Exchange rate regime shift: before and after July 2005

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}					
	Fixed regime: before Jul 2005			Floating regime: after Jul 2005		
brw_t	0.187***	0.183***	0.136***	0.057**	0.031	0.111***
	(0.013)	(0.013)	(0.012)	(0.023)	(0.023)	(0.023)
$Sales_{it-12}$		0.003	0.000		-0.025***	-0.021***
		(0.002)	(0.002)		(0.004)	(0.004)
ΔlnP_{it-1}			0.287***			0.181***
			(0.003)			(0.004)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	708251	689187	594872	389775	380779	320436

Notes: Robust standard errors clustered at the firm level; *, *,*, and *** indicate significance at 10%, 5%, and 1% levels. Columns (1)-(3) cover the period from January 2000 to July 2005, while columns (4)-(6) cover the period from August 2005 to December 2006. All regressions include firm fixed effects.

Table A8: Alternative standard error clusters and fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent Var	Monthly ΔlnP_{it}									
	FE 1		FE 2		Cluster 1		Cluster 2		Cluster 3	
brw_t	0.034***	0.054***	0.219***	0.181***	0.180**	0.150**	0.180**	0.150**	0.180***	0.150***
	(0.010)	(0.010)	(0.012)	(0.012)	(0.075)	(0.064)	(0.076)	(0.066)	(0.021)	(0.022)
$Sales_{it-n}$		-0.017***		-0.005***		-0.005*		-0.005*		-0.005**
		(0.001)		(0.001)		(0.003)		(0.003)		(0.002)
ΔlnP_{it-1}		0.296***		0.299***		0.299***		0.299***		0.299***
		(0.003)		(0.006)		(0.006)		(0.019)		
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	No	No	No	No	No	No	No
Month FE	No	No	Yes	Yes	No	No	No	No	No	No
Cluster	Firm	Firm	Firm	Firm	Firm+Time	Firm+Time	Time	Time	Sector	Sector
Observations	1100400	917419	1100400	917419	1100400	917419	1100400	917419	1100400	917419

Notes: Robust standard errors clustered at the firm level for columns (1)-(4), the firm level and the year-month level for columns (5)-(6), only the year-month level for columns (7)-(8), and industry level for columns (9)-(10); *, **, and *** indicate significance at 10%, 5%, and 1% levels. Regressions for columns (1)-(2) include firm fixed effects and year fixed effects, while those for columns (3)-(4) include firm fixed effects and month fixed effects, and only the firm level for columns (5)-(10).

Table A9: RMB price responses to monetary policy shocks

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}^{RMB}			Annual ΔlnP_{it}^{RMB}		
brw_t	0.180***	0.183***	0.150***	0.180***	0.195***	0.263***
	(0.011)	(0.011)	(0.010)	(0.010)	(0.010)	(0.012)
$Sales_{it-n}$		-0.004**	-0.005***		-0.024***	-0.021***
		(0.002)	(0.001)		(0.003)	(0.004)
ΔlnP_{it-1}			0.299***			-0.317***
			(0.003)			(0.007)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1100399	1072223	917424	155049	150863	97987

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1)-(3) are changes in monthly prices denominated in the Chinese RMB, while columns (4)-(6) are changes in annual prices denominated in the Chinese RMB. All regressions include firm fixed effects.

Table A10: Additional macro time-series controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var	Monthly ΔlnP_{it}							
	CN CPI	CN Value Added	US CPI	US PPI	VIX	Input Price	Oil Price	All
brw_t	0.062***	0.161***	0.126***	0.106***	0.105***	0.157***	0.112***	0.083***
	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.012)
ΔCPI_{t-1}^{China}	0.689***							0.585***
	(0.031)							(0.039)
ΔIVA_{t-1}^{China}		0.118***						0.086***
		(0.011)						(0.013)
ΔCPI_{t-1}^{US}			0.277***					0.199*
			(0.017)					(0.104)
ΔPPI_{t-1}^{US}				0.078***				-0.012
				(0.005)				(0.026)
$ln(VIX)_{t-1}^{US}$					-0.031***			-0.008***
					(0.002)			(0.002)
ΔP_{t-1}^{input}						0.057***		-0.000
						(0.003)		(0.006)
ΔP_{t-1}^{oil}							0.020***	-0.003
							(0.002)	(0.003)
$Sales_{it-n}$	-0.010***	-0.005***	-0.014***	-0.014***	-0.010***	-0.009***	-0.006***	-0.016***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ΔlnP_{it-1}	0.286***	0.288***	0.286***	0.286***	0.287***	0.286***	0.287***	0.285***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	825189	825189	825189	825189	825189	815538	815538	815538

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The control variables in columns (1)-(7) are CPI inflation in China, industrial value-added growth in China, CPI inflation in the US, PPI inflation in the US, log of CBOE volatility index (VIX), global industrial input (agriculture and mineral goods) price change, and global oil price change. The control variables in columns (1)-(8) are all above. All regressions include firm fixed effects.

Table A11: Approximate time match

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}					
	YoY + − 1 month			YoY + − 2 months		
brw_t	0.176***	0.197***	0.167***	0.187***	0.202***	0.172***
	(0.015)	(0.015)	(0.013)	(0.015)	(0.016)	(0.013)
$Sales_{it-n}$		-0.010***	-0.007***		-0.011***	-0.008***
		(0.002)	(0.002)		(0.002)	(0.002)
ΔlnP_{it-1}			0.342***			0.342***
			(0.003)			(0.003)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1275434	1121510	943499	1358899	1130947	945449

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1)-(3) are approximate year-on-year changes in monthly prices with time gaps from 11 to 13 months, while columns (4)-(6) are approximate year-on-year changes in monthly prices with time gaps from 10 to 14 months. All regressions include firm fixed effects.

Table A12: Weighted shocks using announcement dates

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var	Monthly ΔlnP_{it}			Annual ΔlnP_{it}		
$brw_t^{weighted}$	0.210***	0.212***	0.133***	0.159***	0.167***	0.265***
	(0.014)	(0.014)	(0.012)	(0.007)	(0.007)	(0.011)
$Sales_{it-n}$		-0.004**	-0.005***		-0.015***	-0.020***
		(0.002)	(0.001)		(0.002)	(0.004)
ΔlnP_{it-1}			0.299***			-0.318***
			(0.003)			(0.007)
NER Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1100400	1072227	917419	151542	147471	97987

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The specification is similar to the benchmark regression. The only difference here is replacing the original shocks with the weighted shocks, which are calculated according to the exact announcement dates. The frequency of shocks in columns (1)-(3) and (4)-(6) are monthly and annually, respectively. Please refer to the text for more details on the construction. All regressions include firm fixed effects.

B More results on mechanism

Table B1: Borrowing cost changes with lag interaction

	(1)	(2)	(3)	(4)
Dependent Var		Borrowing cost measures		
	$\Delta\frac{IE}{L}$	$\Delta\frac{IE}{CL}$	$\Delta\frac{FN}{L}$	$\Delta\frac{FN}{CL}$
$brw_t \times \frac{IE}{L}_{t-1}$	0.716***			
	(0.190)			
$brw_t \times \frac{IE}{CL}_{t-1}$		0.866***		
		(0.221)		
$brw_t \times \frac{FN}{L}_{t-1}$			1.076***	
			(0.201)	
$brw_t \times \frac{FN}{CL}_{t-1}$				1.156***
				(0.226)
$Sales_{it-1}$	-0.001***	-0.002***	-0.004***	-0.006***
	(0.000)	(0.000)	(0.001)	(0.001)
$Debt_{it-1}$	0.033***	0.038***	0.069***	0.076***
	(0.001)	(0.002)	(0.002)	(0.003)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	155008	153219	155008	153219

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. All firms are exporters. The dependent variables in columns (1)-(4) are changes in changes in interest expense over the total liability ratio, interest expense over the current liability ratio, total financial expense over the total liability ratio, and total financial expense over the current liability ratio. All regressions include firm and year fixed effects.

Table B2: Interactions with trade credit

	(1)	(2)	(3)	(4)
Dependent Var		Monthly ΔlnP_{it}		
$brw_t \times APay_{st-12}$	-2.636***	-1.781***		
	(0.589)	(0.573)		
$brw_t \times ARec_{st-12}$			-0.267	0.233
			(0.257)	(0.240)
$Sales_{it-12}$		-0.027***		-0.017***
		(0.004)		(0.001)
ΔlnP_{it-1}		0.225***		0.296***
		(0.003)		(0.003)
Firm FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
Observations	510638	427767	1072227	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The interaction terms in columns (1)-(2) and (3)-(4) are sector-level ratios of accounts payable over total assets and accounts receivable over total assets. All regressions include firm and time-fixed (year-month pair) effects.

Table B3: Interactions with liquidity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Var			Monthly ΔlnP_{it}			
$brw_t \times FPC_{st-12}$	-0.048***	-0.051***				
	(0.011)	(0.010)				
$brw_t \times Cash_{st-12}$			-1.765***	-2.181***		
			(0.505)	(0.476)		
$brw_t \times Liquid_{st-12}$					-1.133***	-1.062***
					(0.259)	(0.242)
$Sales_{it-12}$		-0.017***		-0.017***		-0.017***
		(0.001)		(0.001)		(0.001)
ΔlnP_{it-1}		0.296***		0.296***		0.296***
		(0.003)		(0.003)		(0.003)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1072227	917419	1072227	917419	1072227	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The interaction terms in columns (1)-(2), (3)-(4), (5)-(6) are the lag change in the first principle component of cash over total asset ratio and net liquidity asset over total asset ratio, and the lag change of each of them respectively. All regressions include firm and time-fixed (year-month pair) effects.

Table B4: Decomposition of prices: markup vs marginal cost

	Monthly sample				Annual sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Var	$\Delta\mu_{it}$	$\Delta ln(MC)_{it}$	ΔlnP_{it}		$\Delta\mu_{it}$	$\Delta ln(MC)_{it}$	ΔlnP_{it}	
brw_t	-0.006	0.177***	0.154***	0.026***	-0.012	0.168***	0.250***	0.094***
	(0.008)	(0.014)	(0.012)	(0.006)	(0.009)	(0.010)	(0.011)	(0.006)
$\Delta\mu_{it}$			0.004*				0.006*	
			(0.002)				(0.003)	
ΔMC_{it}				0.788***				0.618***
				(0.003)				(0.004)
ΔlnP_{it-1}			0.279***	0.063***			-0.312***	-0.119***
			(0.003)	(0.001)			(0.005)	(0.003)
$Sales_{it-n}$	-0.023***	0.024***	-0.005***	-0.019***	-0.023***	0.014***	-0.014***	-0.020***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
NER Control	No	No	Yes	Yes	No	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	830591	767775	665461	661708	110741	105320	81466	80825

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1), (2), (3)-(4) are changes in markup, marginal cost, and price in the monthly sample. The dependent variables in columns (5), (6), (7)-(8) are changes in markup, marginal cost, and price in the annual sample. All regressions include firm fixed effects.

Table B5: Within-sector and across-sector markup

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Var				Monthly ΔlnP_{it}			
$brw_t \times \mu_{it_0}$	0.072						
	(0.047)						
$brw_t \times \mathbf{1}\{\mu_{it_0} > \bar{\mu}_{cic4,t_0}\}$		0.004					
		(0.021)					
$brw_t \times \mathbf{1}\{\mu_{it_0} > \bar{\mu}_{cic2,t_0}\}$			0.006				
			(0.021)				
$brw_t \times \mu_{cic2,t-12}$				0.154			
				(0.191)			
$brw_t \times \mu_{cic2,t_0}$					0.280		
					(0.200)		
$brw_t \times \mu_{cic4,t-12}$						0.156	
						(0.178)	
$brw_t \times \mu_{cic4,t_0}$							0.274
							(0.190)
$Sales_{it-12}$	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ΔlnP_{it-1}	0.295***	0.295***	0.295***	0.296***	0.296***	0.296***	0.296***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	901462	901462	901462	917419	917419	917410	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The interaction terms in columns (1)-(7) are firm-level markup at its initial export year, firms' above-median dummy within the cic 2-digit and 4-digit sector, the median markup of each cic 2-digit and 4-digit sector in which the firm operates, in the last year or its initial year, respectively. All regressions include firm and time fixed effects.

Table B6: Discussion about other production costs

	(1)	(2)	(3)	(4)	(5)
Dependent Var	$\Delta\frac{Input}{Sales}$	$\Delta\frac{Wage}{Sales}$		ΔlnP_{it}	
brw_t	0.075	0.003	0.145***	0.162***	0.161***
	(0.055)	(0.007)	(0.011)	(0.013)	(0.014)
$brw_t \times \frac{Input}{Sales}_{it}$			0.007		
			(0.005)		
$brw_t \times \frac{Wage}{Sales}_{it}$				-0.104	
				(0.076)	
$brw_t \times \phi_{it}^{imp}$					-0.039
					(0.030)
$Debt_{it-n}$	-0.044***	-0.014**			
	(0.180)	(0.162)			
ΔlnP_{it-1}			0.299***	0.299***	0.299***
			(0.003)	(0.003)	(0.003)
$Sales_{it-n}$	0.081***	0.037***	-0.005***	-0.005***	-0.005***
	(0.262)	(0.187)	(0.001)	(0.001)	(0.001)
NER Control	No	No	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	155699	155699	917419	917419	917419

Notes: Robust standard errors clustered at the firm level; *, **, and *** indicate significance at 10%, 5%, and 1% levels. The dependent variables in columns (1)-(2) are changes in intermediate input cost over sales ratio and wage expense over sales ratio, respectively. The dependent variables in columns (3)-(5) are changes in monthly price. All regressions include firm fixed effects.

Table B7: China's bond index responses

	(1)	(2)	(3)	(4)
Period	2003-2006		2003-2022	
Price index	treasury	corporate bond	treasury	corporate bond
brw_t	-0.070	-0.381	-0.031*	-0.052
	(0.093)	(0.364)	(0.018)	(0.037)
Constant	Yes	Yes	Yes	Yes
Observations	27	25	137	135

Notes: *, **, and *** indicate significance at 10%, 5%, and 1% levels. The specification is $y_t = \alpha + \beta * brw_t + \epsilon_t$, where y_t is the bond index overnight return (from last day's close price to today's open price), brw_t is the daily monetary policy shock, and t is Fed FOMC announcement date.

C Proof of propositions

Proposition 1. The export price decreases with trade credit and liquidity conditions and increases with the borrowing interest rate: $\frac{\partial p}{\partial \zeta} < 0$, $\frac{\partial p}{\partial c} < 0$, $\frac{\partial p}{\partial R} > 0$.

Proof

If the borrowing constraint is binding:

$$\frac{\partial p}{\partial \zeta} = \frac{\tau w}{\phi}(1 - R^{\nu}) < 0$$

$$\frac{\partial p}{\partial c} = \frac{\tau w}{\phi} R^{\nu}(-1)\gamma c^{\gamma - 1} < 0$$

$$\frac{\partial p}{\partial R} = \frac{\tau w}{\phi}(1 - c^{\gamma} - \zeta)\nu R^{\nu - 1} > 0$$

If the borrowing constraint is not binding:

$$\frac{\partial p}{\partial \zeta} = \frac{\sigma}{\sigma - 1}\frac{\tau w}{\phi}(1 - R^{\alpha}) < 0$$

$$\frac{\partial p}{\partial c} = \frac{\sigma}{\sigma - 1}\frac{\tau w}{\phi}\gamma(1 - R^{\alpha}) c^{\gamma - 1} < 0$$

$$\frac{\partial p}{\partial R} = \frac{\sigma}{\sigma - 1}\frac{\tau w}{\phi}[\alpha(1 - c^{\gamma} - \zeta) R^{\alpha - 1}] > 0$$

Proposition 2. The export price would increase in response to a tightening monetary shock (i.e.,$\frac{\partial p}{\partial m} > 0$) if the supply side effect dominates.

Proof

If the borrowing constraint is binding:

$$\begin{aligned}\frac{\partial p}{\partial m} =& \frac{\partial p}{\partial \zeta}\frac{\partial \zeta}{\partial m} + \frac{\partial p}{\partial c}\frac{\partial c}{\partial m} + \frac{\partial p}{\partial R}\frac{\partial R}{\partial m} + \frac{\partial p}{\partial w}\frac{\partial w}{\partial m} \\ =& \frac{\tau w}{\phi}(1 - R^{\nu})\rho_{\zeta} + \frac{\tau w}{\phi} R^{\nu}(-1)\gamma c^{\gamma - 1}\rho_c + \\ & \frac{\tau w}{\phi}(1 - c^{\gamma} - \zeta)\nu R^{\nu - 1}\rho_R + \frac{\tau}{\phi}[(1 - R^{\nu})\zeta + (1 - c^{\gamma})R^{\nu}]\rho_w\end{aligned}$$

If the borrowing constraint is not binding:

$$
\begin{aligned}
\frac{\partial p}{\partial m} =& \frac{\partial p}{\partial \zeta}\frac{\partial \zeta}{\partial m} + \frac{\partial p}{\partial c}\frac{\partial c}{\partial m} + \frac{\partial p}{\partial R}\frac{\partial R}{\partial m} + \frac{\partial p}{\partial w}\frac{\partial w}{\partial m} \\
=& \frac{\sigma}{\sigma-1}\frac{\tau w}{\phi}(1-R^{\alpha})\rho_{\zeta} + \frac{\sigma}{\sigma-1}\frac{\tau w}{\phi}\gamma(1-R^{\alpha})c^{\gamma-1}\rho_c + \\
& \frac{\sigma}{\sigma-1}\frac{\tau w}{\phi}[\alpha(1-c^{\gamma}-\zeta)R^{\alpha-1}]\rho_R + \frac{\sigma}{\sigma-1}\frac{\tau}{\phi}[c^{\gamma}+\zeta+(1-c^{\gamma}-\zeta)R^{\alpha}]\rho_w
\end{aligned}
$$

In both cases, the first three parts $\frac{\partial p}{\partial \zeta}\frac{\partial \zeta}{\partial m}$, $\frac{\partial p}{\partial c}\frac{\partial c}{\partial m}$, $\frac{\partial p}{\partial R}\frac{\partial R}{\partial m}$ are positive, while the fourth part $\frac{\partial p}{\partial w}\frac{\partial w}{\partial m}$ is negative. The former three parts are related to the supply-side effect, and the last part reflects the power of demand shrink. When the supply-side cost-push effect dominates the demand effect, the net impact of global monetary policy shock should be positive. This prediction is verified in the empirical part.

Proposition 3. The impact of the monetary shock on export price (i.e., $\frac{\partial p}{\partial m}$) depends on the credit conditions of the firms. If the supply-side factors dominate, it is bigger when firms' trade credits ζ and liquidity conditions c are worse, and their average borrowing costs (δR) are larger.

Proof

This can be easily derived from Proposition 2 as $\frac{\partial p}{\partial m}$ will be a decreasing function of ζ and c an increasing function of δR given some sets of parameters (i.e., supply-side components dominate). The existence of this effect has been verified empirically in the mechanism part.

D Model extension

Our conclusion in the benchmark model is robust to sticky price setting, currency invoicing, and fixed costs inclusion, which are illustrated below.

1. Dynamic optimization and sticky price

In the benchmark model, the optimization problem is static, and the prices are assumed to be flexible. In this part, we are going to illustrate that the main mechanisms still hold under dynamic optimization and sticky prices. We use the classical Calvo (1983) sticky price setting, and the firm's problem is to maximize its expected real profits:

$$\max_{p_t} \ \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R^{\alpha}_{t+i})}{\phi_{t+i} P_{t+i}} \right] \frac{p_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i}$$

$$\text{s.t. } \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[\theta_{t+i} (p_t - \zeta_{t+i} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}}) \frac{p_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i} \right] \geq$$
$$\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[(1 - c^{\gamma}_{t+i} - \zeta_{t+i}) \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} \frac{p_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i} \right]$$

where $\Omega_{t,t+i}$ is the real stochastic discount factor, and λ is the probability of a firm keeping its price unchanged in each period. The left-hand side of the borrowing constraint is the weighted sum of credit access, and the right-hand side reflects the corresponding external credit demands.

If the borrowing constraint is binding, we can rearrange the constraint and obtain the expression of the export price:

$$p_t = \frac{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{Y_{t+i}}{P_{t+i}^{1-\sigma}} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} (R^{-\nu}_{t+i} \zeta_{t+i} + \delta_{t+i})}{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{Y_{t+i}}{P_{t+i}^{1-\sigma}} R^{-\nu}_{t+i}} \tag{10}$$

It is seen that a tightening monetary shock can raise prices by increasing the borrowing proportion δ_{t+i} and reducing the ratio of credit access $R^{-\nu}_{t+i}$. The channel is similar to the static problem we discussed before. However, in this case, the impact of the monetary shock on the discount factor $\Omega_{t,t+i}$, aggregate expenditure Y_{t+i} and price index P_{t+i} will also play a role, which reflects the power of general equilibrium. If $\lambda = 0$, $p_t = [(1 - R^{\nu}_t)\zeta_t + (1 - c^{\gamma}_t) R^{\nu}_t] \frac{\tau_t w_t}{\phi_t}$, which is identical to the static solution.

If the borrowing constraint is not binding, we solve the unconstrained problem and get the first-order condition:

$$\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[(1 - \sigma) \frac{p_t}{P_{t+i}} + \sigma \varphi_{t+i} \right] \frac{1}{p_t} \frac{p_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i} = 0 \tag{11}$$

where $\varphi_{t+i} \equiv \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R^{\alpha}_{t+i})}{\phi_{t+i} P_{t+i}}$ is the real marginal cost in $t + i$. The optimal price can be expressed as:

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{P_{t+i}^{-\sigma}} Y_{t+i} \varphi_{t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{P_{t+i}^{1-\sigma}} Y_{t+i}} \tag{12}$$

We can see that a tightening shock can increase the borrowing proportion δ_{t+i}, the borrowing cost R_{t+i}, and hence the marginal cost ϕ_{t+i}. The channel is similar to the static problem we discussed previously, and now the impact is a weighted sum of the effect on current and future marginal costs. If $\lambda = 0$, $p_t = \frac{\sigma}{\sigma-1}\frac{\tau_t w_t(1-\delta_t+\delta_t R_t^{\alpha})}{\phi_t}$, which is exactly the same as the static version.

2. Invoicing currency

Our benchmark model doesn't explicitly consider the role of exchange rates and invoicing currency. In this part, we will explain that our mechanisms are robust to producer currency pricing (PCP), US Dollar currency pricing (DCP), and local currency pricing (LCP).

(1) *PCP*

The firm's problem is:

$$\max_{p_t} \ \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i}(1-\delta_{t+i}+\delta_{t+i} R_{t+i}^{\alpha})}{\phi_{t+i} P_{t+i}} \right] \left(\frac{p_t}{e_{t+i}^j P_{t+i}^j} \right)^{-\sigma} Y_{t+i}^j$$

$$\begin{aligned} \text{s.t. } \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[\theta_{t+i}(p_t - \zeta_{t+i} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}}) \left(\frac{p_t}{e_{t+i}^j P_{t+i}^j} \right)^{-\sigma} Y_{t+i}^j \right] \geq \\ \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[(1 - c_{t+i}^{\gamma} - \zeta_{t+i}) \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} \left(\frac{p_t}{e_{t+i}^j P_{t+i}^j} \right)^{-\sigma} Y_{t+i}^j \right] \end{aligned}$$

where p is the price in the producer currency, e_j is the nominal exchange rate, defined as the price of the destination country j's currency in terms of the producer currency, P and P^j is the price index in the producer country and country j respectively, and Y^j is the total expenditure in country j.

If the borrowing constraint is binding:

$$p_t = \frac{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{(P_{t+i}^j)^{\sigma} Y_{t+i}^j}{P_{t+i}} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} (R_{t+i}^{-\nu} \zeta_{t+i} + \delta_{t+i})(e_{t+i}^j)^{\sigma}}{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{(P_{t+i}^j)^{\sigma} Y_{t+i}^j}{P_{t+i}} R_{t+i}^{-\nu} (e_{t+i}^j)^{\sigma}} \tag{13}$$

We find that a tightening monetary shock can raise prices by increasing the borrowing proportion δ_{t+i} and reducing the ratio of credit access $R_{t+i}^{-\nu}$. The channel is similar to the dynamic problem we discussed before. However, in this case, the export price is also affected by the bilateral exchange rate e^j and the price index in both the sourcing and destination countries. If $\lambda = 0$, $p_t = [(1 - R_t^\nu)\zeta_t + (1 - c_t^\gamma)R_t^\nu]\frac{\tau_t w_t}{\phi_t}$, which is identical to the static solution.

If the borrowing constraint is not binding:

$$\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[(1-\sigma)\frac{p_t}{P_{t+i}} + \sigma \varphi_{t+i}\right] \frac{1}{p_t} \frac{p_t^{-\sigma}}{(P_{t+i}^j)^{-\sigma}} Y_{t+i}^j (e_{t+i}^j)^\sigma = 0 \tag{14}$$

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{(P_{t+i}^j)^{-\sigma}} Y_{t+i}^j \varphi_{t+i} (e_{t+i}^j)^\sigma}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{1}{P_{t+i}} \frac{P_t^{-\sigma}}{(P_{t+i}^j)^{-\sigma}} Y_{t+i}^j (e_{t+i}^j)^\sigma} \tag{15}$$

We can see that a global monetary policy shock can still affect export prices through its impact on current and future real marginal costs ϕ_{t+i}. Similarly, the bilateral exchange rate and price index will play a role. If $\lambda = 0$, $p_t = \frac{\sigma}{\sigma-1}\frac{\tau_t w_t (1-\delta_t+\delta_t R_t^\alpha)}{\phi_t}$, which is exactly the same as the static version.

(2) ***DCP***

The firm's problem is:

$$\max_{p_t} \ \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t e_{t+j}^{us}}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i}(1 - \delta_{t+i} + \delta_{t+i} R_{t+i}^\alpha)}{\phi_{t+i} P_{t+i}}\right] \left(\frac{p_t e_{t+i}^{us}}{e_{t+i}^j P_{t+i}^j}\right)^{-\sigma} Y_{t+i}^j$$

$$\begin{aligned} \text{s.t. } \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[\theta_{t+i}(p_t e_{t+j}^{us} - \zeta_{t+i} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}}) \left(\frac{p_t e_{t+i}^{us}}{e_{t+i}^j P_{t+i}^j}\right)^{-\sigma} Y_{t+i}^j\right] \geq \\ \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[(1 - c_{t+i}^\gamma - \zeta_{t+i}) \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} \left(\frac{p_t e_{t+i}^{us}}{e_{t+i}^j P_{t+i}^j}\right)^{-\sigma} Y_{t+i}^j\right] \end{aligned}$$

where p is the price in the US dollar, e^{us} is the nominal exchange rate against the US, defined as the price of the US dollar in terms of the producer currency.

If the borrowing constraint is binding:

$$p_t = \frac{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{(P^j_{t+i})^\sigma Y^j_{t+i}}{P_{t+i}} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} (R^{-\nu}_{t+i} \zeta_{t+i} + \delta_{t+i})(e^j_{t+i}/e^{us}_{t+i})^\sigma}{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{(P^j_{t+i})^\sigma Y^j_{t+i}}{P_{t+i}} R^{-\nu}_{t+i} (e^j_{t+i}/e^{us}_{t+i})^\sigma e^{us}_{t+i}} \tag{16}$$

Compared with the PCP version, in this case, the export price is affected by both the bilateral exchange rate e^j and the US exchange rate e^{us}. If $\lambda = 0$, $p_t e^{us}_t = [(1 - R^\nu_t)\zeta_t + (1 - c^\gamma_t) R^\nu_t] \frac{\tau_t w_t}{\phi_t}$, the price in terms of home currency (here RMB) is identical to the PCP version.

If the borrowing constraint is not binding:

$$\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[(1-\sigma) \frac{p_t e^{us}_{t+i}}{P_{t+i}} + \sigma \varphi_{t+i} \right] \frac{1}{p_t} \frac{p_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} (e^j_{t+i}/e^{us}_{t+i})^\sigma = 0 \tag{17}$$

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} \varphi_{t+i} (e^j_{t+i}/e^{us}_{t+i})^\sigma}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{1}{P_{t+i}} \frac{P_t^{-\sigma}}{(P^j_{t+i})^{-\sigma}} Y^j_{t+i} (e^j_{t+i}/e^{us}_{t+i})^\sigma e^{us}_{t+i}} \tag{18}$$

Similarly, the export price here is affected by both the bilateral exchange rate e^j and the US exchange rate e^{us}. If $\lambda = 0$, $p_t e^{us}_t = \frac{\sigma}{\sigma-1} \frac{\tau_t w_t (1 - \delta_t + \delta_t R^\alpha_t)}{\phi_t}$, the price in terms of home currency (here RMB) is identical to the PCP version.

(3) *LCP*

The firm's problem is

$$\max_{p_t} \ \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[\frac{p_t e^j_{t+j}}{P_{t+i}} - \frac{\tau_{t+i} w_{t+i} (1 - \delta_{t+i} + \delta_{t+i} R^\alpha_{t+i})}{\phi_{t+i} P_{t+i}} \right] \left(\frac{p_t}{P^j_{t+i}} \right)^{-\sigma} Y^j_{t+i}$$

$$\text{s.t. } \mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[\theta_{t+i} (p_t e^j_{t+j} - \zeta_{t+i} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}}) \left(\frac{p_t}{P^j_{t+i}} \right)^{-\sigma} Y^j_{t+i} \right] \geq$$
$$\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t}{P_{t+i}} \left[(1 - c^\gamma_{t+i} - \zeta_{t+i}) \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} \left(\frac{p_t}{P^j_{t+i}} \right)^{-\sigma} Y^j_{t+i} \right]$$

If the borrowing constraint is binding:

$$p_t = \frac{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{(P_{t+i}^j)^{\sigma} Y_{t+i}^j}{P_{t+i}} \frac{\tau_{t+i} w_{t+i}}{\phi_{t+i}} (R_{t+i}^{-\nu} \zeta_{t+i} + \delta_{t+i})}{\sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{(P_{t+i}^j)^{\sigma} Y_{t+i}^j}{P_{t+i}} R_{t+i}^{-\nu} e_{t+i}^j} \tag{19}$$

when $\lambda = 0$, $p_t e_t^j = [(1 - R_t^{\nu})\zeta_t + (1 - c_t^{\gamma}) R_t^{\nu}] \frac{\tau_t w_t}{\phi_t}$, the price in terms of home currency (here RMB) is identical to the PCP version.

If the borrowing constraint is not binding:

$$\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \left[(1 - \sigma) \frac{p_t e_{t+i}^j}{P_{t+i}} + \sigma \varphi_{t+i} \right] \frac{1}{p_t} \frac{p_t^{-\sigma}}{(P_{t+i}^j)^{-\sigma}} Y_{t+i}^j = 0 \tag{20}$$

$$p_t = \frac{\sigma}{\sigma - 1} \frac{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{P_t^{-\sigma}}{(P_{t+i}^j)^{-\sigma}} Y_{t+i}^j \varphi_{t+i}}{\mathbb{E}_t \sum_{i=0}^{\infty} \lambda^i \Omega_{t,t+i} \frac{1}{P_{t+i}} \frac{P_t^{-\sigma}}{(P_{t+i}^j)^{-\sigma}} Y_{t+i}^j e_{t+i}^j} \tag{21}$$

when $\lambda = 0$, $p_t e_t^j = \frac{\sigma}{\sigma - 1} \frac{\tau_t w_t (1 - \delta_t + \delta_t R_t^{\alpha})}{\phi_t}$, the price in terms of home currency (here RMB) is identical to the PCP version.

3. Both variable and fixed costs are paid in advance

If we incorporate fixed costs into the benchmark model and allow a proportion of δ ($\equiv 1 - c^{\gamma} - \zeta$) of both types of costs to be paid in advance. The firm's problem now becomes

$$\max_p \, (p - \frac{\tau w (1 - \delta + \delta R^{\alpha})}{\phi}) \frac{p^{-\sigma}}{P^{-\sigma}} Y - f$$

$$\text{s.t. } \theta[(p - \zeta \frac{\tau w}{\phi}) \frac{p^{-\sigma}}{P^{-\sigma}} Y - \zeta f] \geq (1 - c^{\gamma} - \zeta)(\frac{\tau w}{\phi} \frac{p^{-\sigma}}{P^{-\sigma}} Y + f) \tag{22}$$

where f is the fixed cost; if the constraint is not binding, the result is similar to the benchmark model result; if the constraint is binding, we can rewrite it as

$$p^{1-\sigma} = [(\frac{1 - c^{\gamma} - \zeta}{\theta} + \zeta) \frac{\tau w}{\phi}](p^{1-\sigma})^{\frac{\sigma}{\sigma - 1}} + f(\frac{1 - c^{\gamma} - \zeta}{\theta} + \zeta) \frac{P^{-\sigma}}{Y} \tag{23}$$

Adding the new constraint into the objective function, we get the profit:

$$[\frac{1-c^{\gamma}-\zeta}{R^{-\nu}}-c^{\gamma}-(1-c^{\gamma}-\zeta)R^{\alpha}]\frac{\tau w}{\phi}\frac{p^{-\sigma}}{P^{-\sigma}}Y+f(\frac{1-c^{\gamma}-\zeta}{R^{-\nu}}-1+\zeta) \tag{24}$$

To solve Equation 23, we can illustrate it with Figure C1, the straight line represents the left-hand side, and the curve denotes the right-hand side. There are two intersections of these two lines, which means that there are two solutions to this equation. Since the profit is a decreasing function of p, the firm will choose the lower price, corresponding to $p_H^{1-\sigma}$. When trade credit ζ and liquidity conditions c deteriorate and the interest rate R increases, the curve moves upward and $p_H^{1-\sigma}$ will be smaller, resulting in a higher optimal price. Therefore, Proposition 1 still holds. A tightening shock will deteriorate trade credit and liquidity conditions and drive up interest rates so that the price will go up. That is, Proposition 2 also holds. Furthermore, given some sets of parameters (i.e., supply-side forces dominate), one unit of monetary shock will cause the curve to move upward with a bigger magnitude when ζ and c is smaller and δR is larger; thus, the price change is bigger. This is exactly in line with what Proposition 3 predicts. In summary, including fixed costs will not alter our main propositions.

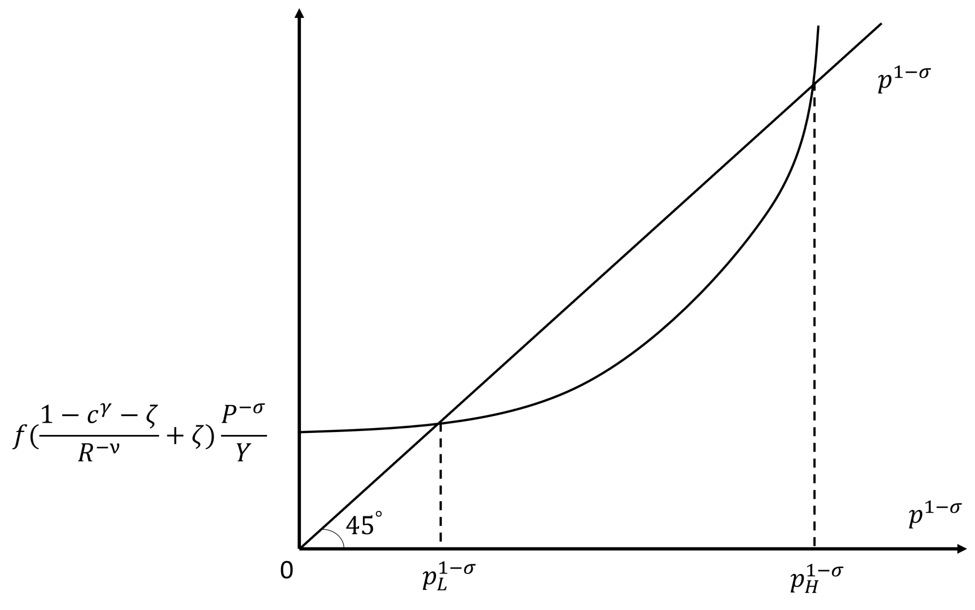

Figure C1: Borrowing constraint when both variable and fixed costs are paid in advance