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ABSTRACT

To what degree were Chinese financial markets integrated with the rest of the world prior to the 1949 Revolution and to what extent was the Chinese foreign exchange market efficient during this period?We estimate silver points for the Shanghai market from 1905 to 1933 to answer these questions. Our inferred measures are small in value, favorably match measured costs of the silver trade derived from contemporary accounts, and fare well in the comparison to estimates of trans-Atlantic gold points. This leads to the conclusion that the degree of Chinese financial market integration was substantial. However, during and immediately after World War I, our estimates of the silver points increased appreciably, foreshadowing the collapse of China's linkages to world financial markets beginning in the 1930s.

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1. Introduction

As the development of financial markets is thought to be a critical mediating factor in modern economic growth, there remains considerable interest among economic and financial historians in chartering the course of financial market integration.[2] In this literature, the rise and fall of the gold standard from the 19th and into the 20th centuries has been of particular prominence (Chernyshoff *et al*., 2009). The main issues underlying this theme have been the relative efficiency of the classical gold standard, its role in moderating nominal exchange rates, the means by which arbitrage in the world gold market ensured its smooth functioning, and the role of the price-specie flow mechanism in keeping financial and trade imbalances in check. Tests of its efficiency have generally revolved around a consideration of the so-called gold points. These are the exchange rates at which arbitrage should have taken place in gold markets, ensuring re-equilibration of the system without official intervention. Key contributions to measuring—both directly and indirectly—these gold points include Canjels *et al*. (2004), Officer (1996), and Spiller and Wood (1988).

At the same time, there is a relative paucity of research into conditions outside the gold club. In particular, the Chinese experience with its silver standard in the early 20th century has been wholly neglected. Little is known about the relative efficiency of the Chinese silver standard and the process of Chinese financial markets' integration into the world economy. For some time, a scarcity of data has proven the most considerable barrier to studies on China's economic and financial history in the early 20th century, but this set of circumstances is rapidly changing. What is more, there is considerable interest in understanding the historical precedents to financial market integration in China and their implications for the conduct of monetary policy in the present day.

China in the early 20th century is also interesting in another respect. It was the only large country in the world on a silver standard throughout this period. While silver was "just another commodity" in other countries, it was the sole basis of currency in China. Thus, Chinese exchange rates vis-à-vis the rest

[2] For the role of financial markets in the process of economic development, see Levine (2005). For example of the analysis of financial market integration, see Mitchener and Ohnuki (2009) and Bodenhorn (1992).

of the world were determined by a different mechanism than was the case for gold standard countries. This difference was driven by the fact that the implied exchange rate between the Chinese *tael* and Great British pounds or US dollars varied considerably as global silver prices were in constant flux. Thus, China was effectively in a floating exchange rate regime while the much of the world remained fixed. While the literature has generally emphasized this floating aspect of the Chinese currency, China's silver standard transmitted external disturbances—in particular, shocks to the world silver price—just as would have occurred in a fixed exchange rate regime, limiting the exchange rate's role as a shock absorber. What is more, with rising world silver prices in the early 20th century, other commodity prices fell as a direct consequence of the revaluation of the Chinese currency, inducing significant deflationary pressures (Ho and Lai, 2013, 2016). In this regard, the choice of exchange rate regime looms as a large determinant of China's macroeconomic performance, both in the past and present.

This paper fills this gap by laying out the conditions of the Chinese economy and monetary system and examining how and how well its silver standard functioned. As China experienced remarkable economic and financial development prior to the outbreak of the Sino-Japanese War in 1937, the analysis of its foreign exchange markets in the early 20th century will provide a useful point of comparison with western countries at that time. This paper also makes two distinct contributions. First, we bring new data to the table in the form of daily and monthly time series data on domestic exchange rates, international silver prices, and silver flows. This allows us to estimate China's silver points from the pre-World War I era and through the Great Depression. In recent years, a literature on modern Chinese market integration has emerged, but its focus has been exclusively on commodities (Shiue, 2002; Shiue and Keller, 2007). Thus, we are in position to make of one of—if not—the first assessments of the degree of Chinese financial market integration for this period.

Second, drawing inspiration from the large literature on gold market arbitrage, we formalize the theory of silver market arbitrage in the presence of trade costs across spatial markets as it relates to circumstances in China at the time. We adopt a non-linear time series methodology for measuring market integration. The intuition underlying the model is straightforward: as the process of arbitrage in the silver market incurs trade costs, the cross-border shipment of silver is thought to only occur if the inherent price of silver in the Shanghai foreign exchange market exceeds that in the global silver market by a sufficient margin. By formalizing this concept, it becomes possible to estimate the relevant threshold for such arbitrage activity. We refer to these estimated thresholds as silver points in direct parallel to the literature on gold points. We also show that the deviations from parity across domestic and foreign exchange markets followed a nonlinear process with the speed of mean-reversion toward equilibrium varying with the size of these deviations. Within the range given by the silver points, there are no profitable arbitrage opportunities and the law of one price does not strictly hold. We estimate the parameters of this system using a threshold error correction mechanism (TECM) which captures all relevant dynamic features and allows us to simultaneously recover the silver points and the speed of adjustment.

Section 2 below sets the scene for China in the early 20th century, highlighting relevant features of its place in the global economy of the day and the mechanics of its foreign exchange market. Sections 3 through 6 represent the main contributions of the paper, drawing together our data and methods. The results suggest that Chinese financial markets were already reasonably well integrated with the rest of the world from the turn of the 20th century. And while World War I had clear disintegrative effects on Chinese financial markets, recovery from the trauma it induced was rapid. What is more, we establish the reliability of our estimates by considering different frequencies, models, and time horizons and conclude with a consideration of the relationship between our indirect measures of trade costs in silver markets and direct measures of physical flows of silver over the period.

2. China and the global economy in the early 20th century

Although there is some uncertainty regarding the nature and pace of Chinese economic growth during the pre-war silver standard, there is extensive evidence that by the 1890s large parts of the Chinese agricultural sector—and along with it, millions of households—had become highly integrated with world markets. For example, Brandt (1989) shows that international forces served to determine the domestic price of cotton and rice in China at large and the Lower Yangzi region, in particular. There is also qualitative evidence to the effect that the process of international commodity price arbitrage vitally affected other key crops such as peanuts, soybeans, sugarcane, and tobacco (Brandt and Sargent, 1989). Likely as a consequence, general price changes in China closely followed developments in prices in the United States when expressed in terms of silver (Graham, 1934; Raeburn, 1937).

In part, this rising tide of integration is reflected in China's pattern of trade. Starting from 1910, Chinese exports rapidly rose in value from 3.27 billion 1990 USD to 6.20 billion 1990 USD in 1919 before a gradual decline throughout the tumultuous 1920s and a 70% collapse in exports from 1929 to 1932. Chinese imports tell a broadly similar story: from 4.03 billion 1990 USD in 1910 to 6.81 billion 1990 USD in 1919 followed by a gradual decline and a 50% collapse in imports from 1929 to 1932. Where Chinese export and import performance slightly diverges is in their respective shares for trade with Asia (ex-Hong Kong), Europe, and North America. In 1910, 23% of its exports went to Asia (ex-Hong Kong), 32% to Europe, and 15% to North America. Following rapid rises for Asia (ex-Hong Kong) and North America during the 1910s, these shares stood at 45%, 18%, and 21% in 1933, respectively. For imports, the share of Asia (ex-Hong Kong), Europe, and North America stood at 32%, 22%, and 6% in 1910, respectively. Less dramatic changes than that for exports followed with these same shares at 37%, 29%, and 29% in 1933. Over this same period, fairly significant trade deficits with Asia (ex-Hong Kong) and modest trade surpluses with Europe and North America were all whittled down to size, so that the aggregate trade deficit was fairly stable at around 1 billion 1990 USD annually.[3]

At the center of it all was Shanghai, acting as the commercial, financial, and industrial capital of China in this period. By the 1930s, it conducted more than half of China's foreign trade, processed one-fifth of Chinese shipping tonnage in its harbor, absorbed nearly half of total foreign direct investment in China, and controlled nearly half of China's stock of financial capital.[4] At this time, Shanghai also occupied an important position in the world economy, acting as the dominant foreign exchange market in

[3] All cited figures for exports and imports come from Jacks and Novy (2016).

[4] Various other figures can be cited to attest to the city's prominence. In the 1930s, it produced over 40% of Chinese manufacturing output (and nearly 50% if one excludes Japanese-controlled Manchuria) and generated about 50% of Chinese electricity production (Ma, 2016). Consequently, some scholars refer to China's growth experience in the early twentieth-century as "Shanghai-based industrialization" (Ma, 2008).

East Asia and thereby earning bragging rights as the third most important foreign exchange market in the world after London and New York (Feng, 1935). By 1926, there were 22 foreign banks established in Shanghai, comprising the Shanghai Foreign Bankers' Association (Kann, 1926). All of these banks traded heavily in foreign exchange. What is more, this period also gave rise to the Chinese Bankers' Association which was comprised of 23 modern Chinese commercial banks. Of these locally domiciled banks, eight regularly took part in foreign exchange transactions.

Much of this activity was predicated by domestic monetary arrangements. Silver acted as the basis of the Chinese monetary system for nearly 700 years and continued in this role until the currency reform of November 1935. And while copper coins circulated as the means of day-to-day transactions, transactions involving large sums of money as in long-distance and wholesale trade were conducted using silver. Furthermore, in the modern era, banks both kept their reserves and balanced their interbank accounts in silver. Thus, China was for all practical purposes on a silver standard before 1935.[5]

As a silver-standard country, China was obliged to derive the parity value of its nominal exchange rate from the price of silver in global commodity markets.[6] In this context, there were only two markets which mattered for China: London and New York City. Conveniently, it was immaterial whether the parity exchange rate of the Shanghai *tael* was calculated off the price of silver in London (quoted in one standard ounce of silver with 0.925 fineness) or in New York City (quoted in one troy ounce of silver with 0.999 fineness): one Shanghai *tael* equaled 1.16782 ounces of London standard silver and 1.08023 ounces of New York fine silver.[7] Multiplying these constants by the price quoted for bar silver at either

[5] For a general history of the Chinese silver standard, please see Ma (2012) and Wang (1981).

[6] Throughout, we make use of term *parity* to denote the implied exchange rate coming from the global price of silver in GBP/USD and the notional mint price of silver in China. This parallels the use of "parity exchange rates" in the gold standard literature. However, it diverges from this literature in that the parity exchange rate there is calculated as the ratio of two gold mint prices. In this case, there is only one mint price. Consequently, the parity exchange rate is not constant in the case of the Chinese silver standard. Regardless of this fact, we follow contemporary accounts in Chinese and English which refer to this implied exchange rate as the "parity exchange rate" (see Kann, 1926 and Lin, 1936).

[7] The physical standard of this monetary system was in the form of ingots known as *sycee*. *Sycee* were not coined by a central authority, but were instead minted privately. The *tael*, a widely quoted Chinese unit of silver weight, varied greatly from city to city. To satisfy the need for a common unit across this mix of currencies, imaginary units of account emerged for the various trading zones within China. These units of account were usually defined by a set of physical characteristics such as the fineness and/or weight of silver, but did not exactly correspond to any circulating

London or New York City, we can obtain the parity quotations for one shanghai *tael* in pounds or in dollars, respectively.[8]

3. Data

We use nominal exchange rates based on US-dollar-denominated telegraphic transfers drawn on New York City, settled in Shanghai, and reported by Wu (1935). The reason is straightforward: the dominant form of arbitrage under the silver standard was via such telegraphic transfers—and not via demand bills (Wu, 1935). For our purposes, the indirect quotation is used in which the price of one Shanghai *tael* is expressed in US dollars. Our monthly data are average nominal exchange rates compiled by the Shanghai Bureau of Social Affairs. It should be noted that these monthly observations are actually the average of only three trading days (drawn from the beginning, middle, and end of the month) and not all trading days in the month. Our sample is comprised of continuous monthly data for the period from January 1905 to December 1933. The sample period ends in 1933 as cross-border arbitrage opportunities were closed off by the silver export restrictions implemented in 1934.[9]

Silver prices in London and New York City are used to calculate the parity rates of the Shanghai *tael*. As London was both the world's preeminent financial and silver trading center prior to World War I,

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currencies. Nonetheless, they provided a reliable anchor against which the value of various currencies could easily be converted. Given Shanghai's role in the greater Chinese economy, its unit of account, the Shanghai *tael*, became the most widely known and used with one Shanghai *tael* containing 518.512 troy grains of pure silver (Young, 1931; Wu, 1935).

[8] The "official" rates of exchange, as issued every morning by the Shanghai Banking Corporation, did not necessarily correspond to the parity nominal exchange rates discussed above. Usually, these "official" rates were either above or below the corresponding parity values, depending on conditions prevailing in the domestic money market. The foreign exchange market in Shanghai was also marked by frequent and wide fluctuations in market exchange rates. Therefore, the "official" rates can be thought of as acting as a guide to or influence on the market, but one which failed to fully check activities created either by demand arising from genuine transactions or by speculators (Kann, 1926).

[9] The *tael* system was abandoned in China in March 1933. However, silver was still used as currency in China until November 1935 when the Central Bank of China announced the Currency Reform Decree and officially took the country off the silver standard and placed it on a fiat currency. Rising sliver prices, accentuated by the 1934 US Silver Purchase Act, wrought severe deflationary effects on China (Friedman, 1992). In the meantime, the Chinese government began to take measures to protect its rapidly dwindling silver supply in 1934, especially through the implementation of duties and an adjustable "equalization charge" on silver exports (Chang, 1988). Of course, in doing so, China had effectively removed itself from a pure silver standard. Given these events and the likely upward bias they may impart on the estimation of silver points, we focus our attention on the period prior to 1934.

we calculate the parity rate of the Shanghai *tael* based on the sterling-denominated price of London standard silver for the period up to and including December 1914. Given the parity exchange rate between sterling and the Shanghai *tael*, the parity exchange rate between the US dollar and Shanghai *tael* can be derived from the gold parity points for sterling and the US dollar. With the outbreak of World War I, not only was London's role as the preeminent world financial center called into question, but also—and more importantly for our purposes—the free movement of silver across the UK border was prohibited. In contrast, the New York City silver market remained open to all comers. Consequently, we use New York City silver prices (that is, US dollar-denominated prices for one ounce of fine silver) in our calculations of the parity exchange rate from January 1915.[10]

The exchange rate for the Shanghai *tael* measured in US dollars in the Shanghai market is denoted by E_t while the parity rate for the Shanghai *tael* measured in US dollars in the London or New York City market is denoted by E_t^* . Defining lower case letters as the natural logarithm of variables, the proportional deviation from parity can be expressed as $x_t = e_t - e_t^*$. Figure 1 depicts x_t from 1905 to 1933 where a value of zero corresponds to the strong form of the law of one price. Given frictions in the form of information and trade costs, one might naturally expect deviations from parity. Here, a positive value of x_t suggests that the *tael* is overvalued in the Shanghai foreign exchange market while a negative value of x_t suggests that the *tael* is undervalued. The dynamics of x_t will be the object of this paper.[11]

The mean and standard deviation of x_t are shown in Table 1. In addition to the results for the entire sample period, we also present the equivalent figures for select sub-periods. This choice is motivated by dramatic changes in both domestic and foreign markets over the period from 1905 to 1933.

[10] Our results would likely be materially unaffected by the use of New York silver prices throughout as the correlation between silver prices in London and New York was extremely high. However, at the present day, we lack the full series of monthly data for New York in the period from 1905 to 1914.

[11] It should be clear that x_t does not exhibit explosive behavior. And apart from relatively large fluctuations of ±10% from parity during World War I and its aftermath, the deviation process appears rather stable. What is more, the augmented Dickey-Fuller test statistic (with an intercept, linear time trend, and one lag chosen by the Schwarz criterion) comes in at a highly significant -10.02. We, therefore, assume stationarity in all that follows.

To this end, we focus our attention across three nearly equally-sized sub-periods: from January 1905 to June 1914, from July 1914 to December 1923, and from January 1924 to December 1933. This yields observation counts of 114, 114, and 120, respectively. The first break in sub-samples is defined by the outbreak of World War I. The second break in sub-samples is intended to capture changes in the world economy attendant upon the late 1920s and early 1930s. We note that the mean of x_t is positive and somewhat sizeable in the full sample. However, this result is primarily driven by the second sub-period: both the mean and dispersion of the deviations from parity greatly increased, especially when compared to the other sub-periods. Taken at face value, this movement implies either that World War I presented enhanced arbitrage opportunities or that trade costs grew in response to hostilities and indicated a possible decline in the degree of market integration during World War I.[12]

We are also able to partially supplement our analysis with higher frequency data. Higher frequency data is likely more informative than monthly as the adjustment of exchange rates would be very quick—if not instantaneous—under a fully efficient silver-arbitrage mechanism. In that context, monthly data might obscure the high-frequency dynamics of the exchange rate. To this end, we have collected data at the daily frequency. This new data set on exchange rates is drawn from contemporary periodicals, namely the *Economic Statistics Quarterly* (various dates) and the *North China Daily News* (various dates). The hope is that this time series more closely corresponds to the time of adjustment in the foreign exchange market. The drawback is that our daily data is only available for the period from January 1923 to March 1933. We choose to limit out attention to the period from January 1, 1924 to March 31, 1933 to match the third sub-period from above. The data cover every trading day in this period. We discard non-trading days—that is, holidays, Sundays, and a few exceptional days on which the exchange was closed—and generate approximately 280 daily observations in each year. All told, we have 2,574 daily

[12] Additionally, we can allow for endogenous breaks in the data. In this context, we employ the sequential testing procedure developed by Bai (1997) and Bai and Perron (1998) to analyze the time series properties of the data in Figure 1. Allowing for a maximum number of three breaks, employing a trimming parameter of 15%, and using a 5% significance level, the sequential test results indicate that there are exactly two endogenous breakpoints in the series: one in October 1914 and the other in February 1923. Not surprisingly, the summary statistics for the sub-periods divided by these breakpoints are very close to those of the equally-sized sub-periods reported in Table 1. Therefore, we only present the econometric results for the latter.

observations at our disposal. Figure 2 displays the daily data. The mean and standard deviation for our daily data corresponding to Table 1 are 0.602% and 1.481%, respectively. This, of course, represents a similar dispersion but a markedly higher mean deviation for the daily as compared to monthly data for the same sub-period.

4. A model of arbitrage in the silver market

Here, we lay out the basic intuition of a model of arbitrage in the Chinese silver market. We follow the lead provided by Canjels *et al*. (2004) in order to ensure a strict comparability of results in between the trans-Atlantic gold trade and the trans-Pacific silver trade and refer the reader to their paper for details. One of the key historical insights for the model is that as China was on a silver standard, net exports or imports of silver would have affected the supply of silver in the Shanghai market and, thereby, affected the prevailing exchange rate. Here, we assume that the deviation in silver prices, $e_t - e_t^*$, is negatively influenced by silver stocks in Shanghai.

We also assume arbitrageurs will ship silver up to the point where their marginal revenue equals their marginal cost. By equating *MR* and *MC*, we can obtain an optimal level of silver in- or out-flows. This, in turn, acts as an arbitrage condition such that when the absolute value of the deviation between exchange rates exceeds a certain threshold (θ), silver would flow into Shanghai from abroad (when the deviation is positive and the *tael* is overvalued in Shanghai) and silver would flow from Shanghai to abroad (when the deviation is negative and the *tael* is undervalued in Shanghai). Additionally, there are likely instances in which the absolute value of the deviation in exchange rates is less than the threshold and for which no profitable arbitrage opportunities arise. Thus, θ can be thought of as the trade costs associated with the trans-Pacific movement of silver.

Our estimating equation is then the following:

$$(1)\ \Delta x_t = \begin{cases} -k - \lambda\left[x_{t-1} - \theta\right] + v_t & \text{when } x_{t-1} > \theta \\ v_t & \text{when } \left|x_{t-1}\right| \le \theta \\ k - \lambda\left[x_{t-1} + \theta\right] + v_t & \text{when } x_{t-1} < -\theta \end{cases}$$

where Δx_t is the first difference of $e_t - e_t^*$, k is a constant, λ measures the speed of adjustment and implies that the deviation will be fractionally reduced by λ in one period, and v_t is an exogenous disturbance term and is assumed to be serially uncorrelated. Generally, we would expect deviations to be reduced through the adjustment of the Shanghai exchange rate. It may also be reduced through adjustment of the parity exchange rate—in other words, the international price of silver. However, since silver was heavily traded globally, its price was predominantly determined by external factors, irrespective of conditions in the Chinese economy (Ho and Lai, 2013; Shiroyama, 2008, p. 31).

This equation also concisely describes the dynamics of exchange rate deviations. This process is divided into three regimes by the symmetric thresholds of θ and $-\theta$ with $(-\theta, \theta)$ constituting a "neutral band". It also incorporates a simple formulation of the relevant silver points. If the contemporaneous deviation is in either the upper or lower regime, then it will revert in value toward the edge of the band (defined by the silver points, θ or $-\theta$) at a speed of convergence defined by λ. In the middle regime within the silver points, there is no reversion, and the change in the exchange rate deviation follows a white noise process. In this case, silver prices in Shanghai and foreign markets will not demonstrate any tendency towards convergence. In other words, efficient silver-market arbitrage does not entail that the value of the exchange rate deviation will necessarily converge to zero. Instead, the equilibrium value of x_t can be any point within the range given by the silver points.

The value of θ is determined by a constant marginal cost component with higher marginal costs making arbitrage more difficult. The value of λ is determined by two parameters. First, there is a quadratic cost parameter in the underlying model of arbitrage. With increasing shipments of silver, a large value for this parameter entails rapidly increasing marginal costs. As a result, some of the potential silver flows are postponed, making the speed of convergence decline. Second, a higher elasticity of the exchange rate deviation with respect to silver flows will serve to increase the speed of convergence.

It should be noted that the threshold error correction mechanism (TECM) specified in (1) is a special case of a threshold autoregressive (TAR) model with three regimes. To test the validity of the TECM, we can also estimate a much less restricted specification. This more general model can be expressed as an *n*-order TAR (Tong, 1983):

$$(2)\ x_t = \begin{cases} \beta_0^u + \sum_{i=1}^{n} \beta_i^u x_{t-i} + \varepsilon_t \text{ when } x_{t-1} > \theta \\ \beta_0^m + \sum_{i=1}^{n} \beta_i^m x_{t-i} + \varepsilon_t \text{ when } |x_{t-1}| \le \theta \\ \beta_0^l + \sum_{i=1}^{n} \beta_i^l x_{t-i} + \varepsilon_t \text{ when } x_{t-1} < -\theta \end{cases}$$

where ε_t is an exogenous disturbance term and is assumed to be serially uncorrelated. In what follows, we will refer to (1) as the restricted model and (2) as the general model. In any case, we estimate these models in a similar fashion using conditional least squares estimators. This entails the use of a grid search to determine the value of the threshold θ. This is implemented as a two-step process: using distinct values for the threshold, each regime is estimated using OLS; subsequently, we minimize the sum of squared residuals over all the values of θ used.

5. Results

We first estimate the restricted (TECM) model as in equation (1), using the full sample of 348 months from January 1905 to December 1933. We confine the grid search to values such that the upper and lower regimes combined have no less than 10% and no more than 70% of the observations. This corresponds to the restriction that the silver points fall within the range of (0.6%, 4.2%). The results are presented in the first column of Table 2. Tests show that the residuals are serially uncorrelated while we fail to reject the null hypothesis of no ARCH effects at the 10% level. Cumulatively, these tests speak broadly in favor of the model's specification.

The threshold—or silver point, θ—is estimated to be 2.6% of parity. Thus, when the deviation of exchange rates lies in the interval (-2.6%, +2.6%), it can be characterized as a random walk process.

Within this range, profits from arbitrage operations are not sufficient to cover costs. The number of observations underlying each regime is also presented in the lower panel of the table. Of the 348 monthly observations of the entire sample, the upper regime accounts for 34 observations. Silver shipments from the United States to Shanghai were, therefore, profitable in these months. The lower regime accounts for 38 observations where silver shipments in the opposite direction were profitable. The remaining 276 observations, representing 79% of the sample, underlie the middle regime. Here, there are no profitable arbitrage opportunities as the deviation from parity is insufficient to cover trade costs. Clearly, exploitable arbitrage opportunities did periodically emerge, but they did not persist for long. What is more, the correlation between the exchange rate in Shanghai and international silver prices could be zero in this middle regime, despite the fact that the two markets were indeed integrated.[13] The estimated convergence coefficient (λ) is 0.37. This implies that deviations greater (in absolute value) than the estimated silver point will be, reduced by 39 percent within a month, or equivalently, that the half-life of such deviations is 1.5 months.

We also estimate equation (1) by sub-periods. We do this to acknowledge the dramatic changes in both Chinese and foreign markets over the entire sample period from 1905 to 1933 which might not be reflected in the previous estimation. Again, we estimate the TECM model across three nearly equally-sized sub-periods: from January 1905 to June 1914, from July 1914 to December 1923, and from January 1924 to December 1933. If the dynamics of exchange rate deviations are not identical across sub-periods, the estimation of a constant silver point and adjustment speed across the entire sample could be seen as the "average" of time-varying results of sub-periods, thus, obscuring interesting developments across sub-periods.

The results are presented in the last three columns of Table 2. The results obtained in the first and last sub-periods are highly consistent. The silver point is estimated to be 1.70% and 2.00%, respectively. The estimates of the speed-of-adjustment parameter λ are 0.80 and 0.49, respectively. We note that these

[13] There is a substantial literature which assesses market integration solely by calculating the correlation of prices in two markets. However, taking into account the random walk nature of prices in the no-profitable-arbitrage regime suggests that low correlations do not necessarily imply low levels of market integration.

values are much higher than those reported for entire sample. The results for the second sub-period from July 1914 to December 1923 are, however, significantly different. During and immediately after World War I, the estimated silver points have increased while the estimated speed-of-adjustment has declined significantly. The estimated silver point for this middle sub-period is 2.8%, or roughly, one- to two-thirds higher than those for the other two sub-periods. The estimated adjustment speed is 0.24 and not statistically significant. This implies the half-life of exchange rate deviations is 2.6 months, or roughly, twice as high as the other two sub-periods. Thus, highly persistent deviations from parity occurred during and immediately after World War I. This relative disintegration during and after the wars years as evidenced by higher estimates of trade costs and slower speeds of adjustment can be rationalized by acute constraints and attendant higher freight rates in the shipping industry as well as a likely scarcity of working capital for arbitrage and greater opportunity costs for traders in the form of Europe's critical need for war materiel.

A natural question at this juncture may be how these various estimates of the silver points compare to contemporary accounts. According to Kann (1926, p. 10), in the New York City-Shanghai silver trade, there were three principal routes to consider: shipping from New York City by direct steamer (or through bill of lading by steamer via San Francisco) to Shanghai which entailed a cost of 1.71%; shipping from New York City via Seattle, Vancouver, or Victoria by rail which entailed a cost of 2.05%; or shipping from New York City via London which entailed a cost of 2.65%.[14] He also notes that unless money was cheap and silver was little needed in Shanghai, the routing of silver from New York City by direct steamer was preferred as it afforded the lowest shipment cost. When silver was urgently needed in Shanghai, the routing of silver from New York City via Seattle, Vancouver, or Victoria was preferred as it afforded the quickest transit ties. Thus, our estimates of the silver points—in particular, those for the last sub-period—are very close to these reported costs. Given this close correspondence, there were apparently no significant informational or policy barriers to the silver trade in this period.

[14] More precisely, Kann reports the dis-aggregated costs of cartage, freight, insurance, interest, and dealer/bank commission. For instance, these are reported as 0.05%, 0.75%, 0.20%, 0.65%, and 0.06% (that is, 1.71% cumulatively) for the direct steamer to Shanghai.

Another natural question is the extent to which these results can be compared to estimates of the more well-known gold points. While the estimates of the trans-Pacific silver points vary across sub-periods as demonstrated above, all of them are higher than estimates of the contemporaneous gold points between London and New York City. For example, Spiller and Wood (1988) estimate gold points of around 0.25% for the period from 1899 to 1908 while Officer (1996) estimates these at 0.50% for the period from 1900 to 1913. In the most recent contribution to this literature, Canjels *et al*. (2004) estimate gold points of 0.67% for the period from 1879 to 1913. Is it safe to say then that the degree of financial integration across the Pacific was lower than that across the Atlantic? We would argue no for three reasons. First, there are the physical characteristics of gold versus silver. Silver suffered from a lower value-to-weight ratio than gold, so that shipping costs for silver were about 2 to 3 times higher than those for gold when evaluated using equivalent dollar figures. Second, there are the geographical characteristics of the cities involved in the two trades. The distance from New York City to Shanghai is 2.6 times the distance from London to New York City. Finally, there are the monetary characteristics of the gold versus silver standard. Both the United Kingdom and the United States were on the gold standard, implying a constant parity value and, thus, no exchange rate risk on the part of arbitrageurs. China was nearly alone on the silver standard. Thus, not only the exchange rate, but also the parity value of the Chinese *tael* versus the US dollar fluctuated with the price of silver. Given that there were often lengthy transit times between New York City and Shanghai, arbitrageurs had to assume the risk of silver price fluctuations. Thus, some sort of risk premium—albeit small in light of the figures provided above—was likely required. This view is informally corroborated by examining the time-series above where it is clear that periods with greater variation in the parity value were associated with larger deviations in the exchange rate.

Robustness: estimation under the general model derived from equation (2) using monthly data

We further estimate a general n-order TAR model as in equation (2). To discriminate between TAR models with different values of n, we choose $n = 2$ as this serves to minimize the value of the Bayesian information criterion (BIC). The results are reported in the first column of Table 3. The estimate of the silver point is 2.8% using the entire sample, which is quite close to the results for the restricted model reported in Table 2. Here, convergence in the lower and upper regimes toward the silver points is allowed to be asymmetric: the estimates of the error correction coefficients are 0.33 and 0.21, respectively.

The results for the general model by sub-period are also presented in the remaining three columns of Table 3. The estimates of the silver points in the first and last sub-periods are 1.4% and 1.6%, respectively. That is, they are slightly smaller than the corresponding results for the restricted model. The estimate of the silver points in the second sub-period is 3.3%. That is, it is a little higher than the corresponding results for the restricted model. As for the speed of adjustment in the first sub-period, the estimates of the error correction coefficients are 0.81 and 0.72 in the lower and upper regimes, respectively. Both are close to the symmetric speed-of-adjustment estimate of 0.80 reported in Table 2. Similarly, in the last sub-period, the estimates of the error correction coefficients are 0.63 and 0.67 in the lower and upper regimes, respectively. Again, both are close to the symmetric speed-of-adjustment estimate of 0.49 reported in Table 2. However, in the second sub-period, we find marked asymmetry in the speed of adjustment. Specifically, the estimates of the error correction coefficients are 0.17 and 0.38 in the lower and upper, respectively. Both are smaller than the results for the general model in the other two sub-periods, a result which is consistent with what was found in the restricted model.

Robustness: estimation under the general model derived from equation (2) using daily data, with and without symmetric thresholds

Our previous results relied on monthly data over the period from 1905 to 1933. To ensure the robustness of the estimates of the silver points, we estimate a general TAR model using 2,574 observations on daily data but for a shorter period of time spanning the years from 1924 to 1933. We choose $n = 4$ to minimize the BIC. The results are reported in the first column of Table 4. Here, the estimate of the threshold is 1.8% which is very close to that of 1.6% generated from the monthly data for the last subsample using the same general TAR model and to that of 2.0% generated from the daily data for the last subsample using the restricted TECM model. We take this as a positive indication of the validity of our previous silver point estimates. Moreover, the steady-state value of x is close to zero in this middle regime which is in line with our expectations. The middle regime is estimated to encompass around 80% of the observations, implying that the Shanghai exchange rate and international silver prices seldom strayed from each other even in the context of daily data. Also as before, the lower and upper regimes encompass 6% and 15% of the observations, respectively. Thus, it was again a more frequent occurrence that the Chinese *tael* was overvalued in the Shanghai foreign exchange market relative to the international silver price. This is a result consistent with China's previously noted net purchases of silver in international markets.

As a final robustness exercise in generalizing the model, we also allow for asymmetric thresholds in the general TAR model using daily data. The results of this exercise are reported in the second column of Table 4 and suggest that no great damage is done by imposing symmetric thresholds when considering our benchmark results using monthly data. Here, we find that the upper threshold is estimated to be 2.1% while the lower threshold is estimated to be 1.8% (in absolute terms). This favorably compares with the estimate of 1.8% under the general TAR model with symmetric thresholds using daily data and the estimate of 1.6% under the ATECM model with symmetric thresholds using monthly data.

6. Silver points and silver flows

Up to this point, we have estimated silver points based on the restricted TECM and general TAR models. We have found a broad correspondence across models and across data frequencies: in general, silver points were estimated to be in the range of 1.5 to 2.0% in peacetime, but they rose appreciably during and immediately after World War I. We also noted that that there were relatively few out-of-equilibrium observations on exchange rate deviations across all frequencies, models, and periods. However, the limitations of our modeling must be acknowledged. In particular, these are methods of indirect observation on activity in silver markets in that the parameters are inferred solely through a consideration of exchange rate dynamics. Thus, it would be reassuring if we could cross-validate our results by seeing if our estimated silver points do a good job in predicting cross-border silver flows.

To this end, we have compiled weekly records on imports of silver from the Americas from 1923.[15] The data were obtained from the *North China Daily News* in its Week's Exchange Notes column. The newspaper collected weekly aggregates of silver arrivals into Shanghai from Japan, the United Kingdom, and, most importantly, the Americas.[16] There are two reasons why this silver volume figure may not be as informative as we wish. First, we can only collect weekly aggregates of silver imports, so the timing of the silver arrivals is not precise. Second, one has to allow for the time from silver shipment to silver arrival, that is, the days in transit. This lag is likely to be somewhere in between 22 and 28 days.

Nonetheless, we can first present an informal cross-check of our results. Previously, Figure 2 demonstrated that there was slightly more variation in the exchange rate series at the beginning of the sample period and significantly more variation in the exchange rate series during the Great Depression which may be useful in determining the relationship with silver flows. Hence, in figures 3 and 4, we plot the maximum of the exchange rate over a two week period (that is, in the six days before and after the potential shipment of silver by arbitragers), our silver point estimates from the symmetric TAR model using daily data (1.8%), and the volume of silver imports from the Americas for the two periods from January 1924 to December 1926 and from January 1930 to March 1933. To highlight the timing of substantial silver imports, we omit weekly aggregates of silver import volume which are less than 1000 bars (about 1 million ounces).

They demonstrate a broad correspondence in between particularly large exchange-rate deviations and silver flows. In Figure 3, almost all of the large net imports of silver occurred when deviations were above the estimated thresholds. The same also holds true during the Great Depression when there was significantly more variation in the exchange rate series and when, presumably, arbitrage opportunities

[15] Only rarely was silver exported from Shanghai to the Americas.
[16] Kann (1926, p. 143) reckons that Mexico and the United States contributed nearly one-third each to world silver production during this period with Canada and South America contributing 10 and 8%, respectively. Thus, total silver production in the Americas amounted to 82% of world production. In a related fashion, over 95% of this silver production of the Americas was processed through one of two places, New York City or San Francisco (Kann, 1926, p. 199).

emerged more frequently in the silver market. Finally, when the deviation fell within the bounds of the silver points, both net exports and imports of silver were generally very small.

However, these results should be interpreted as merely suggestive and not definitive. As mentioned previously, data is only available for weekly aggregates of silver imports. Necessarily, the precise timing of these silver flows remains unknown. This fact could explain why we observe several instances in which silver was shipped to Shanghai when the deviation from parity was actually below the estimated silver point for inflows. It also remains a possibility that silver was shipped for reasons other than arbitrage in the silver market, thus, rendering cross-validation problematic. For these reasons, we are of the view that any single observation on imports of silver should be viewed with caution and instead that it is general tendencies in the data which are most relevant.

In this spirit, we now take a more formal approach. In particular, we estimate a probit model to test the relationship between our estimated silver points and observed silver imports. In this model, the dependent variable is an indicator variable representing the occurrence of substantial silver imports (that is, more than 1000 bars) from the Americas. The explanatory variable is an indicator representing the instance of a deviation in the exchange rate from parity which exceeds our preferred silver point estimate (that is, more than 1.8%). When this model is estimated, we arrive at positive and significant (at the 1% level) coefficient of 9.75. This translates into an average marginal effect of an extreme exchange rate deviation on the conditional probability of above 55%. Thus, the economic and statistical significance of this measure is substantial, leading to a measure of corroboration in between the estimates of our model and independent outcomes taken from the global market for silver itself.

7. Conclusion

In this paper, we have estimated the silver points for Shanghai, thereby, assessing the degree of Chinese financial market integration in the early 20th century and examining to what extent the Chinese foreign exchange market was efficient during this period. Our inferred measures of the Shanghai silver points were low in value and favorably matched the measured costs of the silver trade derived from contemporary accounts. They also fared well in the comparison to estimates from the trans-Atlantic gold point literature. This naturally leads to the conclusion that the degree of Chinese financial market integration was substantial.

At the same time, it did not remain unaffected by events external to China. In particular, both during and immediately after World War I, our estimates of the silver points increased appreciably. While the notion that conflict and war significantly disrupts markets is an uncontroversial one (Hynes *et al*., 2011), it is interesting that market disintegration occurred even though China and the United States remained somewhat peripheral to the war effort and the Pacific Ocean was not an active theatre of war.

What this paper has not addressed is the broader significance of these developments in the context of Chinese history. That a significant component of the Chinese financial market, particularly one which acted as a vital link to the rest of the world, had moved in rapid order to rival its trans-Atlantic counterpart points to the depth of China's transformation from a relatively insular giant to one of the world's largest markets in the span of a few generations (Mitchener and Yan, 2014). That China had progressed so far in its integration into the global economy of the day is a fact more often than not obscured from the perspective of the present day and which points to the impermanent nature of globalized capital and trade flows. This also raises the issue of the potential counterfactual trajectories that Chinese financial markets in particular and the Chinese economy in general could have taken if it were not for the deleterious events of the 1930s and 1940s, starting with the Japanese invasion of Manchuria in 1934 and the outbreak of civil war in 1945. The prospect that much of the history of China in the last half of the 20th century merely represents a long pause in its rise to prominence in global markets is a tantalizing proposition, but one which invariably remains outside the scope of this paper.

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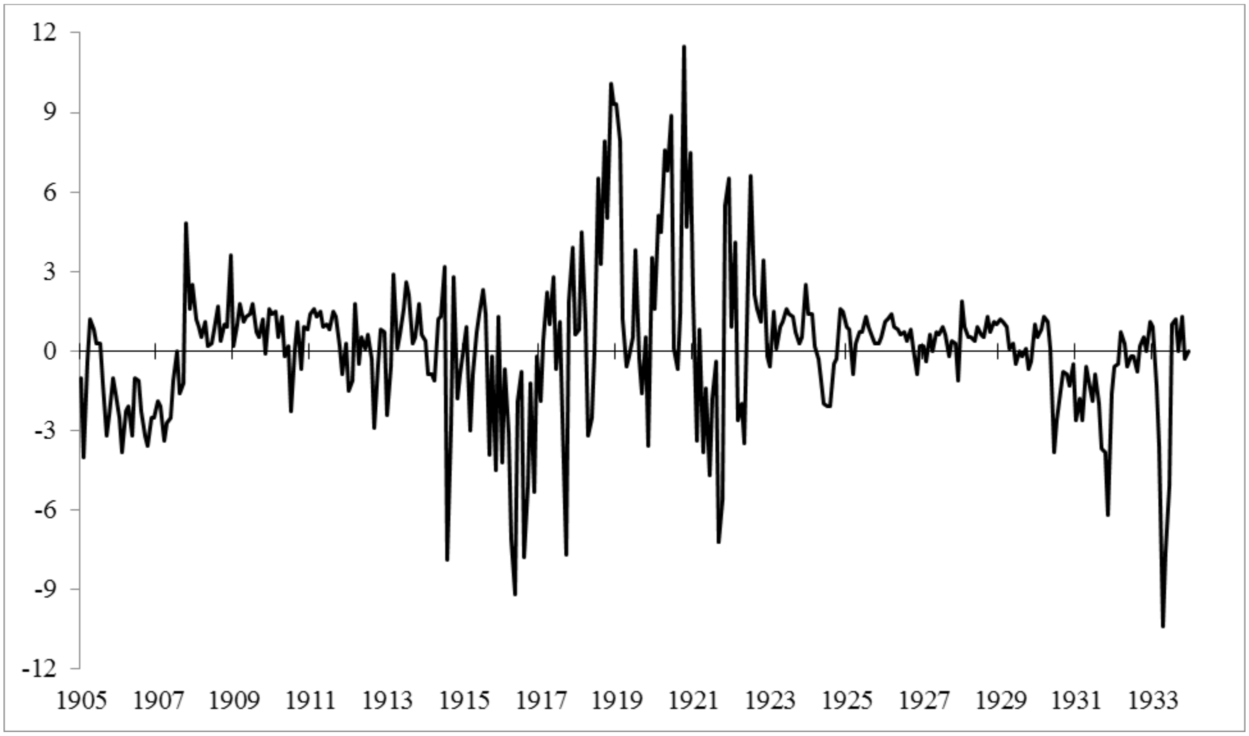

Figure 1: Deviation from parity for the *tael* in percent, monthly, from January 1905 to December 1933. Source: Wu (1935).

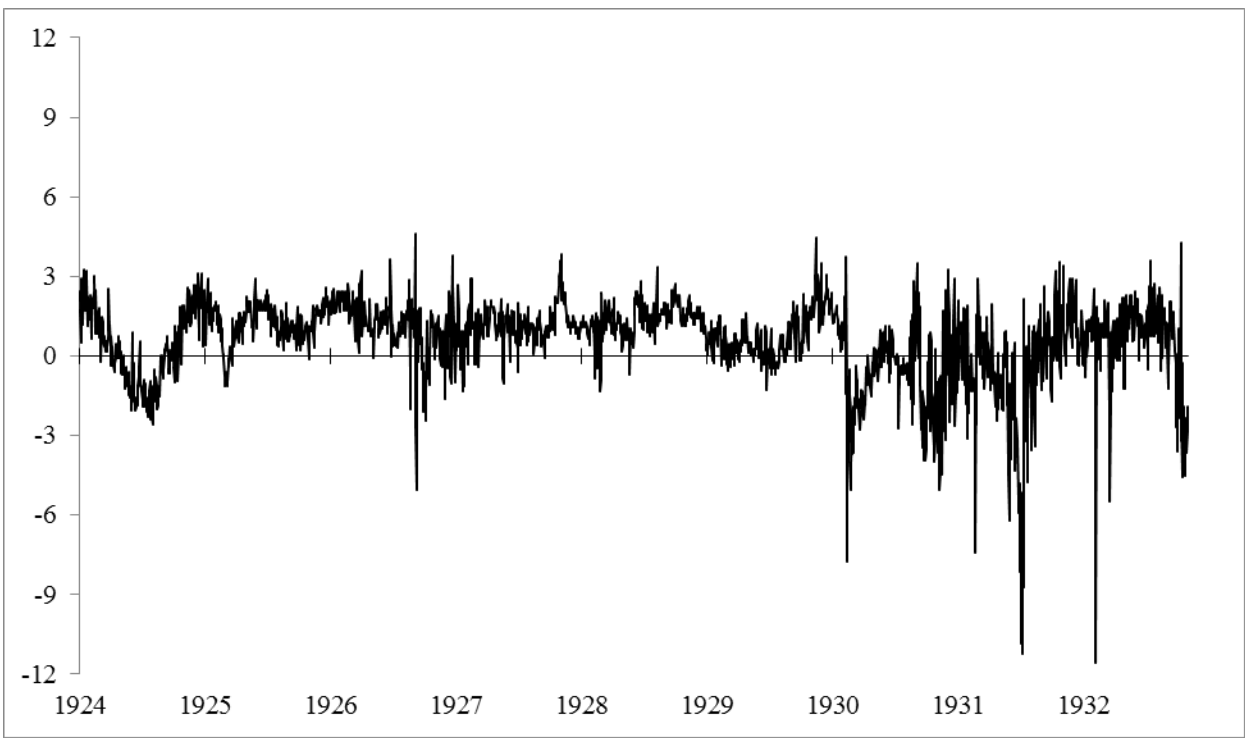

Figure 2: Deviation from parity for the *tael* in percent, daily, from January 1924 to March 1933. Source: *Economic Statistics Quarterly* (various issues, 1924-1933).

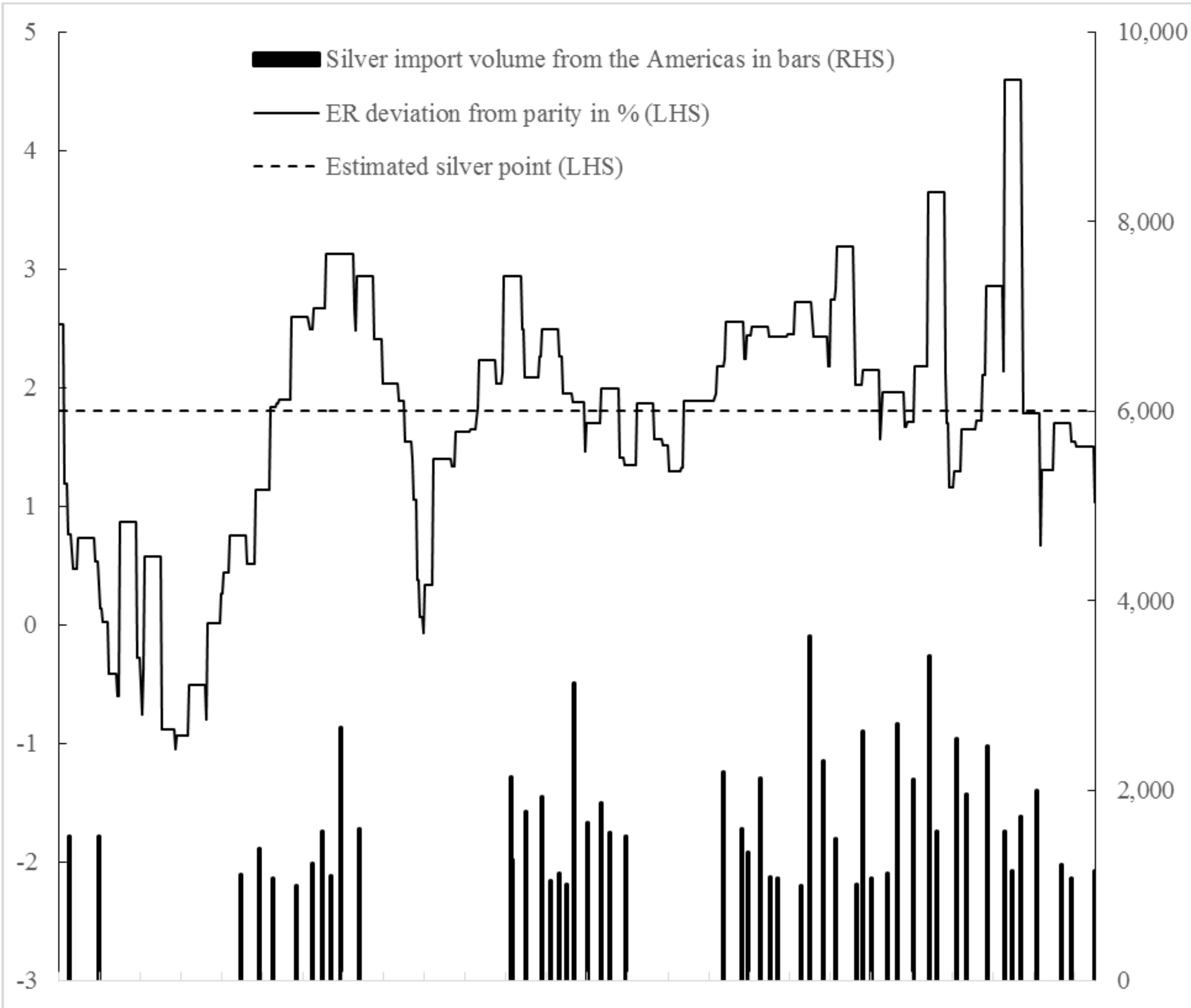

Figure 3: Deviation from parity in the *tael* in percent, estimated silver points, and imports for silver into Shanghai from the Americas, January 1924 to December 1926

Note: The silver point estimates are from the symmetric TAR model using daily data (1.8%).

Sources: Daily exchange rate in Shanghai and silver price data in New York City taken from *Economic Statistics Quarterly* (various issues, 1924-1933); silver import volume into Shanghai from the Americas taken from the *North China Daily News*.

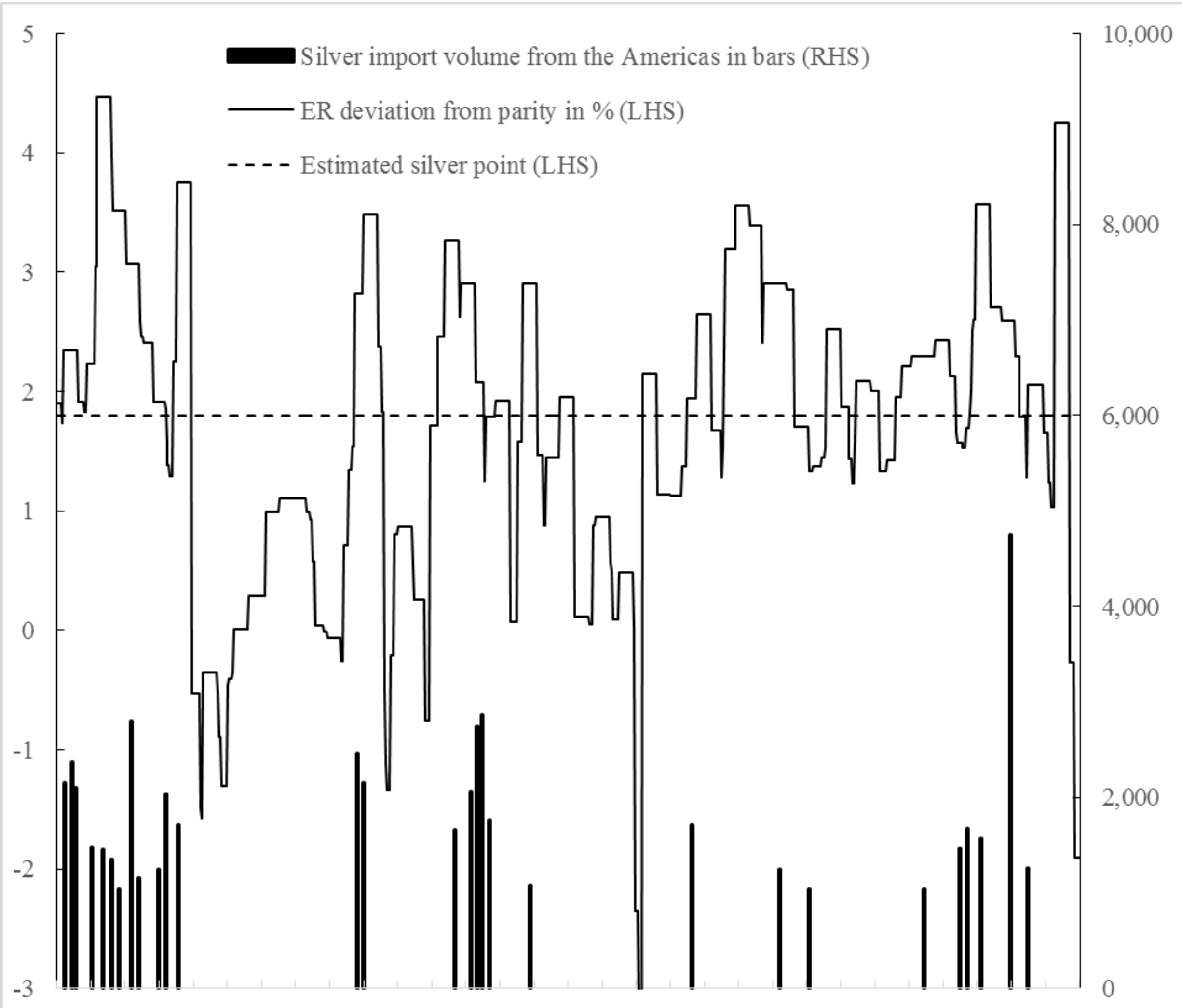

Figure 4: Deviation from parity in the *tael* in percent, estimated silver points, and imports for silver into Shanghai from the Americas, January 1930 to March 1933

Note: The silver point estimates are from the symmetric TAR model using daily data (1.8%).

Sources: Daily exchange rate in Shanghai and silver price data in New York City taken from *Economic Statistics Quarterly* (various issues, 1924-1933); silver import volume into Shanghai from the Americas taken from the *North China Daily News*.

Table 1: Summary statistics of deviations from exchange rate parity

	Full period: 01/1905 to 12/1933	Sub-period 1: 01/1905 to 06/1914	Sub-period 2: 07/1914 to 12/1923	Sub-period 3: 01/1924 to 12/1933
Mean (%)	0.122	-0.013	0.679	-0.277
Standard deviation (%)	2.740	1.684	4.031	1.813

Table 2: Restricted (TECM) model, monthly data

	Full period: 01/1905 to 12/1933	Sub-period 1: 01/1905 to 06/1914	Sub-period 2: 07/1914 to 12/1923	Sub-period 3: 01/1924 to 12/1933
k	0.016 (0.004)***	0.002 (0.004)	0.023 (0.007)***	-0.002 (0.004)
λ	0.370 (0.117)***	0.797 (0.325)**	0.237 (0.217)	0.493 (0.140)***
θ	0.026	0.017	0.028	0.020
Q_1	0.877 [0.349]	1.521 [0.217]	0.144 [0.704]	0.247 [0.619]
Q_3	1.961 [0.580]	3.822 [0.281]	1.907 [0.592]	3.051 [0.384]
R^2	0.225	0.195	0.263	0.135
SE of residuals	0.023	0.013	0.034	0.013
Regime (months)				
Upper $(\theta, +\infty)$	34	10	29	2
Middle $(-\theta, \theta)$	276	83	63	105
Lower $(-\infty, -\theta)$	38	21	22	13

Notes: Standard errors and p-values reported in parentheses and brackets, respectively. *, **, and *** denote 10%, 5%, and 1% levels of significance, respectively. Q_k is the Ljung-Box statistic for residual autocorrelation up to order k. "Upper" refers to the number of months for which the deviation exceeds the estimated (+) silver point. "Middle" refers to the number of months for which the deviation is bounded by the estimated (+) and (-) silver point. "Lower" refers to the number of months for which the deviation exceeds in absolute value the estimated (-) silver point.

Table 3: General (TAR) model, monthly data

	Full period: 01/1905 to 12/1933	Sub-period 1: 01/1905 to 06/1914	Sub-period 2: 07/1914 to 12/1923	Sub-period 3: 01/1924 to 03/1933
β_0^u	-0.004 (0.010)	0.007 (0.008)	0.011 (0.019)	0.016 (0.014)
β_1^u	0.455 (0.189)**	0.029 (0.351)	0.275 (0.317)	-0.180 (0.303)
β_2^u	0.340 (0.107)***	0.256 (0.235)	0.347 (0.175)*	0.505 (1.318)
β_0^m	0.000 (0.001)	-0.003 (0.002)*	-0.003 (0.004)	-0.053 (0.162)
β_1^m	0.716 (0.128)***	0.424 (0.227)*	0.664 (0.264)**	0.425 (0.220)*
β_2^m	0.067 (0.070)	-0.00.051 (0.118)	-0.005 (0.119)	0.248 (0.119)**
β_0^l	0.002 (0.010)	-0.018 (0.010)*	0.051 (0.026)*	-0.013 (0.006)**
β_1^l	0.522 (0.202)**	-0.214 (0.391)	1.161 (0.480)*	0.734 (0.174)***
β_2^l	0.148 (0.127)	0.408 (0.205)**	-0.328 (0.274)	-0.362 (0.152)**
θ	0.028	0.014	0.033	0.016
Q_1	0.024 [0.875]	0.258 [0.611]	0.043 [0.836]	0.001 [0.974]
Q_3	0.876 [0.831]	1.486 [0.685]	0.443 [0.931]	5.623 [0.131]
R^2	0.335	0.478	0.331	0.484
Log likelihood	820.262	337.431	228.893	339.341
SE of residuals	0.023	0.012	0.034	0.014
Regime (months)				
Upper $(\theta, +\infty)$	32	18	27	3
Middle $(-\theta, \theta)$	280	72	67	100
Lower $(-\infty, -\theta)$	36	24	20	17

Notes: Standard errors and p-values reported in parentheses and brackets, respectively. *, **, and *** denote 10%, 5%, and 1% levels of significance, respectively. Q_k is the Ljung-Box statistic for residual autocorrelation up to order *k*. "Upper" refers to the number of months for which the deviation exceeds the estimated (+) silver point. "Middle" refers to the number of months for which the deviation is bounded by the estimated (+) and (-) silver point. "Lower" refers to the number of months for which the deviation is exceeds in absolute value the estimated (-) silver point.

Table 4: General (TAR) model, daily data, 01/1924 to 03/1933.

	Symmetric threshold model	Asymmetric threshold model
β_0^u	0.012 (0.002)***	0.016 (0.004)***
β_1^u	-0.135 (0.097)	-0.385 (0.146)***
β_2^u	0.341 (0.060)***	0.518 (0.085)***
β_3^u	0.071 (0.052)	0.031 (0.101)
β_4^u	0.064 (0.059)	0.153 (0.099)
β_0^m	0.001 (0.000)***	0.001 (0.000)**
β_1^m	0.517 (0.033)***	0.533 (0.029)***
β_2^m	0.108 (0.026)***	0.109 (0.024)***
β_3^m	0.153 (0.027)***	0.134 (0.024)***
β_4^m	0.127 (0.023)***	0.128 (0.022)***
β_0^l	-0.005 (0.001)***	-0.005 (0.001)***
β_1^l	0.159 (0.045)***	0.159 (0.045) ***
β_2^l	0.331 (0.041)***	0.331 (0.041) ***
β_3^l	-0.110 (0.042)***	-0.110 (0.042)***
β_4^l	0.367 (0.041)***	0.367 (0.041)***
θ	0.018	
θ_u		0.021
θ_l		-0.018
Q_1	0.370 [0.543]	0.540 [0.462]
Q_3	2.371 [0.499]	2.775 [0.428]
R^2	0.614	0.617
SE of residuals	0.009	0.009
Regime (months)		
Upper $(\theta, +\infty)$	396	169
Middle $(-\theta, \theta)$	2,015	2,239
Lower $(-\infty, -\theta)$	163	165

Notes: Standard errors and p-values reported in parentheses and brackets, respectively. *, **, and *** denote 10%, 5%, and 1% levels of significance, respectively. Q_k is the Ljung-Box statistic for residual autocorrelation up to order k. “Upper” refers to the number of months for which the deviation exceeds the estimated (+) silver point. “Middle” refers to the number of months for which the deviation is bounded by the estimated (+) and (-) silver point. “Lower” refers to the number of months for which the deviation is exceeds in absolute value the estimated (-) silver point. θ_u and θ_l refer to the upper and lower thresholds, respectively.