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Macroeconomic Trade Effects of Vehicle Currencies: Evidence from 19th Century China*

Abstract

We use the Chinese experience between 1867 and 1910 to illustrate how the volatility of vehicle currencies affects trade. Today's widespread vehicle currency is the dollar. However, the macroeconomic effects of this use of the dollar have rarely been addressed. This is partly due to identification problems caused by its international importance. China had adopted a system, where silver was used almost exclusively for trade, similar to a vehicle currency. While being important for China, the global role of silver was marginal, alleviating said identification problems. We develop a bias corrected structural VAR showing that silver price fluctuations significantly affected trade.

Keywords: vehicle currency, China, SVAR, small sample

JEL Classification: 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 their old bimetallic standard using both copper cash and silver. While conducting its external trade mostly through silver¹, domestic transactions were mainly done in copper based currency (see e.g. Zheng, 1986; Guan, 2008). 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.

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. While there were other sources of silver flows, the correlation between net exports and net silver imports is over 50%, giving further evidence to the huge importance of silver for Chinese trade. Leong (1934) comes to a similar conclusion using the data from 1900 to 1932.

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). Yet, the macroeconomic literature has mostly ignored the impact of vehicle currencies and fluctuations of their purchasing power on the global market. Partly this is probably explicable by the difficulties in identifying the macroeconomic effects of vehicle currencies on trade. Times of high volatility for currencies such as the US dollar, the Euro or the Pound Sterling - e.g. the great financial crisis and the subsequent European debt crisis -, usually coincide with times of duress for their respective economies. Thus, it is problematic to distinguish problems related to the widespread use of a currency as vehicle currency on the one hand from effects caused by business cycle spillovers and more importantly expectations concerning the issuing country's future development that are imbedded in the currency's exchange rate on the other hand. Since silver during the Qing dynasty was relatively unimportant on a global scale, contemporaneous feedback from silver prices to the global business cycle is negligible. Contrarily, contemporaneous feedback from the US dollar fluctuations on the US economy are well possible, introducing a large degree of uncertainty to identification. 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 returns of US investment (or negative expectations con-

cerning 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 and therefore a joint cause, rather than being driven by fluctuations of the US dollar as vehicle currency.

Contrarily, the fluctuations in the price of silver, that plays a similar role in historic China, were mainly driven by the market for precious metal rather than severe crises abroad or speculation.²Neither was China large enough to affect the price of silver, 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.

In this paper, we estimate the impact of silver price shocks on Chinese trade between 1867 to 1910 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 analysis contributes a new perspective to the economic history literature on the bimetallic standard of China. Many contributions on the role of silver in China focus on a narrow period around the Great Depression, using samples ranging from the late 1920s to the mid 1930s, and on the question whether not adopting gold standards and keeping a flexible domestic exchange rate between gold and silver 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

²Remer (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.

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, they focus on a narrative approach and descriptive statistics, instead of a quantitative analysis such as ours.

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).

The remainder of the paper is structured as follows. In Section 2 we present our data and some narrative evidence on the Chinese economy during the late Qing. Section 3 outlines our method and econometric model. In Section 4 we summarize our results and Section 5 concludes.

2 China and The World Economy 1868 to 1910:

Data and Descriptive Evidence

Our sample starts in 1867, when detailed 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.

2.1 Metal Prices and The Double Exchange Rate: why can silver be considered as vehicle currency?

While plenty of countries had bimetallic standards using both gold and silver currency, the bimetallic system in Qing dynasty China was unique in several respects. First, China did not fix an exchange rate between copper cash and silver taels,³ but allowed their relative value to fluctuate. Second, at least in the period covered by our sample, they served almost completely separate purposes. While domestic transactions were to a wide extent conducted in copper cash (which was technically minted from a copper and zinc alloy), foreign trade transactions almost exclusively used silver tael. Qing dynasty China paid and received payment 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. When trading with gold standard countries, the goods' value was converted into gold. 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

³The tael is an ancient chinese unit of weight that corresponds to roughly 35 grams with some limited regional variation.

amount of silver, which is in 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 local 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. Yet, silver differs from standard vehicle 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 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.

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 con-

tribution 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 global silver extraction ⁴ and the detrended price of silver in terms of gold, we find a correlation of about -0.7. Since silver was not produced within China, the increase of silver production had no immediate impact on Chinese production, except through its function as exchange commodity.

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 last subsection of this chapter.

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. To our knowledge price data from China is not available. Yet, 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. 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.

The data on the exchange rate between copper cash and silver is taken

⁴Global silver production data is from Merrill and the Staff of the Common Metals Division (1930). We have data from 1876 to 1910, that is, covering most of our sample period.

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, China was not a producer of silver or copper 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 3. 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

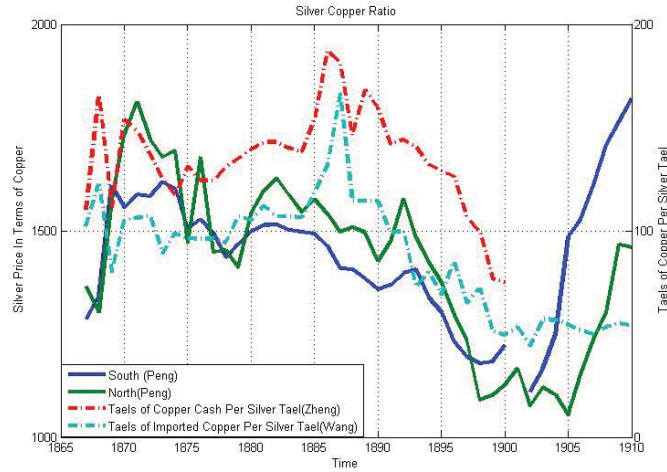


Figure 1: The silver price in terms of copper in Northern and Southern China

produce copper cash (also measured in silver tael).⁵By 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, rather than denominating the silver in terms of copper cash, 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 also are fairly persistent differences. This suggests that copper was actually treated as money in a modern sense, rather than a convenient medium of exchange in barter trade.

⁵This is computed using the data from Zheng(1986). The 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.

2.2 Data on Chinese Trade

Since 1859 the Chinese Maritime Customs had been in charge of trade with foreign countries.⁶ Soon after, they started collecting detailed customs data. In the initial years, they only collected so called “port statistics” for the treaty ports (see e.g. Zheng, 1984). However, starting in 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.⁷ While China gradually diversified its exports, those two still accounted for 36% of the total export in 1910 (starting from more than 90% in 1870).⁸

We can infer the unit price from the 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

⁶Especially before opening customs offices in Hong Kong and Macau in 1887, smuggling was a serious problem. Thus, the data might be slightly contaminated, in particular in the first years of our sample.

⁷Lee (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 tea market.

⁸The data has been obtained from Lee (2010).

of trade based on the import and export prices from the same database. 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. Since we only have net 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 component of exports plus imports as a very rough proxy of GDP. 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.

2.3 Measuring Economic Conditions in China

While generally desirable, we are not able to control for the Chinese business cycle due to lacking data. Although trade data has been excellently documented in China in the last third of the 19th century, data on real economic activity is scarce and even where available often questionable. Before 1919, China did

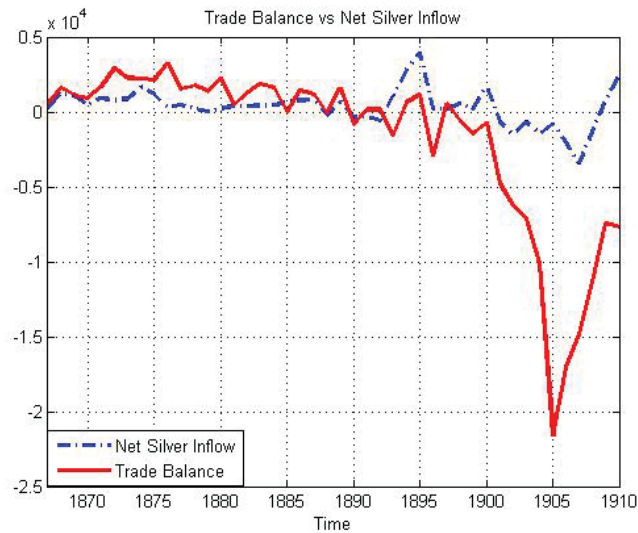


Figure 2: Net silver Inflows and the trade balance

not have a government agency responsible for data collection. There are merely local documents which contain information about production and prices of the respective local market. Even this very limited information is often scattered over various documents, making its collection extremely difficult. Additionally, the market was not well integrated. The price of the same good varies across the counties. That is, even if price data is available for one area, we cannot apply it to the whole country. During the late Qing dynasty there already was a huge gap between the development levels of the inland area and the costal region including the treaty ports. This is why we do not have well documented GDP data at the country level for our period of interests. A lot of research on Chinese economic history is dedicated to investigating the GDP of Qing dynasty, such as Shi et al. (2015). Although they have done a lot of work to get estimates of GDP at different points in time during the Qing Dynasty, no time series data is available at the moment.

However, it is possible to infer at least a limited amount of information from

other macroeconomic behavior to proxy for the role of domestic conditions. In our estimation setups, we aim to exploit rice prices to this end, which are one of the best documented indicators in historical China. At the time of the late Qing, China was still a mostly agricultural economy. Thus, the Chinese economy was strongly influenced by nature, including China's primary export commodities such as tea and silk. Since the production conditions of most agricultural products are highly correlated, conditions on the rice sector should at least be partly representative. In a good year output increased pushing down the rice price, and vice versa. By comparing the rice prices from various previous works, such as Peng (1988) and Wang (1992), as well as prices of other grains he found in the historical literature, Peng (2006) has shown that the grain market was surprisingly well integrated over the country. He finds that the price of different kinds of grain moved in the same direction and that the local rice prices all over the country usually moved in the same direction. For our paper we use the rice price series collected by Wang (1992) for the Yangzi delta, which was the major wholesale center for rice and thus is most representative for the entire economy. According to Peng (2006), the rice price data of Wang (1992) is the most complete annual time series available. It is measured in silver tael per shi⁹ so the value change in silver may have an immediate impact on the rice price, that does not necessarily reflect a change in production. The rice price during our sample period is summarized in Figure 8 in the appendix. Of course the rice price is far from perfect. It cannot be used to measure the business cycle in its entirety, but it is able to filter the system we estimate for some of the more severe business cycle shocks.

We run our VAR both with and without rice prices, and get similar results in share, magnitude and significance of the impulse response functions. Due to the better accounting for business cycle shocks, the VAR including rice prices

⁹The shi (officially cangshi) is a unit of volume equivalent to 1.035 hectoliters.

produces marginally narrower confidence bounds and is thus our preferred specification as reported in the result section.

2.4 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 that 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 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 GDP.

3 Method

3.1 Model and Structural Identification

Our reduced form model underlying our 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 grain price (measured in silver), quantity indices

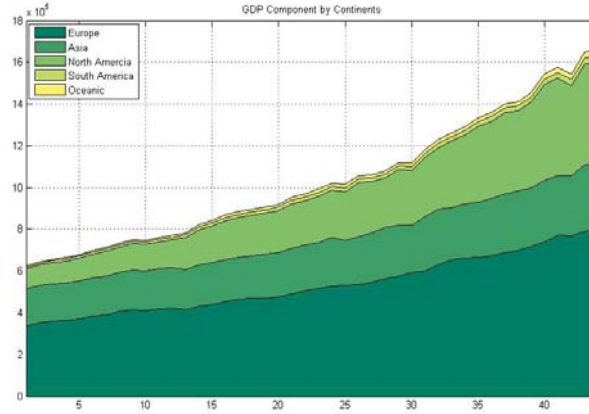


Figure 3: Global GDP and its composition

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.¹⁰

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, rice prices, 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

¹⁰Most of the (log) differences were applied to obtain stationary time series. The exception are the terms of trade which is a borderline case where we can reject a unit root at the 5% level for the original series. However, treating the series as stationary implies that long run effect on the terms of trade are bound to return to zero. This might bias our results towards permanent trade balance effects, because at the same time, we allow permanent effects in the quantity part of the trade balance by using first differences of log imports and exports. Potential permanent quantity effects, can thus not be compensated by price effects due to the construction of the model when including the level terms of trade. As a robustness check we also run the model with level data on terms of trade.

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.¹¹

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 $Y_t = [\text{Global GDP}_t \text{ silver price}_t \dots]'$, 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:

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

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 shocks to global GDP and more importantly to our variable of interest - the price of silver - are well identified

¹¹The 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.

without respect to the ordering of the other variables (or the lack thereof). We can thus estimate the silver supply shock using any Cholesky decomposition of the covariance matrix obtained from our VAR(1), where global GDP comes first, and the price of silver in terms of gold comes second.

3.2 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.

3.3 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.

4 Results

4.1 Impulse Response Functions

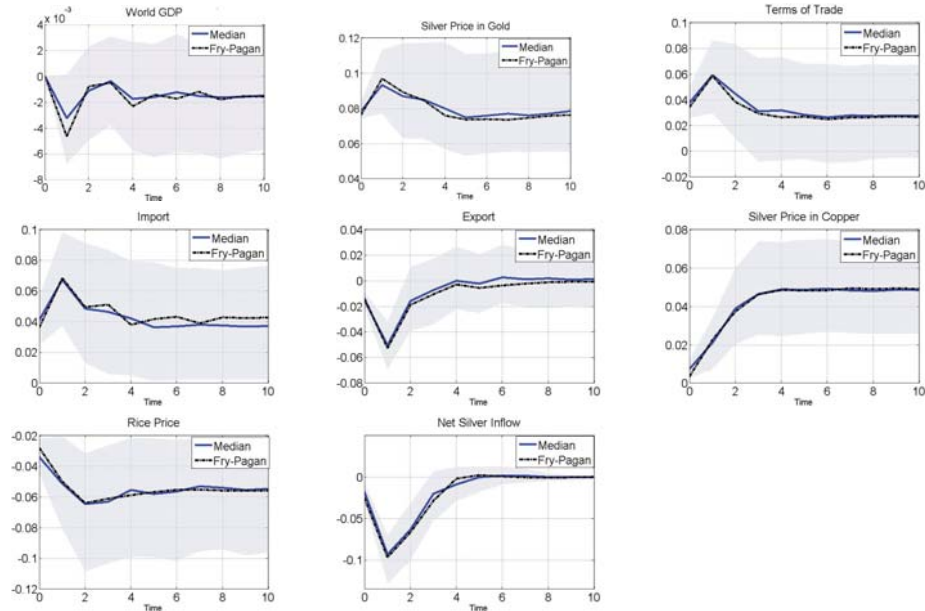
The impulse response functions summarized in Figure 4 show that the silver price did have a statistically and economically significant impact on Chinese trade, both in terms of quantities and prices. For all time series where we used first differences (i.e. world GDP, the price of silver in terms of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

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 a little bit less than 8%, the silver price in terms of copper cash merely increases by 5%, i.e. about two thirds 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 appreciate about 34% against silver during the same period." The terms of trade increase substantially and immediately and keep rising considerably for one more period, before they start to decline and gradually stabilize at a level of about 2.5%. Since prices measured in silver should generally decline after an increase in the value of silver, the terms of trade increase points to a substantially stronger reaction of import prices compared to export prices. While import prices seem to adjust strongly in the period of the shock and right thereafter (partly augmented by silver prices still rising during that time), export prices in terms of silver seem to be much more rigid, catching up to import prices after a few periods and thus driving the terms of trade down, but never to its original level. 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. While the point estimator indicates a permanent effect on terms of trade, the effect becomes (slightly) insignificant after about 3 years, making definite conclusions about its persistence problematic.

Since imports just became cheaper from a 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), followed by a recovery, stabilizing around their original level. All this goes hand



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

in hand with a fairly sizable decline in silver inflows. While the initial impact is small, net silver inflow drastically decrease in the period after the shock and take 2 to 3 years to stabilize again. Since the effect on trade prices and trade quantities partly compensate in terms of the trade balance effect, we believe that this is mostly a reduction in non trade related silver inflows.

The rice price in terms of silver is falling in response to silver becoming more valuable, albeit the magnitude of the decline in prices does not match the increase in the price of silver. Rather, the response of the rice price in terms of silver mirrors the change of the price of silver in terms of copper, indicating

that the price of rice in terms of the domestically used currency is fairly stable. This is in line with the general separation of the markets using silver and copper currency in China. While changes to the price and quantity of silver affect trade strongly, this does not imply a corresponding change in domestic money supply, and thus of domestic prices in terms of copper.

Considered jointly, our IRFs suggest that the valuation effects of an appreciation 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 indicate the ratio of export over import prices, stabilized at about 2-3% while imports increase by 4% and exports returned to their original level. Assuming that those results can be generalized, countries whose vehicle currency appreciates (depreciates) can suffer (or benefit) from substantial volatility in their trade due to fluctuations of their vehicle currency, but will typically not experience permanent effects. However, we should note our example 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 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. This does of course imply, that a shock hitting the emerging markets simultaneously, might well have major price effects on the commodities provided by those countries. Qing dynasty China, might thus be considered an analogy of the emerging world, rather than an individual emerging market.

4.2 Variance Decomposition

Table 1 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, 8.4% 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 sizable contribution, indicating that denominating trade in foreign currency might indeed import substantial volatility if that currency comes under duress.

horizon	GDP_{global}	P_{silver} (in gold)	tot	imports
1	0.000	0.783	0.032	0.061
2	0.018	0.724	0.052	0.066
3	0.024	0.716	0.062	0.067
4	0.024	0.715	0.061	0.067
5	0.025	0.714	0.062	0.067

horizon	exports	P_{silver} (in copper)	rice price	net silver inflow
1	0.062	0.000	0.009	0.010
2	0.073	0.028	0.013	0.130
3	0.084	0.036	0.014	0.157
4	0.084	0.036	0.015	0.166
5	0.084	0.036	0.015	0.168

Table 1: Contributions of silver supply shocks to forecast error variance

4.3 Robustness tests

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 themselves, 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. The price of gold in pounds sterling in London, the main trading hub of the day, remains essentially unchanged over our entire sample period. However, in the first decade of our sample we still observe a period of volatility of the US dollar price of gold 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. only covering the period where both the UK and the US had highly stable gold standards. Our results concerning trade are robust both in terms of the qualitative effects and the order of magnitude of the effects.

Higher lag order While our preferred specification uses one lag only, since we are already facing small sample problems as it is, one might argue that cyclical movements might be better captured by a higher lag order. We therefore reestimate the model using a lag order of 2. Again, our results concerning trade are robust both in terms of the qualitative effects and the order of magnitude of the effects.

5 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. 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. 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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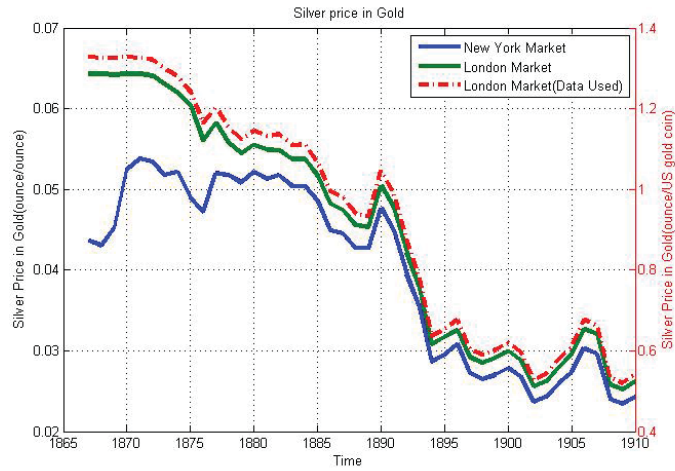
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Appendix

Appendix A: Data Appendix



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 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

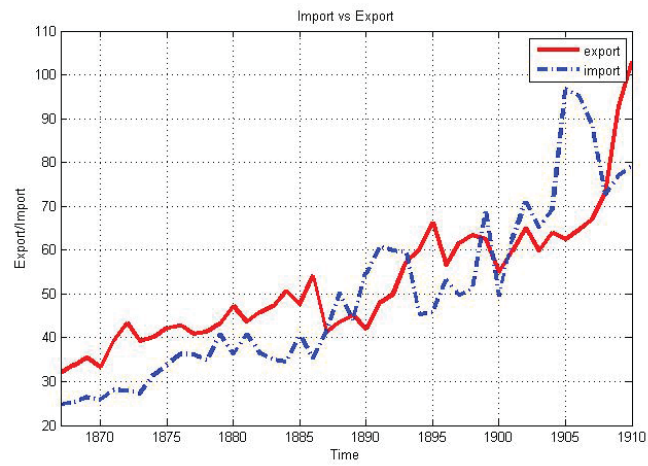


Figure 6: Imports and exports 1867 to 1910

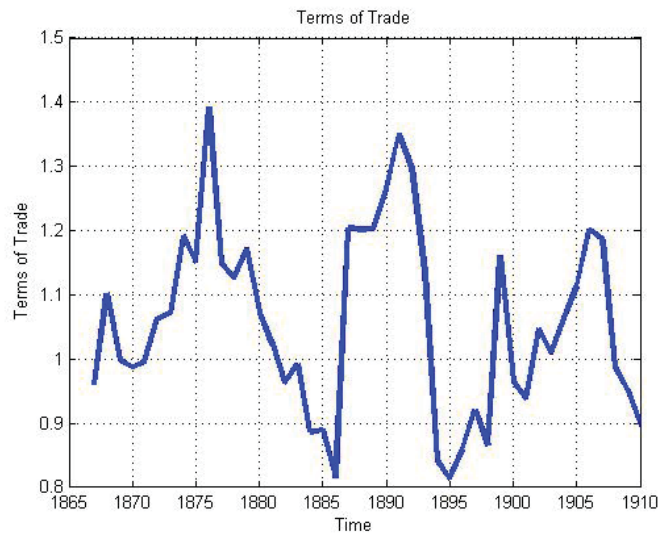


Figure 7: Terms of trade 1867 to 1910

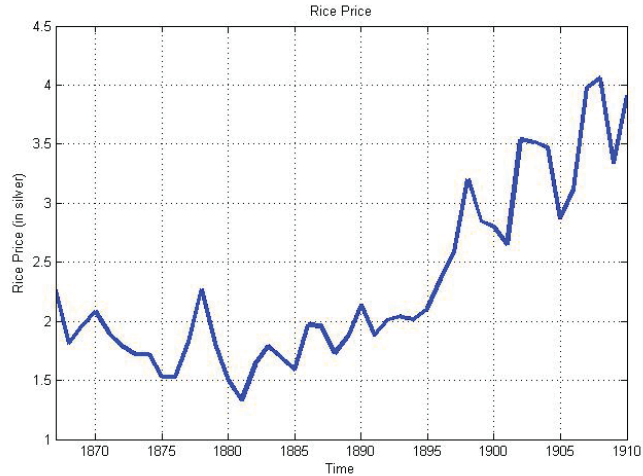
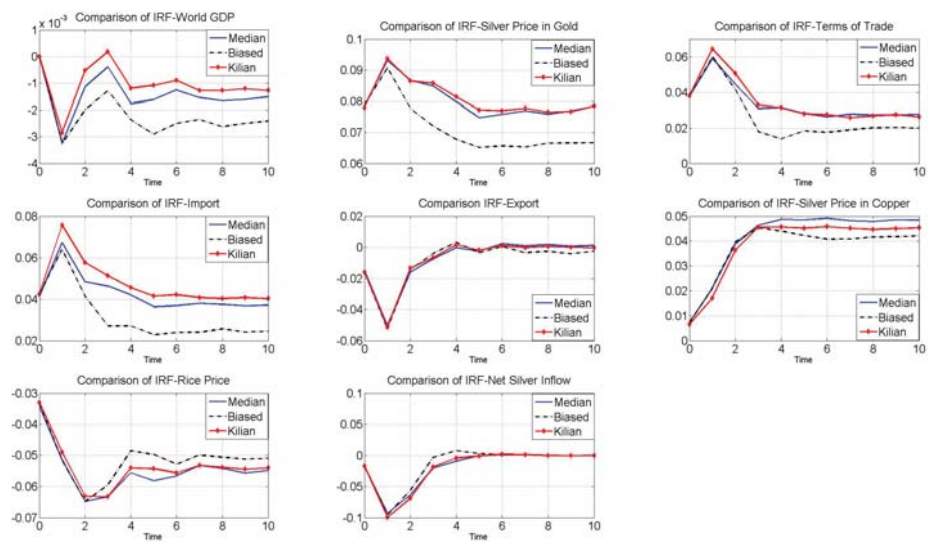


Figure 8: Rice price in the Yangzi delta from 1867 to 1910

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, imports and the grain price, 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 the 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

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