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Trade Effects of Silver Price Fluctuations in 19th Century China: A Macro Approach

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Abstract

We assess the role of silver price fluctuations on Chinese trade and GDP during the late Qing dynasty, when China still had a bimetallic monetary system where silver was mostly used for trade. Using a structural VAR with a newly proposed small sample bias correction and blockwise recursive identification, we identify the impact of silver price shocks on the Chinese economy from 1867 to 1910. We find that silver price changes have substantial impact on trade, but barely affect GDP. Our results can partly be applied to the analysis of the role of vehicle currencies in today's emerging economies.

Keywords: vehicle currency, China, SVAR, small sample

JEL: C32, F14, F31, F41, N15

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1 Introduction

When the industrialized world started introducing various versions of a gold standard in the late 19th century and early 20th century, the Chinese empire under the late Qing kept its old bimetallic standard using both copper cash and silver. While conducting its international trade mostly through silver,¹ domestic transactions were mainly done in copper based currency (see e.g. Zheng, 1986; Guan, 2008; Ma, 2012). The exchange rate of silver and copper coins was allowed to fluctuate freely in the domestic market. This differentiates the Chinese bimetallic system from the rest of the world, where the relative value of coinage that used different kinds of metal was fixed. Due to this unique arrangement the drastic change in the market for precious metal (gold vs. silver and silver vs. copper) severely affected the Chinese economy. In many ways, this is one of the first documented examples of a problem common to many emerging markets in our time. A huge fraction of trade is denominated in a foreign currency, typically one of the main currencies of the industrialized world, in particular US dollar (Auboin, 2012). While this currency might have been adopted originally for its stability and reliability, it might still be subject to severe distortions that can easily spill over to the countries trading in that currency. Silver in the Qing dynasty plays a similar role as the US dollar plays for many emerging countries today. The value change in the US dollar would affect the countries which use it as international payment in a similar way silver affected China in the late 19th century. In both cases, historic China and modern emerging markets, the value of nondomestic currency used as the international trade payment varies over time.

Thus, we can use this Chinese experience from 1867 to 1910 to illustrate how

¹Zheng (1986) states that China mainly used silver as its international payments. When exporting goods, China received payment in silver; when importing goods, China paid an amount of silver which was equal in value to the goods' value in gold. Leong (1934) supports this statement using the data from 1900 to 1932.

the volatility of foreign trading currencies affects trade. To this end we develop a structural VAR and propose an improved finite sample bias correction to allow estimation in our fairly short annual sample. Our results suggest a substantial impact of silver price fluctuation on Chinese trade.

Of course our paper is not the first to address the question of foreign currencies used in international trade, which have been extensively discussed in the literature on vehicle currencies. In particular, there is a large microeconomic theoretical and empirical literature on the choice of the invoice currency (Rey, 2001; Bacchetta and Van Wincoop, 2005; Goldberg and Tille, 2008, 2009). However, the macroeconomic literature on exchange rates that is most closely related to our paper has primarily focused on only remotely related issues such as exchange rate pass-through (see e.g. Cao et al., 2015; de Bandt and Razafindrabe, 2014; Choudhri and Hakura, 2015), or the impact of a country's own exchange rate on that country's trade (examples are Koray and Lastrapes, 1989; Kroner and Lastrapes, 1993). Goldberg and Tille (2006) investigates trade adjustments when the US dollar is used as vehicle currency while the exchange pass-through is assymetric across countries. Yet, the macroeconomic literature has mostly ignored fluctuations of purchasing power of these trading currencies on the global market.² Partly this is explicable by the difficulties in identifying the macroeconomic effects of these currencies on trade. For example, contemporaneous feedback from the US dollar fluctuations on the US economy are well possible, which in turn affects the global economy, including the countries using US dollar as their trading currency. At the same time the US dollar is also driven by future expectations of the US economy. In modern times with global capital markets, a US dollar appreciation, might easily reflect strong capital movements from the rest of the world to the US driven by positive expectations about the

²A notable exception is Devereux and Shi (2013) who - based on a DSGE model - analyzes the global efficiency gains of using vehicle currencies from the perspective of saving the foreign exchange cost in the international trade.

returns of US investment (or negative expectations concerning the rest of the world). Business cycle movements across the globe, that are correlated with US dollar movements, might thus easily reflect those capital movements. Therefore, it is problematic to disentangle the effects of the purchasing power fluctuation in US dollar from the global impact of the US economy.

Contrarily, compared to the main trading currencies such as the US dollar and the Euro, silver during the late Qing dynasty was relatively unimportant on a global scale. Moreover, the fluctuations in the price of silver in historic China were mainly driven by the market for precious metals rather than severe crises abroad or speculation.³ Neither was China large enough to affect the variation in the value of silver in the international market, nor was silver important enough globally to affect global business cycles. Since the Chinese Maritime Customs started collecting detailed national trade data in the late 1860s, the Chinese economy during the late Qing dynasty creates a great natural experiment to assess the impact of fluctuations of a vehicle currency that is used in foreign trade on the local economy.

The contribution of our paper is threefold. First, we provide empirical evidence on the importance of vehicle currencies for trade, by estimating the impact of silver price shocks on Chinese trade during the late Qing dynasty using finite sample bias corrected structural VAR with a block recursive identification scheme introduced by Christiano et al. (1999). In addition to its main objective, i.e. the analysis of foreign currency denominated trade, this paper provides a new perspective to the economic history literature on the copper-silver bimetallic standards of China. Many contributions on the role of silver in China focus

³Remer (1926) has argued that the relative price of gold and silver was mainly driven by a surge of silver supply in this period. While the original argument referred mostly to the steep downward trend of the silver price during the period of interest, the correlation between the detrended silver price and detrended silver production is only marginally weaker than the level correlation (with both being in the order of magnitude of -0.7). That is, contrary to modern day exchange rates, it is not a reflection of real economic conditions in the issuing country.

on a narrow period around the Great Depression, using samples ranging from the late 1920s to the mid 1930s , and on the question whether or not adopting gold standards and keeping flexible domestic exchange rates among the metal currencies sheltered China from the Great Depression rather than trade effects (see e.g. Brandt and Sargent, 1989; Lai and Gau Jr, 2003; Ho and Lai, 2013; Ho et al., 2013). Others, such as Chen (1975) cover much longer periods (1650 to 1850 in this case) but are in consequence restricted to a more narrative approach due to data constraints. Contrarily, our sample is restricted to a period where an abundance of high quality annual data is already available for China. Yet, since we cover 44 years and correspondingly a larger number of business cycles it is long enough to allow fairly general conclusions on the trade effects of silver as a vehicle currency in China. Very few studies, such as Zheng (1986) and Guan (2008), provide detailed data and an analysis on a similar period as ours (1870-1900). However, contrary to us, they focus on a narrative approach and descriptive statistics instead of a quantitative analysis.

Finally, our paper contributes to the methodology to estimate small sample structural VARs. Given merely 42 observations of annual data (after taking first differences and one lag), correction of the small sample bias is a necessity. To this end, we develop a new bias correction, enhancing Kilian's (1998) original bias correction for impulse response functions with a bootstrap based bias correction for VAR coefficients proposed by Bauer et al. (2012).

We find a fairly strong impact of silver prices on trade (imports, exports and terms of trade). Our terms of trade effect confirms China as small open economy in terms of imports, but a large economy on its export markets. While contradicting the previous literature, this is in line with the anecdotal evidence we will present. The strong effect on trade is not mirrored by a corresponding effect on production, which we find to be fairly stable in the presence of silver

price fluctuations. Also, we find that the domestic price of silver in term of copper responds to the fluctuations of the value of silver, even though with a smaller magnitude and time lags. This implies an incomplete pass-through of silver price fluctuations into the domestic market, which may have helped shelter the Chinese economy from further real economic consequences. From this point view, our result echoes the previous literature about China and the Great Depression.

The remainder of the paper is structured as follows. In Section 2 we present a general background on the double exchange rate system in China. Section 3 summarizes our data and provides some further narrative evidence on the Chinese economy during the late Qing. Section 4 outlines our method and econometric model. In Section 5 we summarize our results and Section 6 concludes.

2 The double exchange rate and the role of silver in China

2.1 Metal Prices and the Double Exchange Rate: the role of silver in the market

While plenty of countries had bimetallic standards using both gold and silver currency, the bimetallic system in Qing dynasty China was unique in two respects. First, China did not fix an exchange rate between copper cash and silver taels⁴, but allowed their relative value to fluctuate. Second, at least in the period covered by our sample, they served almost completely separate purposes, where copper rather than silver has most of the typical features of a

⁴The tael is an ancient Chinese unit of weight that corresponds to roughly 35 grams with some limited regional variation.

domestic currency⁵. Most notably, domestic transactions were to a wide extent conducted in copper cash (which was technically minted from a copper and zinc alloy), while silver was used for foreign (and long distance) transactions, very large transactions and as store of value (see e.g. Kuroda (2000)) for a number of reasons. First, as mentioned for example by Peng (1955), silver currency had an extremely high purchasing power which drastically exceeded the daily needs of a family. Second, silver ingots were mainly privately minted by silversmiths. Thus, the lack of a unified standard (in terms of the silver ingots' weight and purity) required a tedious evaluation process before actual use, preventing them from ever gaining wider popularity as a means of payment. During our sample period, provincial governments started to mint their own silver coins. However, due to the differences among silver currency from different provinces, those domestically minted silver coins did not overcome the problem of a lacking unified standard and thus never were widely accepted. Even China's central government did not acknowledge the status of provincially minted silver coins until 1910.⁶ Peng (1955) concludes that silver coins were mostly collected and stored by people instead of being treated as a medium of exchange, especially when they were circulated into the countryside area.⁷ During our sample period, there were foreign silver coins flowing into China. However, Ma (2012) states that these silver coins only prevailed in the coastal areas, especially the treaty ports. Even though the foreign silver coins overcame the problems of silver ingots, they never became a popular way of payment across China. Their penetration into the inland China was very limited. This evidence suggests that the vast majority of domestic transactions were conducted in copper, including wages⁸

⁵Ma (2012)

⁶Wang (1990); Peng (1955); Ma (2012)

⁷Peng (1955) states that "the circulation speed (of silver coins) was greatly reduced when they were in the countryside area, each silver coin can only be used once per year at the best."

⁸Wages in the Peking area have been thoroughly investigated in the literature, using historical accounting data available for several industries, such as the fuel industry and carpenters. The wages were paid in copper cash. Please refer to Gamble (1943); Peng (2013)

and payments done by the government, such as soldiers wages.⁹

Qing dynasty China paid and received payments mostly in silver in its international trade. According to Guan (2008) and Zheng (1986), the cost of goods meant for export was mainly measured in copper coins since the production was mostly conducted in the inland area. Materials and labor were paid in copper coins. Only after the goods were transported to the treaty ports and ready to be exported, their value was converted into silver. For the imported goods, the value conversion happened in the opposite way. That is, when the imported goods were transported into the local market, the importing merchant first paid an amount of silver, which is equivalent to the goods' price in gold, the final consumers paid in copper currency. The exchange rates between gold and silver and between silver and copper cash thus affected the economy at the same time. While the market for copper cash was mostly local, to an extent that the exchange rate of copper to silver varied across regions and was determined by the local market, the silver price in terms of gold was determined in the highly competitive international market. The exchange rate between silver and gold was therefore exogenous for China.

Since silver was used predominantly as a trading currency, but only sparsely in the domestic market for large and correspondingly rare transactions, it has many features of a vehicle currency although technically being a domestic medium of exchange. For Qing dynasty China, it played a very similar role to the role the US dollar (and to a lesser extent other currencies of industrialized nations) plays today for developing countries. Because of the (partial) dollarization, the US dollar is a quasi-official currency circulating along with their own domestic currencies in many developing economies, such as South Asian countries like Philippines, Cambodia and Vietnam and some countries in South America, such as Panama, Costa Rica and Nicaragua. Yet, silver differs from standard vehicle

⁹Please refer to Pi (1995)

currencies in that it is not used as (main) currency in other countries. This greatly simplifies identification of pure valuation effects of the vehicle currency. The external value of the dollar is closely tied to the economic conditions in the US and expectations about the future performance of the US economy. While it is fairly straightforward to control for immediate business cycle spillovers, the impact of expectations concerning the US economy is hard to account for. Also, dollar fluctuations might have immediate repercussions on the US economy, which complicates shock identification even further. Contrarily, the price of silver was mostly driven by silver supply and had very limited effects on the international business cycle during our sample period.

A caveat of our study is that not all of China's trading partners at the time had already established a gold standard. However, it seems fair to assume that gold dominated their currency systems. The first notable exception is Hong Kong, that - like China - used silver through our entire sample period. However, while listed as foreign trading partner in the customs data due to British occupation, Hong Kong de facto filled the role equivalent to a treaty port,¹⁰ i.e. trade was merely channelled through Hong Kong, rather than China importing goods produced in Hong Kong or exporting for consumption in Hong Kong. Assuming that the trade channeled through Hong Kong had a similar composition as the remainder of Chinese trade, gold standard countries clearly dominated among the Chinese trading partners for both exports and imports. The second exception is India, which was on a silver standard until the late 1890s and contributed substantially to Chinese imports in the first decade of our sample. However, it seems that most trade with India was actually the opium trade with British India, that the UK enforced after the opium wars, so it is fairly safe to assume that gold played a major role here, since the UK had

¹⁰Keller et al. (2010) explicitly states that Hong Kong was an entrepôt for Chinese international trade.

already established the gold standard in 1821.¹¹ Moreover, the relevance of India as a Chinese trading partner declined quickly, and we find that our results are robust in shorter samples that omit the first decade of our full sample. The third notable exception is Japan which - like India - introduced the gold standard fairly late.¹² However, Japan only developed into an important provider of China's import in the latter half of our sample, limiting the importance of this issue.¹³

2.2 The exogeneity of silver prices for the Chinese economy

While we aim to create a framework, where we can remain as agnostic as possible in our structural identification, the exogeneity of silver prices for the Chinese economy is essential to our identification. There is a long standing consensus in the literature, that the silver price during the late Qing dynasty was mainly determined by global silver supply, which was driven by both increased production of silver and to some extent the gradual adoption of gold standards. The major contribution came from the increase of global silver production driven by newly discovered silver mines. Remer (1926) has proposed that “the fall in the gold price of silver during the closing decades of nineteenth century was due to such a cause as a great increase in the supply of silver in the West.” In many recent studies, Remer's proposal is widely accepted. While the original hypothesis mostly referred to the downward trend at the time, we find that the same holds true for short term movements of silver prices. When comparing the detrended data of global silver extraction¹⁴ and the detrended data of price of silver in terms of gold, we find a correlation of about -0.7. The increase

¹¹Indeed, some authors include the trade with India into the trade with UK.

¹²Japan officially adopted gold standard in 1897. But it started the process since 1893.

¹³Data on Chinese trade by country is taken from Hsiao (1974).

¹⁴Global silver production data is from Merrill and the Staff of the Common Metals Division (1930). The data ranges from 1876 to 1910, covering most of our sample period.

of silver production had no immediate impact on Chinese production, except through its function as exchange commodity (mainly vehicle currency). During our sample period the net silver inflow into China accounted for roughly 5% of total world silver production. This confirms our identifying assumption, that silver demand or supply from China would not significantly affect the price of silver in the international market. Moreover we also find no meaningful impact of lagged indicators of the Chinese economy on silver prices, lending further support to the exogeneity hypothesis.

It seems plausible that the remaining variation of silver prices, was strongly driven by the afore mentioned gradual introduction of the gold standard across the globe. Since many countries experienced a boom with the introduction of the gold standard, there might still be some business cycle spillovers related to silver prices. Thus, although silver is not the main currency of China's trading partners during our sample, we still have to account for the global business cycle, as detailed in the Subsection 3.5.

3 Futher data

3.1 Sample selection

Our sample starts in 1867, when detailed national level trade data for China first became available, and ends in 1910, the year before the revolution that eventually toppled the Qing dynasty. That is, we use the largest sample available without running into too severe problems due to structural changes or political turmoil overshadowing usual economic behavior. To allow a deeper understanding of the data behind our model, the following subsections not only summarize the sources and details of our data, but also some stylized facts on the Chinese monetary system, Chinese trade, the Chinese economy, and the

global environment at the time.

3.2 Measuring silver prices

As we have mentioned before, China has negligible effects on the value of silver and it was a price taker in the silver gold exchange market. The silver and gold exchange rate is well documented. The price of silver is measured in US gold coins for one ounce of Bar Silver in British standards. The high similarity between the price of silver traded in New York and London suggests a highly integrated competitive market with minor price differences at best after 1878. In our paper we follow the literature (see e.g. Guan, 2008) and use data from the London market, which was the main trading hub for silver at the time. Even though there did exist some discrepancy of the silver prices in London and New York market before 1880, our robustness check by using a subsample starting from 1878 shows that our full sample results are robust.

The data on the exchange rate between copper cash and silver is taken from Peng (2006). It is measured in the number of copper coins per silver tael. The Qing government had tried to keep the exchange rate fixed at 1000 in previous centuries but had ultimately failed. The silver and copper cash exchange rate was allowed to move freely since the mid Qianlong era (around 1800s). As mentioned earlier, the production of both silver and copper in China was very small in our period of interest. Most of the currency metals relied on import. Not only the international supply and demand for silver affected the relative price between copper and silver, but also supply and demand for copper. Indeed many studies such as Peng (2013), Zheng (1986), Guan (2008) and Chen (1975), explicitly or implicitly imply that the relative scarcity of the two metals was the main driven force of the exchange rate. However, the government minted standardized copper coins, whereas silver was merely traded

as a commodity in the form of ingots cast by individual silversmiths. Therefore, silver supply affected the copper silver ratio in a more timely manner. When silver flowed into China, the domestic silver supply would increase at the same time. Contrarily, when copper supply increased, the government first minted coins from this copper and then put coins into circulation, which introduced some time lag between the increase in supply of copper as a commodity and the corresponding increase in the copper based money supply. Figure 1 shows the development of the silver price in copper cash for both Northern and Southern China. While both time series are clearly cointegrated, showing that markets are integrated to some extent, the relatively high persistence of minor deviations highlights the lower speed of price adjustments in the silver to copper exchange rate. This finding will be crucial in our identifying assumptions discussed in Section 4. For our study, we use the price in Northern China. Our figure also displays the inverse of the price of one picul (1,600 tael) of imported copper in terms of silver tael, and the inverse of the price of one picul of the copper-zinc combination used to produce copper cash (also measured in silver tael).¹⁵ By reporting the inverse of the price, rather than the import price of copper and our copper-zinc commodity basket respectively, we allow for easy comparison with the price of silver taels measured in copper cash. Essentially, those time series show the silver price in terms of the resource value of copper or copper cash. While there apparently is a long run relation between resource value of copper and its actual purchasing power on the Chinese domestic market, there are also fairly persistent differences. This suggests that copper was actually treated as money in a modern sense rather than a commodity money.

¹⁵These are computed by using the data from Zheng (1986) and Wang (1990). The former paper documented the import price of both copper and zinc, which were the two materials used in copper cash at a 6 to 4 ratio.

Figure 1: The silver price in terms of copper in Northern and Southern China

3.3 Data on Chinese trade

Since 1859 the Chinese Maritime Customs had been in charge of trade with foreign countries. Soon after, they began to collect detailed customs data. In the initial years, they only collected so called “port statistics” for the treaty ports (see e.g. Zheng, 1984). However, since 1867 the Chinese Maritime Custom started to publish national data.

By the late Qing Dynasty, the early industrialized nations had grown to a size, that China - despite its size in terms of population - was a small economy in terms of its import demand and also was clearly a price acceptor in regards to imports. However, due to its specialization China was still a recognizable force on its export markets, especially in the early part of our sample. Although competitors such as India, Japan, and Sri Lanka were gaining ground, China held a market share of about 30% for both of its main export commodities, tea and silk, during most of our sample period.¹⁶ While China gradually diversified

¹⁶Lee (2010) mentions that the total export of Indian tea and Ceylon tea was twice as much as Chinese tea exports. So China still accounted for almost 30% of the market share in the

its exports, those two still accounted for 36% of the total export in 1910 (starting from more than 90% in 1870).¹⁷

We can infer the unit price from the custom reports which documented units and total price of each import and export commodity. However, the reports do not offer any information on the overall price level of traded goods. Many scholars and agencies provide different aggregate indices and user-friendly time series based on the customs reports, such as the Nankai Economic Indicators, Kong (1988) and Hsiao (1974). Our trade data uses the Nankai Economic Indicators import and export price and quantity indices. We compute our terms of trade as the ratio of export prices over import prices. Figure 6 and 7 in the appendix summarize the development of trade and the terms of trade during our sample period.

In order to capture silver supply in China, we also include net silver inflows in our analysis. According to Lee (2009), Chinese domestic production of silver only accounted for a very small portion of the domestic silver supply. Thus, silver inflows almost completely cover the change in silver supply. While the trade balance does of course contribute strongly to (net) silver inflows, there are numerous other factors such as borrowing, war indemnities, and remittances from Chinese workers. An auxilliary regression shows that the trade balance merely explains about 35% of the variation in silver inflows, suggesting that non trade related factors dominate (see Figure 2 for a visual comparison). Our data is taken from Lee (2010), who did a thorough investigation of net silver inflows during the Qing dynasty.

tea market.

¹⁷The data has been obtained from Lee (2010).

Figure 2: Net Silver Inflows and the Trade Balance

3.4 Measuring economic conditions in China

Measuring economic activity in China in the late Qing dynasty is a difficult endeavour. Yet, several recent working papers by Ma et al. (2014) and Ma et al. (2016) attempt to estimate Chinese GDP over our sample period¹⁸. In our paper, we use the more recent of those estimations provided by Ma et al. (2016), which has more detailed production data on agriculture, and uses more detailed price data.¹⁹ China experienced a prolonged period of real stagnation and even slow decline (in per capita terms) at the time. In total, real GDP per capita grew by less than 2 percent in our entire sample period with an annual growth rate of 0.05 percentage points per year. Yet, volatility was higher than indicated by those numbers, with GDP peaking about 3.5 % above, and falling

¹⁸Stephen Broadberry (2017) provides a detailed estimation of Chinese GDP including the agricultural sector, the industrial sector and the service sector. However, their GDP estimation does not cover our sample period.

¹⁹Previous working paper versions of our paper used rice prices as provided by Wang (1992) to account for fluctuations in productivity. Since the demand for rice is fairly stable, price fluctuations mostly reflect the production side, which is fairly representative due to the large share of agriculture in Chinese GDP.

up to 4% below the initial level.

3.5 The global economic environment

To make sure that we do not misinterpret global demand shock as silver price shocks, we also include global GDP as an indicator of the international economy in our model. World GDP is based on historic GDP data obtained from the Maddison dataset. Because not every country's GDP data is available for our sample period, we choose those countries whose GDP is continuous and available at least from 1870 and those also have at least one observation of GDP data for an earlier year. For countries where GDP is missing between 1867 and 1870, we interpolate by assuming a constant growth rate between the last available data point before 1870 until the continuous observations start. Our sample contains the major economic powers of the world, including 14 European countries, the US, Australia, Canada, New Zealand, 3 South American countries and 4 Asian countries. The proxy for global GDP is computed as the simple sum of real GDP in those countries. As seen in Figure 3, the bulk of production still happens in Europe during our sample, although growth is primarily driven by North America, and both North America and Asia have a substantial contribution to the dynamics of global GDP.

To properly account for supply and demand shocks it would be preferable to include both international prices and quantities, rather than quantities only. However, there is no international price data for our period of interests. Yet, price data is available for the two major economies of the time, the US and Great Britain. Since reducing the “rest of the world” to the UK and US only is a loss of information that seems more substantial than ignoring prices (at times before fiat money was introduced), our benchmark model concentrates on GDP using the afore mentioned composition. However, in our robustness section, we

Figure 3: Global GDP and its composition

will thus present a model, where global GDP is proxied by US and UK real GDP and we also control for the corresponding price development, thereby accounting for supply and demand separately.

3.6 Transformations and stationarity

Unsurprisingly, we have stationarity issues with many of our variables. The logarithms of global GDP, the silver price (in both terms of gold and copper), and the quantity indices for imports and exports, exhibit unit root behavior in levels. Despite the low average growth of real per capita GDP, we find the fluctuations in GDP to be highly persistent. An ADF test clearly fails to reject for level and log level GDP data also indicating a unit root. Since we only have net silver inflows which are negative for several years, rather than inflows and outflows separately, we cannot compute log differences to obtain stationary data. Differences of the raw data are not covariance stationary, and fluctuate with an increasing amplitude. We, therefore, normalize the data using the trend

Variable	measurement	transformation	ADF test
silver price (gold)	gold Dollar/bar	log differences	-5.54 ***
silver price (copper)		log differences	-6.71 ***
imports	quantity index	log differences	-8.86 ***
exports	quantity index	log differences	-7.00 ***
terms of trade	price index ratio	differences, levels	-2.97 **, - 7.53 ***
net silver inflows	silver tael	normalized by openness	-3.34 **
Chinese GDP	quantity index	log differences	-4.66 ***
global GDP	quantity index	log differences	-8.94 ***
UK+US GDP	quantity index	log differences	- 7.93 ***
UK+US prices	price index	log differences	-5.35 ***

Note: In the ADF test column, the test statistic is given. *** indicates a rejection of the unit root at the 1% level, ** indicates a rejection at the 5% level.

Table 1: Variable transformations and unit root test results

component of exports plus imports. The resulting series is stationary in levels. Net silver inflows are the only nonstationary time series, where we perform any transformation other than log differences to obtain $I(0)$ data. The normalization is done with trade rather than GDP, which would be a more straightforward choice. But GDP, unlike trade, did not grow considerably during our sample period. In consequence, the series of net silver inflows measured as GDP ratio still exhibits the similar exploding variance as found in the original series.

We find no evidence that the terms of trade are $I(1)$, with an ADF test rejecting unit root behavior at the 1% level. However, modelling terms of trade as stationary implies that no shock can have a long term effect on the terms of trade. While this might be plausible for Chinese shocks to some degree, it seems unpalatable that international shocks cannot affect the terms of trade. Thus, our benchmark specification uses terms of trade in differences. However, we run robustness tests, where we model terms of trade in levels as indicated by the results of the unit root test. Table 1 summarizes the transformations we apply to the data to obtain stationary series, and the results of the ADF test for the reported transformation.

4 Method

4.1 Model and structural identification

Our reduced form model underlying the structural estimation is a simple VAR(1) including the log differences of world GDP, the price of silver in gold, the price of silver in terms of copper, the log difference of Chinese GDP, log differences of quantity indices of imports and exports, as well as net silver inflows normalized with the trend component of total trade, and the first difference of terms of trade. We perform robustness tests with different lag orders, as reported in the robustness section.

Due to the low annual frequency of our data, it is hard to determine a valid ordering for the Chinese variables considered such as imports, exports, domestic GDP, net silver inflows, and to a lesser extent terms of trade and the price of copper. While one might make the point that some of these variables respond slower than others, it is hardly plausible that they do not respond at all to each other over the course of a year, making a Cholesky decomposition economically implausible. However, at the time China had little enough impact on the world economy to treat both the growth of world GDP and the price of silver in terms of gold as exogenous. Therefore, we would like to restrict our additional assumptions to the existence of a global supply shock, that can affect global GDP, silver prices and the Chinese economy immediately, and a silver supply shock can affect silver prices and the Chinese economy, but is without contemporaneous consequences to global GDP.²⁰ In terms of a traditional Cholesky decomposition, this would imply a model where world GDP is ordered first, silver prices are ordered second, followed by a block of domestic Chinese variables

²⁰The most controversial part of this assumption might be, whether the terms of trade should be considered exogenous for China as well, as has been argued by some scholars despite the high market share of China in its export products (see Zheng, 1986). However, as long as a terms of trade shock does not affect silver prices, this is of no consequence to our identification scheme.

that may or may not mutually affect each other.

Writing our reduced form model as:

$$Y_t = BY_{t-1} + A\varepsilon_t, \quad (1)$$

where Y_t is the (8×1) vector of demeaned endogenous variables at time t taking the shape $Y_t = [\Delta \ln(\text{Global GDP}_t) \Delta \ln(\text{silver price}_t) \dots]'$, B is a (8×8) coefficient matrix, ε_t is a vector of mutually independent structural shocks with mean zero and variance 1. The matrix A mapping structural shocks on reduced form shocks thus takes the form:

$$A = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} & a_{37} & a_{38} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} & a_{47} & a_{48} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} & a_{57} & a_{58} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & a_{67} & a_{68} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77} & a_{78} \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & a_{88} \end{bmatrix}. \quad (2)$$

Christiano et al. (1999) have demonstrated that given a vector $Y_t = [V_{1t} \ x_t \ V_{2t}]$, where V_1 and V_2 are vectors and x is the variable of interest, the sorting of variables in the 'blocks' V_1 and V_2 is without consequence for the identification of shocks to x . That is, while the number of restrictions imposed to this system is obviously insufficient to identify all 8 shocks driving the model, it follows from the seminal argument brought forward by Christiano et al. (1999) that the shock to our variable of interest - the price of silver - is well identified without respect to the ordering of the other variables (or the lack thereof) within the Chinese block. We can thus estimate the silver supply shock using any Cholesky decomposition

of the covariance matrix obtained from our VAR(1), where a global 'block' only consisting of global GDP is followed by the price of silver in terms of gold ordered second. The final block is composed of the domestic Chinese variables, which might affect each other, can follow in an arbitrary order that is of no consequence to the identification of the shocks of interest, i.e. the global supply shock and the silver supply shock.

4.2 Bias Correction of the IRF - An “indirect inference after indirect inference” approach

To account for small sample bias in the impulse response functions (IRFs), we propose a new technique that combines the bootstrap-after-bootstrap mechanics developed by Kilian (1998) with a more recently developed bias correction of point estimates of the coefficients proposed by Bauer et al. (2012). In his seminal paper, Kilian (1998) argues that it is insufficient for the correction of small sample bias in IRFs that are bootstrapped in the spirit of Runkle (1987) to simply simulate based on the bias corrected coefficients estimate $\tilde{\beta}$. Since the simulations are subject to a small sample bias in the same order of magnitude as the original OLS estimation, bootstrapping based on $\tilde{\beta}$ would yield a distribution of IRFs that essentially corresponds to the (distribution of) the OLS coefficients $\hat{\beta}$. To get dynamics that resemble those implied by $\tilde{\beta}$ but account for uncertainty, we need to bootstrap simulations that usually generate point estimates in this order of magnitude. Thus, Kilian (1998) advocates a second layer of bias correction. For the simulations that produce the bootstrapped confidence bounds of the IRFs, we use the coefficient vector $\tilde{\beta}^*$ that (on average) yields OLS estimates of $\tilde{\beta}$ due to small sample bias, rather than $\tilde{\beta}$ that yields OLS estimates of $\hat{\beta}$. Thus, the distribution of OLS estimated coefficient vectors that is generated by the bootstrap, and that is underlying the distribution of

IRFs, is centered around $\tilde{\beta}$, which is the unbiased estimate of the true but unknown coefficients β . In his original paper, Kilian (1998) adopts the bootstrap proposed by Efron (1993). While having some advantages over an analytic bias correction, this approach assumes a constant bias in the neighbourhood of $\hat{\beta}$.

In our paper, we replace this simple bootstrap with a recently developed indirect inference bias correction developed by Bauer et al. (2012) which can account for nonlinearities in the bias term while still being computationally feasible. Bauer et al. (2012) repeatedly generate rough approximations of the distance between the expected biased estimate for a candidate coefficient vector $\beta^{(j)}$ and the original OLS estimate $\hat{\beta}$ using a bootstrap with a very low number of repetitions. The estimate of this distance is then used to generate a new candidate vector $\beta^{(j+1)}$ following the rule $\beta^{(j+1)} = \beta^{(j)} + \alpha(\hat{\beta} - \bar{\beta}_{OLS}^{(j)})$, where $\bar{\beta}_{OLS}^{(j)}$ is the bootstrapped OLS estimate based on the coefficient vector $\beta^{(j)}$ and $0 < \alpha < 1$. Even though the distance $(\hat{\beta} - \bar{\beta}_{OLS}^{(j)})$ is only a very noisy measure of the true distance when the number of bootstrap repetitions is low, this algorithm quickly produces candidate coefficient vectors in an order of magnitude such that the expected OLS estimates roughly match $\hat{\beta}$. By taking an average over several thousand candidate vectors that are generated by this algorithm after a short *burn in* period, it is possible to compensate small sample bias in the OLS estimate very accurately. In appendix B, we compare the results obtained without bias correction, using Kilian’s bias correction, and our improved version thereof.

Contrary to Kilian (1998), our structural identification is not based on the original OLS estimate of the covariance matrix $\hat{\Sigma}$ but uses the bootstrapped covariance matrix.

4.3 Impulse Response Function

In their seminal paper, Fry and Pagan (2011) note that the commonly reported pointwise medians of the distribution of potential impulse response functions might defy any economic logic, since they are not produced by a single model. Thus, following Fry and Pagan (2011) we report the set of IRFs produced by a single model that follows the median IRF most closely.

5 Results

5.1 Impulse response functions

The impulse response functions summarized in Figure 4 show that the silver price did have a statistically and economically significant impact on Chinese trade, both in terms of quantities and prices. For all time series where we used first differences (i.e. world GDP, the price of silver in terms of gold and in terms of copper, imports, exports, terms of trade and Chinese GDP) we report cumulative IRFs.

As expected, the impact of the silver price on global GDP is insignificant both in a statistical sense and economically. Note that the IRFs are scaled individually, so despite looking highly volatile, the IRF of global GDP is essentially flat in economic terms. We find the growth rate of silver prices in terms of gold to be mostly stochastic. There is only mild autoregressive behavior, and other included variables do not explain silver prices very well, with the exception of world GDP, which has a quantitatively larger - but still insignificant - effect. This essentially matches our story that silver prices are exogenous for the Chinese economy. Since there is no substantial impact of silver on the world economy, a shock to silver prices dies out almost immediately in terms of first differences. It is correspondingly highly persistent in terms of the level, declining

only slightly after peaking in the period following the shock. Since autocorrelation is very moderate the peak only slightly exceeds the original shock, thus a shock to the price of silver in terms of gold, changes the expected value of the price of silver permanently in the same order of magnitude.

Interestingly, the price of silver in terms of copper proves surprisingly rigid in response to this shock. The initial effect is negligible, and while the price of silver in copper does increase over time, it does not reach the same order of magnitude. While the silver price in terms of gold increases by about 7%, the silver price in terms of copper cash merely increases by 3%, i.e. about half of the change in the silver price in terms of gold. This relation coincides with the anecdotal evidence provided by Zheng (1986) who states that "the silver price in gold depreciates more than 50% while the copper coin price appreciates about 34% against silver during the same period." The slow response of silver price in terms of copper also implies that the nominal exchange rate between domestic currency and vehicle currency adjusts with rigidity as well as time lags after a shock hitting the value of the vehicle currency. Moreover, the smaller magnitude of the response shows that the vehicle currency's international value changes are not fully passed through into the domestic economy.

The terms of trade increases substantially and immediately and keeps rising considerably for one more period, before they start to decline and gradually stabilize at a level of a little less than 3%. In our data, both import and export prices were measured in silver. Our findings are thus consistent with a situation, where after an appreciation in silver the import prices decrease as imports (where China is a price taker) maintain their gold value. Export prices, however, seem to respond less, causing the terms of trade to change in favor of China after a silver appreciation. This interpretation is also in line with the finding that the IRF of the silver price (in terms of gold) has a very similar shape

as the terms of trade IRF. Both peak in the second year, and then stabilize at a level round the magnitude of the original impact of the shock. From all those findings above, we can see that the import prices adjust strongly, while export prices in terms of silver seem to be much more rigid. This high degree of price persistence in terms of the currency favored by the Chinese merchants, points to at least some degree of market power in the market for export goods.

Since imports just became cheaper from Chinese perspective, we find an increase in imports that accelerates for one year. After that, imports start falling again stabilizing on a level that matches the initial impact of the shock. We find similar dynamics with an opposite sign for exports, which are falling for about two years (due to the increase in price from the international perspective, which is caused by the smaller adjustment of export prices), followed by a recovery, stabilizing at around 1.5% below its original level. Yet, since the confidence bounds in this region are much wider, the long run effect is insignificant. All this goes hand in hand with a fairly sizeable decline in silver inflows. While the initial impact is small, net silver inflow drastically decreases in the period after the shock and takes 2 to 3 years to stabilize again. Since the effect on trade prices and trade quantities partly compensate each other in terms of the trade balance effect, we believe that this is mostly a reduction in non trade related silver inflows. Being stationary, silver inflows return to their long run equilibrium eventually by construction.

The initial impact on Chinese GDP is statistically significantly negative, but the order of magnitude is economically inconsequential. At longer horizons statistical significance also disappears. A very moderate negative effect of GDP is in line with the evidence on increasing imports and decreasing exports that is not entirely compensated by the terms of trade effect.

Considered jointly, our IRFs suggest that the valuation effects of an appreci-

Note: The solid line is the pointwise median of the bootstrapped impulse response function. The dotted line is the individual bootstrap simulation coming closest to the median as suggested by Fry and Pagan (2011). The shaded area represents the 16th to 84th percentile of the distribution, i.e. roughly a one standard deviation confidence bound.

Figure 4: Impulse response functions

ation of a vehicle currency will not lead to a serious trade deficit in the medium or long run, even though the trade deficit may be significant in the first 2 or 3 years after the shock. In our example, the terms of trade, which indicates the ratio of export over import prices, stabilized at about 3% while imports increase by 4% and exports decreases by 1.5%. That is, the quantity effect on the terms of trade is (partly) offset by the price effect. Countries whose vehicle currency appreciates (depreciates) can suffer (or benefit) from substantial volatility in their trade due to fluctuations of their vehicle currency, but may typically not experience permanent effects on their current account balance or growth. The observation that the initially small but significant negative impact on GDP erodes over time and GDP returns to its long run trend, while the domestic exchange rate (silver price in copper) adjusts, suggests that the flexibility of the exchange rate between silver (as vehicle currency) and copper (as primary domestic currency) might have played some role in shielding China from long run consequences of silver price fluctuations.²¹ Nowadays the countries that on the way to dollarization must fix the exchange rate of their own currencies with the US dollars. According to our IRF results, this fixed exchange rate may exaggerate the effect of the value change in US dollars by allowing a full pass through of the value change into the domestic economies. We would expect a much larger effect of the valuation change in the US dollars on those developing economies.

However, there is one caveat to the applications to our findings to today's emerging markets. We should note that our example only applies to countries that have some market power for their export commodities. Nowadays, this only applies to the few largest emerging economies, while most of emerging markets are not able to affect global prices. Yet, there might be some applicability of

²¹The increased silver price in copper pushed down the cost (in terms of silver) of exports and lifted up the domestic price (in terms of copper) of imports, which actually has neutralized some effects from the silver appreciation.

our results even in that case. In most countries where vehicle currencies are widely used, the chosen currency is the US dollar. At the same time, many emerging markets specialize in similar commodities, such as crude oil and some agricultural products. Qing dynasty China, might thus be considered an analogy of the emerging world, rather than an individual emerging market.

5.2 Variance decomposition

Table 2 summarizes the importance of the silver supply shock for our system. Although we find a significant impact, the share of variation in Chinese trade that is driven by the silver price is only of moderate size. In the long run, the price of silver only explains about 6% of the variation in trade prices, 8.8% in exports, and roughly 7% of imports. Thus, it seems as though Chinese history would not have taken a substantially different course, even if silver prices had been more stable. Yet, given that Chinese exports were mainly agricultural, and thus strongly driven by exogenous supply shocks such as weather, this still is a sizeable contribution, indicating that denominating trade in foreign currency might indeed import substantial volatility if that currency comes under duress. However, the impact on production itself is very limited. I.e. despite the fluctuations in trade, output itself remains fairly stable.

5.3 Robustness tests

We run a range of robustness tests that are graphically summarized in Figure 10. For the ease of presentation, the figure only includes each change (such as adding or replacing a variable, the lag order or the sample size) individually. Moreover, we also tested all possible combinations of those changes to our baseline model and - unless noted otherwise - still find that our results are robust.

Table 2: Contributions of silver supply shocks to forecast error variance

horizon	GDP_{global}	$P_{silver/gold}$	tot	imports
1	0.000	0.767	0.032	0.061
2	0.019	0.720	0.056	0.066
3	0.021	0.715	0.059	0.067
4	0.021	0.713	0.059	0.067
5	0.021	0.713	0.059	0.067
horizon	exports	$P_{copper/silver}$	GDP_{China}	silver inflows
1	0.058	0.001	0.024	0.013
2	0.075	0.023	0.021	0.147
3	0.085	0.030	0.032	0.190
4	0.087	0.033	0.032	0.206
5	0.088	0.033	0.032	0.210

Terms of trade: first difference or levels We estimated the model by using level data of terms of trade and got similar results, except for the impulse response of the terms of trade itself, which returns to 0 by construction.

Starting in 1878 It is preferable for our analysis if the shocks to the silver price in terms of gold are truly driven by the silver side of the market, rather than fluctuations in gold supply or demand. If a seeming increase of the silver price actually reflects a general decline in the purchasing power of gold, this would greatly change our interpretation of the results. Generally, there is little reason to worry. Our data ²²show that the official price of gold in pounds sterling and in US dollars, remain essentially unchanged over our entire sample period and the market price of gold in London was exactly the same as its official price in pounds sterling. However, in the first decade of our sample we observe a substantial deviation of the market price of gold in New York market from its official price in US dollars, which may be due to large changes in the US gold reserves. To make sure, that this is not driving the results, we reestimate our model using data from 1878 to 1910, i.e. covering the period when not only both the UK and the US had highly stable gold standards, but also the main

²²The data is available upon request.

industrial countries and their colonies converted to gold standard. Our results concerning trade are robust both in terms of the qualitative effects and the order of magnitude of the effects.

Global supply and global demand To make sure that our results were not driven by erroneously combining global supply and demand shocks by only considering global GDP, we extend our model by augmenting the global block of our model, that precedes the silver supply shock, by including an international price index. Due to data availability this comes at the cost of reducing our “rest of the world” to the UK and US only. The Chinese block remains unchanged. Since we are not aiming to actually identify global supply or demand shocks, but are merely interested in the silver supply shock, the order of global prices and global GDP is irrelevant to our identification. It is sufficient to assume that global GDP and global prices jointly capture the effect of global supply and demand shocks on silver prices.

As with our other robustness tests, the results are robust to this modification of the model.

Higher lag order Both an AIC and a sample size corrected AIC prefer a one lag specification whether we use terms of trade in first differences or levels, and whether or not we include global prices. However, one might argue that cyclical movements are better captured by higher lag orders. Generally, we find comparable results. The only exception is the model including both global supply and demand shocks. In this case, bias correction drives the process out of the stationary region. Preventing this, as usually done in the bootstrap bias correction literature, to avoid artificially introducing instationarity, implies that the bias cannot be fully corrected. Yet, looking at the biased results, indicates that the response also is generally similar in a model with two lags and the one

lag specifications we report.

6 Conclusion

We find that fluctuations in the value of silver had an economically and statistically meaningful impact on Chinese trade during the late Qing dynasty. We have two main findings: first, a floating exchange rate between domestic currency and vehicle currency could help shielding China from some of the disturbances from the international market, in particular silver price fluctuations. Second, when the vehicle currency silver appreciated, the domestic economy suffered a short run trade deficit. The appreciation of the vehicle currency may have neither economically nor statistically significant long run effects on either the trade balance or the domestic GDP. We find persistent effects on imports, exports and the terms of trade, and a substantial explanatory power of silver price shocks on the variation of trade over time. Given that silver played a very similar role as a vehicle currency just like the US dollar (and some other currencies) play nowadays for many emerging markets, this suggests certain risks when denominating trade in foreign currency, especially when the domestic country allows a full pass-through of this valuation change into the domestic economy. Evidently the situations in ancient China and modern day emerging markets are not the same and apparently, exporters (and importers) in emerging markets often do not have much choice when it comes to the invoice currency. Yet, we believe the valuation effects of vehicle currency is larger than perceived before, in particular since the latest experience during and after the great financial crisis has created strong revaluations of the main vehicle currencies.

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Appendix

Appendix A: Data Appendix

Table 3: Timeline of countries which adopted the gold standard

country	year
UK	1821
US	1873/1879
Germany	1873
France	1878
Australia	1852
Netherlands and Netherlands East Indies	1875
Canada	1854
Belgium and Scandinavians	1873
Japan	1897
Russia	1897
India	1898
Hong Kong	silver standand
Italy	Bimetallic standard
Siam, Straits Settlements and Federated Malay States	enforced gold standards, but silver was in circulation

Note: Date taken from Mitchener et al. (2010); Michele Fratianni (1984); Committee (1893); Powell (2005); Drummond (1976); Patterson (1918)

Note: The dashed line of the London market series is the price of silver as originally published in the Annual Report Of The Directors Of The Mint in 1933. The prices of silver are the average of bar silver in London per ounce in equivalent of the United States gold coins. The two solid lines are also the silver prices in gold but calculated as ratio of local currency value of one ounce gold relative to the local currency value of one ounce silver for London and New York respectively. The two series for London Market are almost the same, while the silver price in gold in New York deviated from that of London market in the first decade of our sample. Since London was the main trading center for silver and gold, we use the officially reported London data for our analysis. A robustness test removing the first part of the sample where the dynamics of the price in London and New York deviate, yields identical results.

Figure 5: The silver price in gold dollars from 1867 to 1910

Figure 6: Import and export volumes 1867 to 1910

Figure 7: Terms of trade 1867 to 1910

Figure 8: Growth rate of Chinese GDP from 1867 to 1910

Appendix B: Bias Correction

Qualitatively, bias correction makes little difference in our application. Yet, the quantitative differences (and thus of course the assessment of significance) are substantial. Figure 9 shows all impulse responses as obtained from our bias corrected VAR (that accounts for potential nonlinearities in the bias relatively precisely), the Kilian bias correction that assumes linear bias, and no bias correction at all. We find a bias in the order of magnitude of up to about 40% of the bias corrected estimate for several IRFs. Generally, the biased estimate substantially underestimates the effect. In most cases, the bias seems to be almost linear in our case, so our bias correction and Kilian's bias prediction produce almost identical results. However, in those cases where the bias is most substantial such as terms of trade and imports, we often find that Kilian's approximation - that ignores the nonlinearities - yields a result between our bias corrected estimate and the biased estimate. This suggests that there is some potential for application in cases of severe bias.

Note: The solid “median” line is the median of our preferred bias corrected bootstrap, the dotted “biased” line is the median of a bootstrap based on the original OLS coefficients, the line with diamonds labeled “Kilian” is the median of the bootstrap based on a Kilian bias correction (using the original covariance matrix rather than a bootstrapped one along the lines of Kilian, 1998)

Figure 9: Impact of bias correction on the IRFs

Appendix C: Robustness tests

Figure 10: Robustness tests