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

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Abstract

In this paper we use a natural experiment provided by the experience of the Chinese economy during 1870 and 1910, to illustrate how the volatility of vehicle currencies used in international trade can affect the terms of trade, imports and exports. While many modern day emerging markets use the USD as an invoice currency for trade, the empirical effect of dollar fluctuations on their trade has rarely been addressed. This is partly due to difficulties in separating fluctuations in the value of the dollar from business cycle spillovers. China had adopted a unique bimetallic standard, where copper was mainly used for domestic transactions and silver for external trade and larger transactions, with a flexible exchange rate between copper and silver. Due to many countries adopting the gold standard and silver supply sharply increasing, the value of silver was subject to severe fluctuations in this period. Since silver was no longer the currency of the trading partners, this situation simplifies the identification of the impact of fluctuations in the currency used for trading. We develop a bias corrected structural VAR with a block recursive identification to show that fluctuations of the silver price had significant impact on Chinese trade.

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 centrury and early 20th century, the Chinese emprire under the late Qing kept their old bimetallic standard using both copper cash and silver. While conducting its external trade mostly through silver, 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. 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 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.

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 countries 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 distingish problems related to the widespread use a currency as vehicle currency on the one hand from effects caused by direct business cycle spillovers or expectations concerning the issuing countries future development that are imbedded in the currenies exchange rate on the other hand. It is therefore extremely hard to separate the pure valuation effect of the currency used to conduct trade. Contrarily, the fluctuations in the price of silver, that plays this role in historic China, were mainly driven by the market for precious metal rather than severe crises abroad.[1] 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 and terms of trade between 1867 to 1910 using 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 denom-

[1] Remer (1926) has argued that the relative price of gold and silver was mainly driven by a surge of silver supply in this period. That is, contrary to modern day exchange rates, it is not a reflection of real economic conditions in the issuing country

inated 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 (see e.g. Brandt and Sargent, 1989; Lai and Gau Jr, 2003; Ho and Lai, 2013; Ho et al., 2013), and on the question whether the silver standard sheltered China from the Great Depression and how US silver purchases at the time affected Chinese money supply, and prices rather than trade effects. 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 40 years and correspondingly a larger number of business cycles it is long enough to allow more general conclusions than studies focussing on the Great Depression. Very few studies, such as Zheng (1986) and Guan (2008) provide detailed data and an anlaysis on a similar period as ours (1870-1900). However, they focus on a narrative approach and descriptive statistics, instead of a quantatitive 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 sever 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

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,[2] 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 transaction almost exclusively used silver tael. Guan (2008) and Zheng (1986) both state that the cost of goods meant for export was mainly measured in copper coins since the production was mostly conducted in the inland area. The materials and labor wages were paid with copper coins. Only

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

after these 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 paid the price in silver, but 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 time 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 determined in the international market and purely 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 that the US dollar (and to a lesser extent other currencies of industrialized nations) plays today for developing countries. The key difference is that the external value of the dollar is closely tied to the conditions in the US. Contrarily, the price of silver was mostly driven by silver supply during that period.

Remer (1926) has proposed that "the fall in the gold price of silver during the closing decades of ninteenth 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. The data supports this hypothesis: the fast decrease in the gold price of silver corresponds to the period when the silver production increased a lot. With this historical China example, we can see how the value change of the nondomestic currency used in trade affects the home economy and these effects are abstract from the influence of international business cycles.

The silver and gold exchange rate is well documented. The gold 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. During our sample period, many silver mines were found in South America which greatly increased silver supply in the world market. Moreover, all major Westen countries had started to abandon the silver-gold bimetallic system for a gold standard, which increased the silver supply even more while increasing demand for gold. The price of silver was thus strongly falling over time, as seen in Figure 5 in the appendix, and China correspondingly faced a strong depreciation of its main trade currency. The silver supply shock in our model contains both the increased production of silver and the gradual adoption of gold standards.

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, 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 market of silver affected the relative price between copper and silver, but also the market for copper. The international market of copper directly influenced the domestics supply of copper, which would make copper abundend or scarce. 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 silvers smiths. Therefore, the 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 intergrated to some extent, the relatively high persistence of minor deviations highlights the lower speed of price adjustments in the silver to copper exchange rate compared to the international market. 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 produce copper cash (also measured in silver tael)[3]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, rather than denominating the silver in terms of copper cash, those time series show the silver price in terms of the ressource value of copper or copper cash. While there apparently is a long run relation between ressource

[3]This 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.

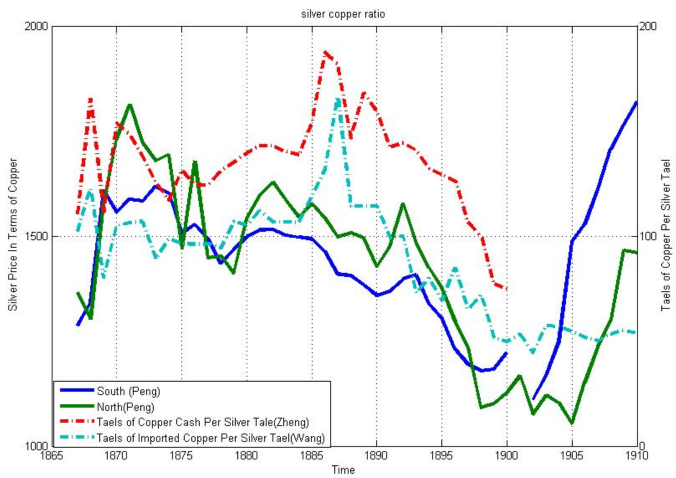


Figure 1: The silver price in terms of copper in Northern and Southern China

value of copper and its actual purchasing power on the Chinese domestic market, there also are fairly persistent differences. This suggests that copper taels were actually treated as money in a modern sense, rather than a convenient medium of exchange in barter trade.

2.2 Data on Chinese Trade

Since 1859 the Chinese Maritime Customs had been in charge of trade with foreign countries.[4]. 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 accepter in regards to

[4]Especially 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.

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.[5]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).[6]

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

[5]Lee (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.

[6]The data has been obtained from Lee (2010).

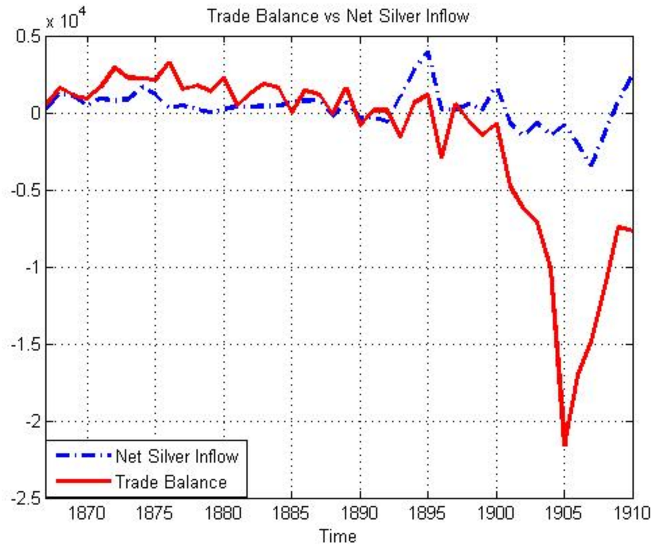


Figure 2: Net silver Inflows and the trade balance

factors dominate (see Figure 2 for a visual comparison). Our data is taken from Lee (2010), who did a thourough 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 trade data has been excellently documented in China in the last third of the 19th century, data on real economic activiy is scarce and even where available often questionable. Before 1919, China did 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. Many works in China are 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, to capture the role of GDP for the economic dynamics, a proxy of variations in production is of great importance to our work, not only to avoid omitted variable bias but also to reduce uncertainty in a model that is already plagued by the low number of observations. Given the lack of actual production data, we opt to proxy current domestic conditions in China indirectly by including the price of rice. The rice price is of course not a perfect indicator of GDP, but in the agriculture economy China was at the time, it can reflect the variation in production to a large extent. During the period of interest, the output of agriculture in China and thus the Chinese economy was mostly determined by the nature. In a good year output increased pushing down the rice price. 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 shi[7] 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.

2.4 TheGlobal 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 ealier year. For countries where GDP is missing between 1867 and 1870, we interpolate by assuming a constant growth rate between the last availabe 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

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

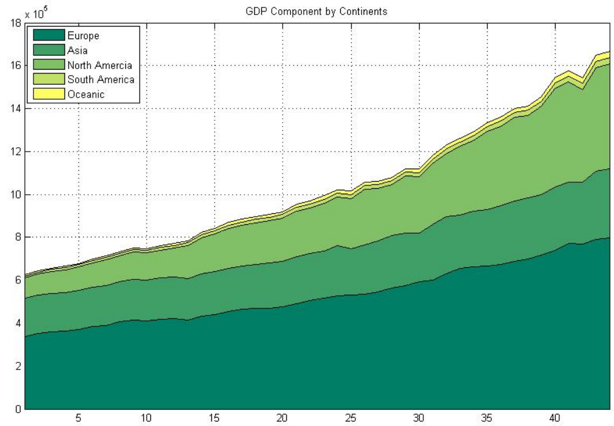


Figure 3: Global GDP and its composition

the dynamics of GDP.

3 Method

3.1 Model and Structural Idenfication

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 of imports and exports, as well as net silver inflows normalized with the trend component of total trade, and the terms of trade.

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, grain 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 - both were mainly determined out of China - 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 consequence to global GDP.[8]

Writing our reduced form model as:

$$Y_t = BY_{t-1} + A\varepsilon_t, \tag{1}$$

where Y_t is the (8×1) vector of demeaned endogenous variables at time t, B is a (8×8) coefficient matrix, $\varepsilon_t$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:

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

While the number of restrictions imposed to this system is obviously insufficient

[8]The 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.

to identifiy 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 idenfied 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 $\beta^{(j+1)} = \beta^{(j)} + \alpha(\hat{\beta} - \bar{\beta}^{(j)}_{OLS})$, where $\bar{\beta}^{(j)}_{OLS}$ is the bootstrapped OLS estimate based on the coefficient vector $\beta^{(j)}$ and $0 < \alpha < 1$. Even though the distrance $(\hat{\beta} - \bar{\beta}^{(j)}_{OLS})$ is only a very noisy measure of the true distance when the number of bootstrap repetitions is low, this algorithm quicky 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 covarance 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

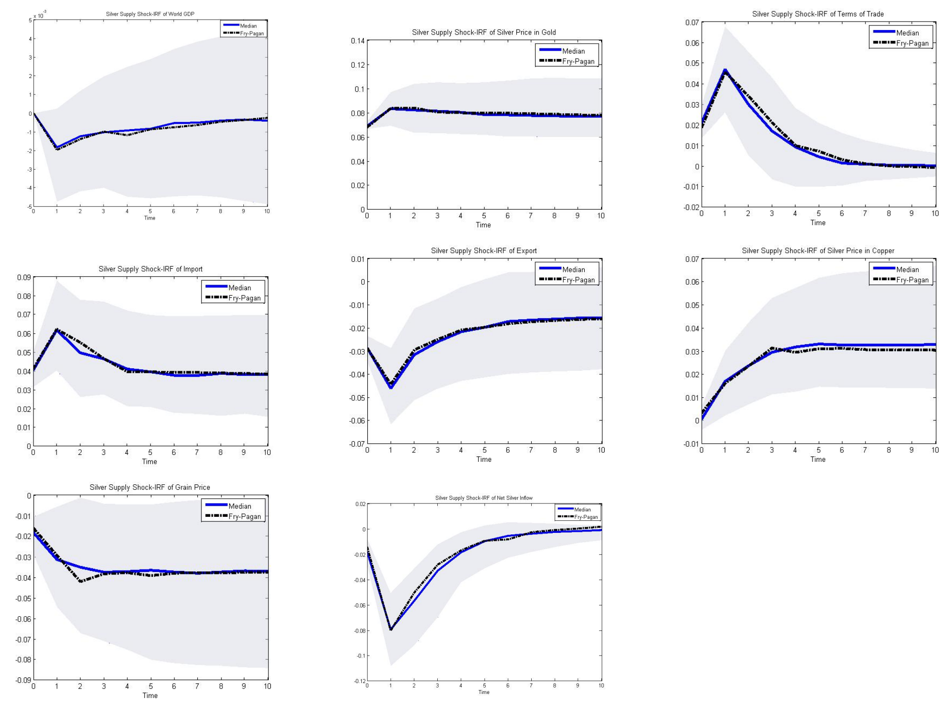
4.1 Impulse Response Functions

The impulse response functions summarized in Figure 4 show that 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 to obtain stationary time series (i.e. world GDP, the price of silver in terms of gold and in terms of copper, imports, exports, 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 about 8%, the silver price in terms of copper cash merely increases by half of that. The terms of trade incrase substantially and immediately and keep rising considerably for one more period, before they start returning to their original level. The terms of trade effect seems to last for about 5 to 6 years, and is siginficant for the first 3 years. 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 back. 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 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 mild recovery, stabilizing slightly below their original level. All this goes hand in hand with a fairly sizable decline in silver inflows. While the initial impact is small, silver imports drastically increase in the period after the shock and take quite a while to stabilize again. Since the effect on trade prices



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

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 grain 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 reponse 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 domesitally 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 corresponing change in domestic money supply, and thus of domestic prices in terms of copper.

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 10% of the variation in trade prices and exports, and roughly 8% 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	0.800	0.027	0.069
2	0.013	0.752	0.092	0.075
3	0.014	0.733	0.097	0.078
4	0.014	0.731	0.097	0.077
5	0.014	0.730	0.096	0.078

horizon	exports	P_{silver} (in copper)	grain price	net silver inflow
1	0.081	0.000	0.015	0.012
2	0.087	0.033	0.021	0.135
3	0.098	0.042	0.021	0.167
4	0.097	0.044	0.021	0.175
5	0.098	0.045	0.021	0.176

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

4.3 Robustness tests

Starting in 1878 It is preferable for our analysis if the shocks to silver price in terms of gold are truly driven by the silver side of the market, rather than gold. 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, essentially 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 volatiliy 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 of the silver price 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 risk of spillovers through exchange rate volatility is higher 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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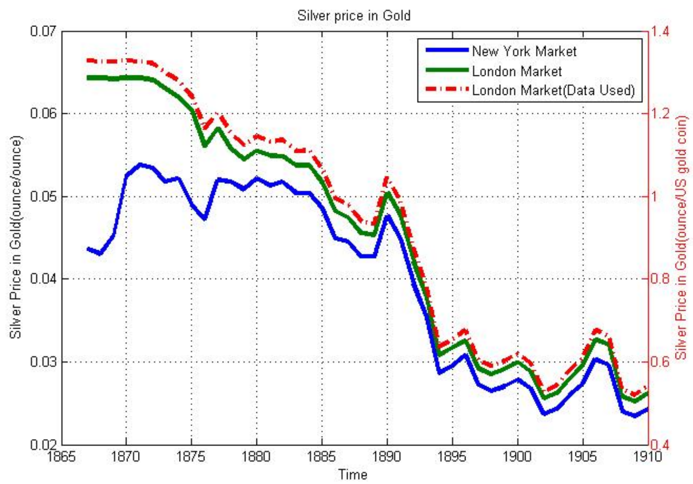
Appendix

Appendix A: Data Appendix



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 respecitvely. 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

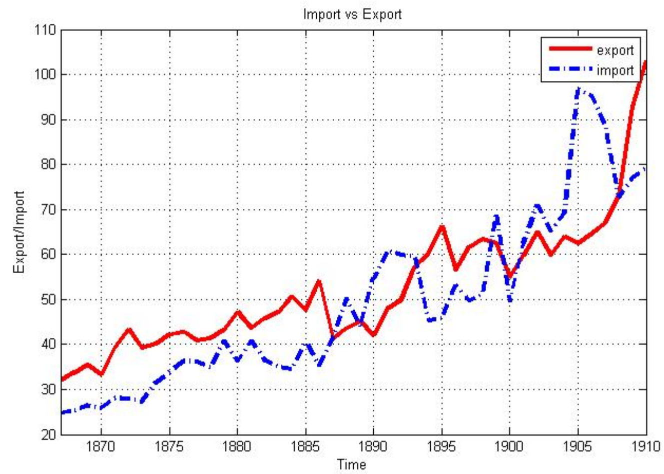


Figure 6: Imports and exports 1867 to 1910

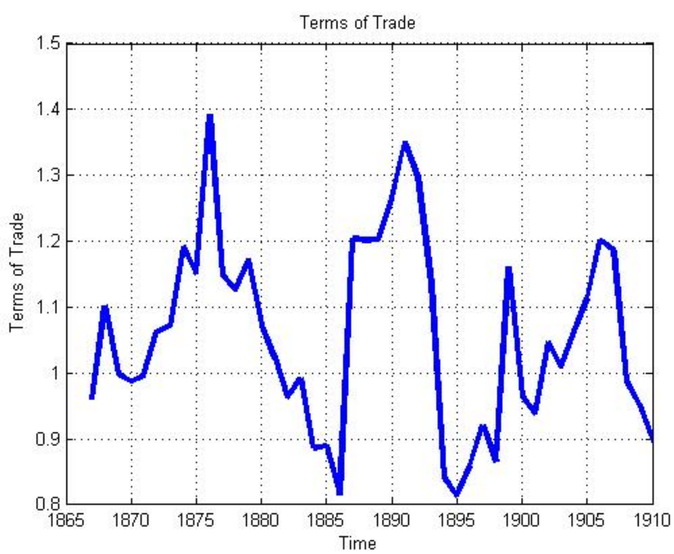


Figure 7: Terms of trade 1867 to 1910

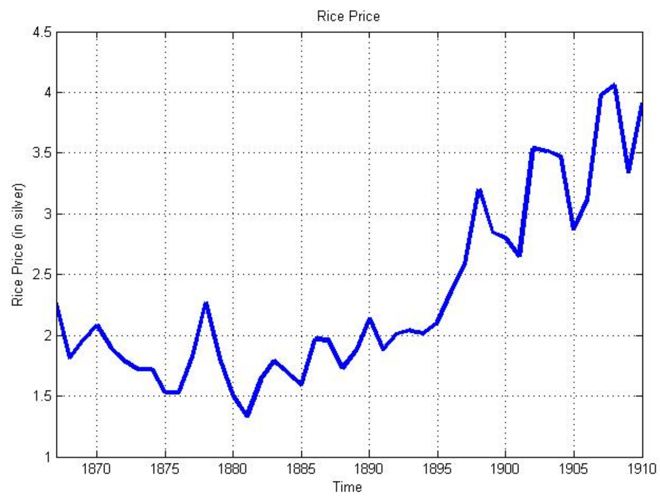
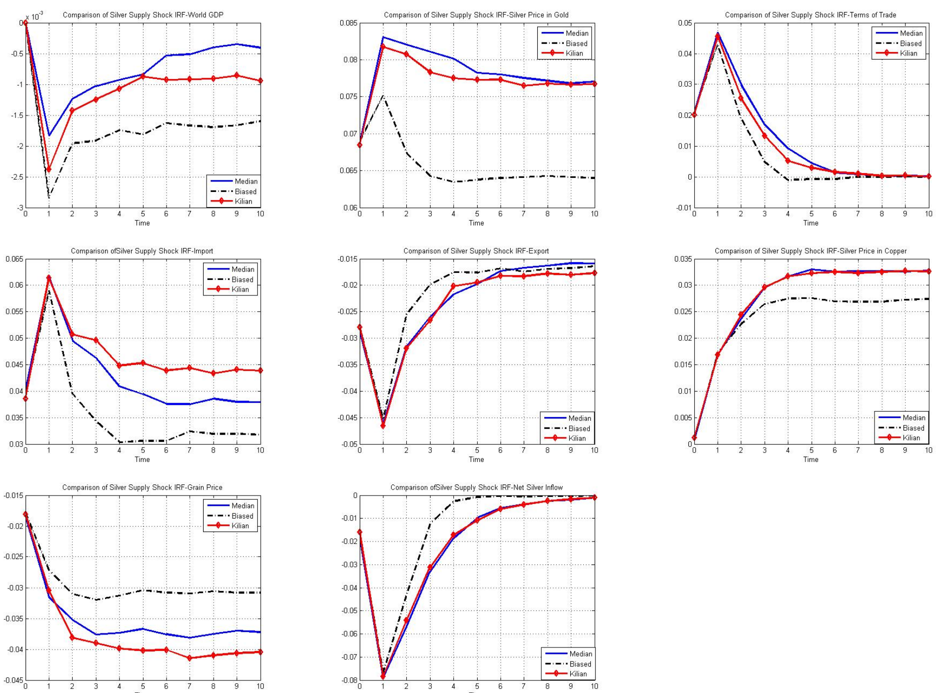


Figure 8: Rice price in the Yangzi delta from 1867 to 1910

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 magniture of up to about 40% of the bias corrected estimate for several IRFs. Generally, the biased estimate subastantially undererstimates 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 suggest 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