Omitted Variables and how the Chinese Yuan Affects other Asian Currencies

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Abstract

Bi-Directional Reiterative Truncated Projected Least Squares (BD-RTPLS) is a relatively new analytical technique that greatly reduces the bias from omitted variables. In this paper, I explain BD-RTPLS and apply it to monthly and weekly data to produce reduced form estimates of the relationship between China’s exchange rate and exchange rates in the rest of Asia. I show how omitted variables have affected those relationships across countries and over time. My data spans from when China began appreciating the yuan in July 2005 through May of 2007. I find that the marginal effect of China appreciating the yuan by 2.1% at the beginning of this time period was negative, but that the marginal effect of China’s slower appreciation of the yuan from September 2005 through May 2007 was positive for most time periods and most countries.

Mathematics Subject Classifications: 62J05, 62L12, 65C60

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1. Introduction

In July 2005, China allowed the value of its currency, the yuan, to appreciate (let the dollar/yuan exchange rate rise) for the first time in many years. China had seriously studied appreciating its currency since 2003 and had even sponsored a conference where internationally renowned economists, specialists in exchange rates, would present and argue their opposing views on appreciating the yuan [1]. Even after July 2005, the debate on China appreciating the yuan has raged on contentiously (for examples see [15], [16], and [19]). Meanwhile the US government was disappointed with how slight (2.1%) the July 2005 appreciation was and it has continued to “encourage” a much more substantial appreciation [17]. China has promised to allow its currency to appreciate, but it has been doing so at an extremely slow pace.

When there is market pressure for the yuan to appreciate, the Chinese government can resist this pressure by printing more yuan and using it to buy US dollars or US treasury bills (hereafter called US dollar reserves). The fact that China’s holdings of US dollar reserves recently have climbed so much that China now has more US dollar reserves than any other country in the world, more than 1.2 trillion dollars [3], is prima fascia evidence of the market pressure for the yuan to appreciate. Since a future appreciation of the yuan is likely, it is important to study the affects of such an appreciation. This paper will examine how China’s measured and slow appreciation of the yuan since July 2005 has affected the exchange rates of other Asian countries.

Unfortunately, there are many forces that affect the relationship between the Chinese yuan and other Asian currencies which are extremely hard to measure and model. These forces include the influence of expectations and currency speculation, how relative exchange rates affect the exports and imports of different countries, and how the governments of different countries react to the influence of market forces on their exchange rates and to changes in their competitor’s exchange rates, etc. If a traditional econometric analysis was conducted on the effects of the yuan, then many of these forces would have to be omitted or inadequately modeled. The omitted variable problem is the single biggest problem with econometrics. Omitted variables often cause the error term and the explanatory variables to be correlated which ruins all the resulting statistics and estimated coefficients. Both autocorrelation and heteroscedasticity are due to omitting important variables.

Fortunately, Branson and Lovell [4] developed PLS (projected least squares), an alternative to OLS (ordinary least squares). PLS eliminates the influence of
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unfavorable omitted variables. Leightner [8] added a reiterative process and several other improvements to PLS to create RTPLS (reiterative truncated projected least squares). Leightner and Inoue [14] theoretically prove that OLS produces more bias then RTPLS when there are omitted variables that interact with the included variables. They quantify the benefits from using RTPLS (relative to OLS) by conducting more than 90,000 simulation tests. These tests show that OLS produces (on average) double the error of RTPLS (or more) when there are omitted variables that interact with the included variables. This result is robust to when the omitted variable makes a 10%, 100% or 1000% difference to the real slope, to when 0%, 1%, or 10% measurement and rounding error is included, and to when sample sizes of 100 or 500 observations are used. Leightner [9] and [11] are the first published applications of RTPLS. Leightner [10] proposes improvements in RTPLS to produce BD-RTPLS (bi-directional RTPLS). Two applications of BD-RTPLS are in Leightner and Inoue [12] and [13]. Most importantly, BD-RTPLS captures the influence of omitted variables without resorting to using proxies or instruments. Furthermore, the omitted variables do not have to be measured, known, or modeled to use BD-RTPLS.

This paper will use BD-RTPLS to estimate how a one percent increase in the value of the Chinese yuan would affect the value of 17 other Asian currencies. We find that the marginal effect on other Asian currencies of China allowing the yuan to appreciate by 2.1% in July of 2005, was negative. In contrast, when China allowed the value of the yuan to appreciate more slowly between September 2005 and May 2007, the marginal effect on other Asian currencies was positive. Although Leightner and Inoue [14] discussed (and ran simulations for) when omitted variables could change a slope from positive to negative, this is the first empirical application where such an effect was found.

The remainder of this paper is structured as follows. Section 2 provides an intuitive explanation of BD-RTPLS. Additional information can be found in Leightner and Inoue [14] and Leightner [10]. Section 3 explains the data and how exchange rates are modeled. Section 4 presents and discusses the empirical results from applying BD-RTPLS to Asian exchange rates. Section 5 concludes.

2. Analytical Techniques:

The key to understanding BD-RTPLS is Figure 1. To construct Figure 1, I randomly generated two series of numbers, X and q, which ranged from 0 to 100. I then defined $Y = 100 + 10 X + 0.5 Xq$. I plotted (in Y, X space) the resulting points in Figure 1 and identified each point with its value for q. Notice that the upper left hand edge of the data corresponds to when q is at its largest values --100, 99, and 98. Also notice that the lower right hand edge of the data corresponds to the lowest
values for q -- 2, 3, and 4. This makes sense, Y is actually generated in a three
dimensional plane. When that plane is projected down to a two dimensional surface
in just Y and X dimensions, the upper edge of the data will correspond to when q was
at its most favorable level, and the lower edge will be the opposite. Viewed a slightly
different way, the true value for \( dY/dX = 10 + 0.5q \). Thus when q is large, the slope
will be big. When q is small, the slope will be small. Furthermore, since q ranges
from 0 to 100, the true slope will range from 10 (when q = 0) to 60 (when q = 100).
Thus, in this case, q makes a 600% difference in the true slope.

Now imagine that we do not know what q is, and we have to omit it from our
analysis. In this case, OLS produces an estimate for \( dY/dX \) of \( 10 + 0.5 \times E(q) \), where
\( E(q) \) is the expected (mean) value for q. Notice that this OLS estimate is a single
number (it does not vary) and that the true slope does vary from observation to
observation. Thus OLS is hopelessly biased. BD-RTPLS is based upon the insight
that, even though we may not know q, we do know that the relative vertical position
of different observations in Figure 1 contains information about q. Specifically, we
know that the upper edge of the data corresponds to when q is at its most favorable
level and that the lower edge is when q is at its least favorable level.

Branson and Lovell [4] were the first to realize this intuition. They would
recommend using data envelopment analysis (DEA)\(^1\) to construct a best practice
frontier for the data in Figure 1. This frontier is constructed by connecting the dots
that are on the upper, left hand edge of the data in Figure 1. Those dots are identified
with the numbers for q of 100, 99, and 98. All observations are then projected to this
frontier, thus purging from the data variation caused by the omitted variables. The
projected data points are then used to estimate the relationship between Y and X
when q is at its most favorable level (approximately 99). I call the Branson--Lovell
method “Projected Least Squares” (PLS).

The math underlying PLS is as follows. Denote the output of an observation
by \( y_i, \) i=1,..., I, and the inputs of an observation by \( x_{in}, \) i=1,...,I, n=1,...,N. Consider
the following DEA problem:

\[
\begin{align*}
\text{max } & \Phi \\
\text{subject to } & \sum_i \lambda_i x_{in} \leq x_n^o, \quad n = 1,..., N \\
& \Phi y^o \leq \sum_i \lambda_i y_i, \\
& \sum_i \lambda_i = 1; \quad \lambda_i \geq 0, \quad i=1,...,I.
\end{align*}
\]

This problem is solved I times, once for each observation in the sample. For
observation "o" under evaluation, the problem seeks the maximum vertical expansion
in output \( y^o \) consistent with best practice observed in the sample, i.e., subject to the
constraints in the problem. Consider the \( \Phi \) for the specific observation that
corresponds to an X of 80 and a q of 3. Draw a vertical line that passes through this
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observation and proceeds to the frontier (to approximately where a different observation is noted with a q of 99). Φ is the distance from the X axis to the frontier divided by the distance from the X axis to the observation. Φ for the noted observation would be approximately 4. To project the data to the frontier, PLS multiplies the Y of each observation by its Φ, and by so doing moves that observation to the frontier. After projecting all observations to the frontier, an OLS regression is run through the projected data to find the slope estimate for when the omitted variables are at their most favorable levels. DEA is only used to eliminate the influence of omitted variables; all estimations are conducted with OLS.

Leightner [8] improves on Branson and Lovell [4] in several ways. First, Leightner [8] notes that DEA frontiers often contain an upper right hand horizontal section. In Figure 1, this horizontal section starts at the X = 92, q = 98 point. DEA drew a horizontal line from this point because there are no points both above and to the right of this point. When PLS “projected” all observations to the frontier, it projected all points with X values greater than 92 to this horizontal section of the frontier. In this example, that would involve the 6 observations on the far right side of Figure 1. In some applications, like Leightner and Inoue [12], this horizontal section can be much bigger than the positively sloped section of the frontier. The positively sloped section of the frontier shows the true relationship between Y and X when q is at its most favorable level, the horizontal section does not. Thus Leightner [8] “truncates” off any horizontal section before using OLS to find the slope of the projected data.

Leightner [8] also notes that PLS works best if all the observations that determine the frontier correspond to the same value for q. However, the observation with the smallest value for X will always be on the frontier, no matter what value for q is associated with it. For the data underlying Figure 1, the observation with the smallest X (X = 0.495) is associated with a q of only 16. Thus Leightner [8] recommends truncating off the first 3% of the projected observations and the horizontal section of the frontier before using OLS to get the slope estimate. When this is done for Figure 1, the omitted variable values on the frontier correspond to values of 97 through 100. Leightner [8] calls this process “truncated projected least squares” (TPLS).

Leightner [8] explains that once TPLS has determined an estimate of dY/dX when q is at its most favorable level, the observations that determined the frontier can be deleted and the process conducted again to find a dY/dX for when q is at its second most favorable level. This can be done repeatedly; peeling the data from the upper left hand side towards the lower right hand side. Each subsequent iteration produces a TPLS slope estimate for when q is less favorable than the previous iteration. The TPLS slope estimates for a given iteration are inserted into the data for the observations that determined the frontier for that iteration. This reiterative
process stops when the sample size gets too small. 3

Next, the TPLS coefficients produced by this reiterative process are treated as
the dependent variable and regressed on a constant, the inverse of the included
independent variable and the ratio of the original dependent variable to the included
independent variable (equation 8 below). The following derivation shows why these
regressors are used.

\[ Y_i = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{1i}^n q_i^m + e_i \]  (2)
\[ dY/dX_1 = \alpha_1 + n\alpha_2 X_{1i}^{n-1} q_i^m \]  (Derivative of equation 2)  (3)
\[ Y_i/X_{1i} = \alpha_0/X_{1i} + \alpha_1 + \alpha_2 X_{1i}^{n-1} q_i^m + e_i/X_{1i} \]  (Dividing equation 2 by \( X_{1i} \))  (4)
\[ \alpha_1 + \alpha_2 X_{1i}^{n-1} q_i^m = Y_i/X_{1i} - \alpha_0/X_{1i} - e_i/X_{1i} \]  (Rearranging equation 4)  (5)
\[ e_i/X_{1i} = e_{1i}/X_{1i} + e_{2i} \]  (separating \( e_i/X_{1i} \) into two parts: one correlated with
1/\( X_{1i} \) and the other one not correlated (\( e_{2i} \)).)  (6)
\[ \alpha_1 + \alpha_2 X_{1i}^{n-1} q_i^m = Y_i/X_{1i} - (\alpha_0 + e_{1i})/X_{1i} - e_{2i} \]  (From equations 5 and 6)  (7)
\[ dY/dX_1 = fn(Y/X_{1i}, 1/X_{1i}) - e_{2i} \]  (From equations 3 and 7) 4  (8)

When equation 8 is estimated, a constant is used to capture the \( \alpha_1 \) part of \( dY/dX_1 \), and
\( Y/X_{1i} \) and 1/\( X_{1i} \) are used to capture the \( n\alpha_2 X_{1i}^{n-1} q_i^m \) part of \( dY/dX_1 \). In other words,
\( Y/X_{1i} \) and 1/\( X_{1i} \) are used as a proxy for the omitted, unknown, or un-measurable \( q \).
This makes intuitive sense because \( Y \) is co-determined by the known \( X_{1i} \) and the
unknown \( q \), therefore the combination of \( Y \) and \( X_{1i} \) contains information about \( q \).
Data for \( Y/X_{1i} \) and 1/\( X_{1i} \) are plugged back into the estimate of equation 8 to produce
an RTPLS (reiterative truncated projected least squares) estimate of \( dY/dX_1 \) for each
observation. (Notice that equation 8 is the same no matter what values \( n \) and \( m \) take
in equation 2 -- this means that the relationship between the omitted variables and the
dependent variable does not have to be modeled or known to use RTPLS.)

Leightner [10] improved on RTPLS. In essence, RTPLS peeled the data in
Figure 1 downward, starting with the upper left hand side and ending on the lower
right hand side. It also is possible to peel the data up from the lower right hand side.
BD-RTPLS (Bi-directional RTPLS) peels the data from both directions (up and
down), resulting in approximately double the number of observations used in the final
regression. When peeling the data down, the dependent variable was used as the
output and an output oriented DEA problem was solved. When peeling the data up,
the dependent variable is used as the input and the following input oriented DEA
problem is solved.

\[
\begin{align*}
\min \Phi \\
\text{subject to} \\
\sum_k \lambda_k y_k \geq y_i \\
\Phi x_{ji} \geq \sum_k \lambda_k x_{jk} & \quad j=1,\ldots,J \\
\sum_i \lambda_i = 1; \quad \lambda_k \geq 0, & \quad k=1,\ldots,I 
\end{align*}
\]  (9)
In the 90,000 simulations reported in Leightner and Inoue [14], RTPLS produced less than half the error of OLS when there are omitted variables that interact with the included variables. Furthermore, this result was robust to different sample sizes, to different levels of importance of the omitted variable, and to different amounts of measurement and rounding error. It makes intuitive sense that BD-RTPLS would be even better than RTPLS and the few (approximately 30) simulations conducted on BD-RTPLS to date show that this is true: BD-RTPLS produces less than one fourth the error of OLS.

The benefits from using BD-RTPLS are extensive. BD-RTPLS greatly reduces the error from using OLS and OLS’s omitted variables bias. Furthermore, since autocorrelation and heteroskedasticity are due to omitting variables, BD-RTPLS reduces those problems. Moreover, BD-RTPLS produces reduced form estimates that capture all the ways that Y and X are correlated. Thus complicated systems of equations do not have to be created, justified, and solved to use BD-RTPLS.

3. The Data and Model

BD-RTPLS was applied to the data two times – once with monthly data and a second time with weekly data. For both analyses, the exchange rate used was the average inter-bank bid exchange rate. The exchange rate data was downloaded from www.oanda.com/convert/fxaverage. The exchange rate was expressed as the value of each Asian country’s currency per one US dollar. Thus an Asian currency appreciates when this exchange rate falls, and depreciates when it rises. I used data from China, Bangladesh, Hong Kong, India, Indonesia, Japan, Malaysia, Nepal, New Guinea, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, and Thailand.

All data was normalized by adding one to the percentage change in each country’s exchange rate. The percentage change in each country’s exchange rate was found by subtracting the previous time period’s exchange rate from this time period’s exchange rate and then dividing by the previous time period’s exchange rate. For example, if the monthly exchange rate did not change between January and February 2006, then the normalized exchange rate was one for February 2006 (or 100 percent of January 2006’s value). If the annual exchange rate fell by ten percent between January 2006 and February 2006, then February 2006’s exchange rate’s normalized value was 0.90 (or 90 percent of what it was in January 2006). By normalizing the data, all exchange rates were placed on a common level, making it possible to run BD-RTPLS on all the countries in a given data set at the same time.

Figure 2 plots the weekly normalized data for the Chinese yuan and the
average of the normalized exchange rates for the other 17 Asian countries. Notice the relatively large appreciation of the Chinese yuan in July of 2005. Notice also that after this 2.1% appreciation, the Chinese yuan appreciated much more slowly; however, between July 11, 2005 and June 8, 2007 the Chinese yuan had appreciated an accumulated total of 7.6%.

In order to use BD-RTPLS, one must know if the dependent variable is positively or negatively related to the included explanatory variable. Theoretically, there are many reasons why China’s exchange rate may be positively correlated with other Asian currencies and many other reasons why it may be negatively correlated. For example, if international forces were causing a general decline in the value of the US dollar, then all other currencies (relative to the US $) will have upward market pressure applied to them, ceteris paribus. Furthermore, if China allowing the yuan to appreciate causes the price of Chinese exports to rise relative to China’s Asian competitors’ prices, then upward pressure will be brought to bear against the competitor’s exchange rates as their exports increase. However, if China allowing the yuan to appreciate causes international currency speculators to expect the yuan to appreciate further in the near future, then these speculators have a profit incentive to sell other Asian currencies and buy the yuan. Such a speculative response would produce a negative correlation between the yuan and other Asian currencies.

When there are theoretical reasons for both a positive and negative correlation between the dependent and included independent variable, Leightner and Inoue [14] recommend that the researcher run a preliminary OLS regression on the data and then assume the sign of the effect found in that regression.5 Leightner and Inoue [14] show that this procedure works even when omitted variables change the true sign of a slope from positive to negative. What is important is that the researcher assumes which ever sign is more common in the data. A preliminary OLS regression using this paper’s weekly data produced the following results, where “e” = other Asian exchange rates per dollar and t-statistics are given in the parentheses:

Observations = 1700; R Bar2 = 0.0029; F-Statistic. = 5.94
e = 0.7633 + 0.2364 yuan
(7.875) (2.437)

Notice the tiny R Bar Squared statistic that indicates that this regression explained only a miniscule percent of the variation in Asian exchange rates. Notice also the positive (and statistically significant at a 92% confidence level) relationship between Asian exchange rates and the Chinese yuan. Running the same regression using the monthly data produced the following weaker results:
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Observations = 391; R Bar$^2$ = 0.00074; F-Statistic. = 1.29

e = 0.7423 + 0.2571 yuan

(3.289) (1.136)

As per Leightner and Inoue’s [14] advice, this paper will assume a positive relationship between the yuan and other Asian currencies based on these two regressions showing a positive relationship. Additionally, Figure 1 shows a positive relationship between the yuan and the average Asian exchange rate for most time periods, with the extremely important exception of the 30th week of 2005 which is when China appreciated the yuan by 2.1%.

The slope estimates of the normalized data that emerge from the analysis are actually elasticities of the original data. These elasticities carry the same interpretation as the elasticities that emerge when estimating a log linear equation. My approach produces estimates that are the “change in the percent of y divided by the change in the percent of x.” Estimating a log linear equation produces estimates of the “percentage change in y divided by the percentage change in x.” Although the “percent” and “change” are switched in these two approaches, the interpretation of the results are the same. Finding an elasticity of 4, for example, implies that a change in x of one percent is correlated with a 4 percent change in y, under both methods.

4. Empirical Results

Table 1 presents all the results based on using monthly data and Table 2 part of the results from using weekly data. Figure 3 plots all the monthly results over time and Figures 4a and 4b plot all the weekly results. The average elasticity, over all countries and time periods using monthly data was 2.86 and using weekly data it was 2.80. This 2.80 elasticity means that a one percent appreciation of the Chinese yuan would be accompanied by a 2.8 percent appreciation in other Asian currencies, on average. This is good news for the Chinese companies that export and bad news for the Chinese companies that import. It implies that the Chinese government allowing the yuan to slowly appreciate is not likely to eliminate China’s trade surplus with the US. Indeed, it may increase China’s trade surplus as other Asian currencies appreciate more than the yuan and, thereby, make Chinese exports relatively cheaper. Indeed, China’s trade surplus with the US has grown between 2005 and 2007 in spite of the 7.6% appreciation in the Chinese yuan over that time period.

However, it is important to remember that BD-RTPLS, like OLS, can only show correlations. They cannot prove causation. The average weekly elasticity of 2.8 may mean that China’s resistance to upward pressure on the yuan was
approximately three times stronger than the resistance employed by the governments of other Asian countries, on average and ceteris paribus. Finally note that the magnitude of this average effect, 2.8, is consistent with what Figure 2 showed – in Figure 2, the fluctuations in the yuan appear to be between a half and a fourth of the fluctuations in the average Asian exchange rate, except for July and August of 2005 (when China let the yuan appreciate by 2.1 percent).

When monthly data was used (Table 1, Figure 3) every one of the 17 Asian countries examined had a negative elasticity in either July or August (or both) of 2005. When weekly data (Table 2, Figure 4a) was used, every one of these countries had a negative elasticity in the 30th week of 2005 – July 25-29, 2005. The probable cause of this negative elasticity is currency speculators moving out of other Asian currencies into the Chinese yuan in the anticipation that the yuan would appreciate even more. Notice the consistency of these results with Figure 2. In Figure 2, the yuan appreciated (the line for China fell) in the 30th week of 2005 (July 25-29, 2005), while the average of the other Asian currencies depreciated (their line rose). This implies a negative relationship.

In contrast to the July and August 2005 results, the vast majority of the estimated elasticities for September 2005 through May 2007 are positive, indicating that while China very slowly appreciated the yuan during this time period, the marginal effect was an appreciation of most other Asian currencies. Furthermore, the September 2005 through May 2007 results are much more varied than the July and August 2005 results. The consistency of the July and August 2005 results could be due to currency speculators moving out of all other Asian currencies; the variability in the September 2005 through May 2007 results could be due to how the yuan affects different countries to different degrees and in different ways. For example, the yuan would affect each country differently because each country is in competition with and/or trades with China different sets of goods and services and each one of these goods and services is affected in unique ways by changes in the value of the yuan.

The empirical results found in this paper are significant for at least two reasons. First, they imply that China was wise to appreciate the yuan by only 2.1 percent in July of 2005 instead of the 5 percent considered [1]. If a five percent appreciation had been implemented, then the currency speculators’ effect would have been even stronger, causing an even greater depreciation of other Asian currencies. If China’s goal is to avoid a significant currency speculator’s effect, then its extremely slow appreciation of the yuan from September 2005 through May 2007 is the best course of action.

Secondly, the US has exerted tremendous pressure on China to appreciate the yuan. If the US hopes that an appreciation of the yuan will eliminate China’s trade surplus with the US and stop China’s accumulation of US dollar reserves, then the
US will be disappointed. If China initiated a larger appreciation of the Chinese yuan than China has since July 2005, then currency speculators would sell other Asian currencies and buy the yuan in anticipation of further appreciations. This implies that if China wanted to maintain a fixed exchange rate, it would have to continue to buy up US dollars in spite of the appreciation; indeed China might have to buy up even more US dollars than it has in the recent past to maintain its fixed exchange rate. However, if China decides to stay the course and continue to slowly appreciate the yuan, then China’s trade surplus is likely to continue to grow as other Asian currencies appreciate more than the yuan appreciates. The US would be unhappy with either of these two choices.

China does have a third choice: it could float the yuan. However, given how undervalued the yuan currently is (as evidenced by the increase in China’s holdings of US dollar reserves) such an action would cause major adjustment pains in both China and the US (and throughout Asia). Furthermore such a move is likely to cause even more currency speculation due to speculators expecting the value of the yuan to fluctuate more than it has in the past. Moreover, since the fundamental cause of China’s trade surplus with the US is China exporting its excess savings, which makes it possible for the US to enjoy excess consumption [16], such a move may reduce the trade surplus, but it would not eliminate the trade surplus.

5. Conclusion

A new analytical technique, BD-RTPLS, is available to researchers. BD-RTPLS produces reduced form estimations without having to construct and solve complicated systems of equations. Furthermore, BD-RTPLS greatly reduces the bias from omitted variables, and thereby greatly reduces problems of autocorrelation and heteroscedasticity. BD-RTPLS exploits the insight that the relative vertical position of observations contains information about omitted variables.

This paper used BD-RTPLS to estimate how a one percent increase in the value of the Chinese yuan would affect the value of 17 other Asian currencies. We find that the marginal effect on other Asian currencies of China allowing the yuan to appreciate by 2.1% in July of 2005, was negative. In contrast, when China allowed the value of the yuan to appreciate more slowly between September 2005 and May 2007, the marginal effect on other Asian currencies was positive. These results make sense because the relatively large July 2005 appreciation would cause currency speculators to sell other Asian currencies and buy the Chinese yuan in anticipation of future appreciations. In contrast, the September 2005 through May 2007 slower appreciation of the yuan would tend to discourage currency speculators, ceteris paribus.
This paper’s finding of a change in the sign of a slope estimate adds yet another example to the literature that shows that BD-RTPLS can capture intuitively reasonable, but dramatic results. For example, Leightner and Inoue [13] show that the fiscal policy multipliers for decreases in government spending were greater than the multipliers for increases in government spending in Japan during deflation. This result makes sense in the context of overwhelming negative expectations due to the doldrums of deflation. Leightner and Inoue [12] show that pollution abatement multipliers for an electricity generating company in Thailand, which burns high sulfur content coal, were four times greater in winter months than they are in summer months. Although this result is dramatic, it fits the company’s experience – between 1991 and 1994, this company cut electricity generation by approximately 26% during the winter, yet sulfur dioxide concentrations increased 2.5 fold in the winter (relative to the summer). The reason is that temperature inversions trap the pollution in the local area in winter; while heat rising during the summer spreads the pollution over a wide area.

BD-RTPLS holds great promise. It is worthy of additional research.
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Table 1:
(percentage change in exchange rate)/(percentage change in yuan/dollar)
Monthly data: June 2005 – April 2007

| A | B | H | I | I | J | M | N | N | N | P | P | S | S | S | S | T | T | T | M |
| U | A | O | N | N | A | A | E | E | A | H | I | R | A | H | E |
| S | N | N | D | D | P | L | P | W | W | K | I | N | K | I | A | A |
| T | G | I | O | A | A | I | L | G | O | W | I | N |
| R | L | A | N | N | Y | L | G | Z | S | L | A | R | L | A |
| A | K | E | S | U | E | T | I | P | E | A | N | A |
| L | D | O | S | I | I | A | A | P | O | A | N |
| I | E | N | I | A | N | N | P | R | K | D |
| A | S | G | A | E | A | I | E | A |
| H | A | N | N | D | E | S |

5.06  3.8  3.4  3.9  3.5  2.4  1.8  3.8  5.5  4.9  2.3  3.5  2.2  2.5  2.7  3.6  3.5  1.1  3.2
5.07  -0.1  1.6  1.8  2.0  -0.1  -1.1  2.1  2.0  2.9  -2.4  1.9  0.4  1.2  -0.5  1.5  0.2  -0.0  0.8
5.08  -0.3  -3.4  -1.4  -1.7  -3.1  -0.3  -0.7  -1.7  -1.4  0.9  -1.5  -1.4  -0.3  -0.1  -1.9  -2.1  -0.2  -1.2
5.09  3.8  2.6  3.5  2.7  0.8  2.9  3.1  4.4  3.8  3.1  2.9  2.2  2.9  2.2  2.6  2.8  0.8  3.6  2.9
5.10  2.2  3.5  3.7  1.7  4.9  0.4  3.5  4.1  2.9  3.5  3.7  4.6  3.1  2.2  3.5  2.0  4.0  3.1
5.11  1.1  3.4  3.5  1.6  4.1  0.4  3.4  1.6  5.2  2.3  3.4  5.5  3.1  3.9  3.2  3.2  3.0  3.1
5.12  4.2  3.3  3.4  3.6  5.1  3.5  3.4  1.0  4.1  3.9  3.3  5.2  4.8  5.2  3.2  4.3  3.5  3.8
6.01  4.4  3.2  3.3  6.1  7.1  5.6  4.0  5.4  3.6  2.5  3.3  5.1  5.7  7.0  3.3  6.9  6.8  4.9
6.02  2.1  2.3  3.1  3.2  5.3  1.2  3.8  3.5  3.3  1.0  3.1  4.6  3.4  4.5  3.0  2.4  3.8  3.2
6.03  1.4  1.9  3.5  3.2  4.6  3.9  4.1  3.0  3.7  -2.6  3.3  4.6  3.9  2.9  3.0  3.1  4.4  3.1
6.04  3.8  3.7  2.5  1.4  4.8  2.6  3.6  1.6  3.6  0.6  2.7  2.3  3.7  4.7  2.5  3.0  5.0  3.1
6.05  7.1  4.6  3.7  2.8  3.1  8.1  5.1  3.0  3.7  5.1  3.6  2.4  5.2  4.9  3.5  5.3  3.7  4.4
6.06  0.2  3.1  3.2  1.9  -0.5  0.9  1.9  2.2  3.1  1.4  3.3  1.3  2.4  2.0  2.7  1.2  2.4  1.9
6.07  6.1  1.9  3.0  2.1  4.9  2.2  3.0  1.4  3.9  3.0  2.8  4.8  3.6  3.5  2.7  2.6  3.8  1.9
6.08  2.7  2.6  2.7  2.6  3.7  2.7  3.4  2.5  3.7  5.0  2.9  4.4  3.2  3.4  3.2  2.7  3.2  3.0
6.09  1.3  4.9  2.0  2.9  1.6  1.0  1.7  2.9  2.0  5.3  1.7  4.0  1.9  2.4  3.3  1.7  2.6  2.5
6.10  1.9  3.8  2.3  3.8  1.8  1.0  2.1  3.3  2.8  3.3  2.3  3.0  2.3  2.5  -0.9  1.5  2.6  2.3
6.11  4.5  -1.7  2.2  3.4  2.8  3.2  3.0  4.7  0.9  3.3  1.8  2.5  3.5  4.0  0.1  3.1  4.1  2.7
6.12  3.7  1.4  2.0  2.3  2.2  2.0  4.4  3.3  3.0  5.4  1.6  2.7  2.9  2.9  2.4  3.0  4.3  2.9
7.01  2.1  2.2  2.1  3.1  2.8  -0.1  3.6  1.6  3.0  2.8  2.6  3.4  2.6  1.3  1.3  1.7  3.5  2.3
7.02  1.9  3.0  1.9  2.5  2.1  1.7  2.5  2.4  1.5  1.7  2.4  3.4  2.4  2.3  2.2  1.4  6.2  2.5
7.03  4.3  3.1  3.1  3.4  2.0  5.8  3.3  2.8  2.7  3.9  3.0  2.8  3.7  2.4  2.4  3.0  6.6  3.4
7.04  7.2  3.2  3.2  7.0  4.0  2.0  4.7  6.5  3.1  7.8  3.2  4.5  3.8  4.0  3.4  2.8  4.2  4.4
mean  3.0  2.5  2.7  2.8  2.9  2.2  3.2  2.9  3.1  2.8  2.6  3.3  3.1  3.1  2.4  2.5  3.6  2.9
Table 2:

(percentage change in exchange rate)/(percentage change in yuan/dollar)

Weekly data: July 11, 2005 – December 31, 2005*

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5.28  4.2  3.2  3.1  3.2  3.6  3.1  3.1  2.9  4.1  3.2  3.2  3.3  3.7  4.3  2.8  3.1  2.5  3.3  5.29  1.9  0.9  0.3  0.7  0.2  0.6  0.6  -0.2  2.5  1.1  0.3  0.9  0.9  1.8  1.2  1.2  0.7  1.1  0.9  5.30  -3.6  -4.8  -3.9  -3.9  -4.4  -4.3  -2.3  -4.4  -5.0  -3.3  -3.9  -4.6  -3.0  -2.5  -4.4  -3.9  -3.6  -3.9  5.31  4.2  1.3  2.8  2.7  3.8  3.2  2.9  3.4  2.2  4.0  2.7  2.9  3.5  3.5  3.0  2.6  3.7  3.1  5.32  3.4  1.9  3.1  2.8  2.7  4.4  3.1  2.9  2.4  5.3  3.0  3.6  3.4  3.7  2.9  2.9  4.1  3.3  5.33  1.5  2.6  3.0  2.9  1.0  4.0  2.4  2.9  5.1  3.3  3.0  2.7  1.9  2.3  2.6  2.2  2.4  2.7  5.34  2.1  3.1  3.1  2.8  -1.2  2.9  2.8  3.2  3.3  2.3  3.0  2.8  2.4  1.9  3.2  2.3  3.4  2.5  5.35  3.2  2.5  2.8  1.9  0.7  2.5  2.9  2.7  2.0  3.3  2.8  2.6  2.2  2.4  2.4  1.3  2.7  2.4  5.36  5.1  2.2  2.8  3.0  3.1  3.4  2.6  2.3  4.3  4.4  2.6  2.6  3.0  3.4  2.4  2.3  3.2  3.1  5.37  3.0  3.0  3.2  3.0  6.2  2.1  3.0  3.1  5.5  2.6  3.0  3.2  2.7  3.2  3.1  2.2  3.2  3.3  5.38  1.9  3.7  3.0  2.8  1.3  1.2  2.8  3.0  -0.8  1.0  2.7  2.4  2.6  2.4  2.9  1.6  2.5  2.2  5.39  2.1  2.4  3.1  2.8  2.1  1.5  3.2  3.1  2.1  1.3  3.4  3.4  2.5  2.1  3.2  2.5  2.9  2.6  5.40  3.3  3.2  3.2  2.4  5.3  4.4  3.2  3.2  4.6  3.2  3.8  3.3  3.3  2.1  3.1  3.2  3.7  3.3  5.41  1.8  2.9  3.0  1.1  3.7  2.5  3.0  4.4  4.0  3.1  2.9  3.2  3.1  3.3  2.9  2.5  3.4  3.0  5.42  2.4  3.1  3.1  2.2  3.1  1.7  3.0  4.2  -1.9  3.7  3.1  3.5  2.7  1.4  3.0  2.0  3.1  2.5  5.43  3.5  3.0  3.1  3.0  3.8  2.7  2.9  0.6  8.8  4.2  3.1  4.4  3.1  3.3  2.8  2.7  3.3  3.4  5.44  0.9  3.1  3.1  2.5  2.7  1.4  3.1  3.1  2.2  0.9  3.1  4.0  2.7  3.7  3.0  3.2  2.9  2.7  5.45  1.8  3.5  3.5  2.1  4.0  2.3  4.2  3.8  4.7  1.5  3.4  4.0  3.0  3.1  3.4  3.5  2.6  3.1  5.46  2.6  2.7  2.7  2.7  2.9  1.5  3.0  -0.7  4.1  3.1  2.8  3.0  2.6  2.7  5.6  2.7  3.2  2.5  2.8  5.47  4.0  3.0  3.2  2.9  2.7  2.8  3.1  2.0  2.7  4.6  3.2  3.6  3.8  3.0  3.1  3.0  3.2  5.48  3.4  3.2  3.0  2.3  3.2  2.2  2.9  2.8  3.4  4.8  3.0  3.7  3.3  3.2  3.0  3.1  2.9  3.1  5.49  5.1  3.3  3.0  2.3  5.4  1.7  3.0  1.0  3.0  4.9  2.9  4.0  3.5  3.6  3.8  3.2  2.7  3.3  5.50  3.3  2.6  2.8  4.4  4.4  4.9  2.8  2.5  2.9  1.4  2.7  3.7  3.7  4.6  3.0  3.5  3.6  3.4  5.51  0.4  2.9  3.1  4.8  1.7  6.4  3.1  4.9  3.6  -1.0  3.1  3.2  4.0  3.8  2.1  3.6  3.8  3.1  5.52  1.4  2.0  3.1  3.2  3.5  2.4  2.9  3.4  2.6  1.6  3.2  3.7  3.2  3.6  3.0  3.8  3.1  2.9  

* The weekly results for January 2, 2006 – June 9, 2007 are available from the author upon request. These results are plotted in Figures 4a and 4b.
Omitted variables, the Chinese yuan and other Asian currencies

Figure 1: The Intuition behind BD-RTPLS
Data points are identified by the value of $q$
Figure 2: Percentage Change in Exchange Rates Over Time
Weekly Data: July 11, 2005 - June 8, 2007
Omitted variables, the Chinese yuan and other Asian currencies

Figure 3: (% Change in exchange rate)/(% change in yuan/dollar) monthly data: June 2005 - April 2007
Figure 4a: (% Change in exchange rate)/(% change in yuan/dollar)

weekly data: July 11, 2005 - June 24, 2006
Figure 4b: (% Change in exchange rate)/(% change in yuan/dollar)
weekly data: June 26, 2006 - June 8, 2007

| Year/Week | Australia | Bangladesh | Hong Kong | India | Indonesia | Japan | Malaysia | Nepal | N Guinea | N Zealand | Pakistan | Philippine | Singapore | S Korea | Sri Lanka | Taiwan | Thailand |
|-----------|-----------|------------|----------|-------|-----------|-------|----------|-------|----------|-----------|----------|------------|----------|---------|-----------|--------|----------|--------|----------|
Acknowledgments

I would like to thank the East Asian Development Network for partially funding the project and Yonok Research Institute for helping with the project that led to the development of BD-RTPLS. I appreciate the comments and suggestions of Knox Lovell, Ron Smith, Lawrence Marsh, and Colin McKenzie on precursors of BD-RTPLS. I greatly appreciate my research assistant, Eduardo Passaglia finding the data and helping with the processing of it.

References


Omitted variables, the Chinese yuan and other Asian currencies


Endnotes

1 DEA techniques are based upon Shephard [20], Debreu [6], Farrell [7], Charnes, Cooper, and Rhodes [5], and Banker, Charnes, and Cooper [2].

2 PLS is similar to 2SLS (two stage least squares). The major difference is that in the first stage, PLS uses a DEA frontier to eliminate the influence of unfavorable omitted variables, while 2SLS uses a regression of the endogenous variables on all exogenous variables to eliminate simultaneous equation bias. Both PLS and 2SLS eliminate the part of the error which can be attributed to the “problem” – “simultaneous equation bias” for 2SLS and “omitted variables” for PLS.

3 Leightner [8] stops when the next iteration would use fewer than 10 observations. Leightner readily admits that he does not know if this is the “optimal” point at which to stop or not. He also admits that he does not know if truncating off the first “3%” of the lower left hand projected observations is optimal or not. Extensive simulation tests need to be conducted to determine the optimal decision rules for RTPLS and BD-RTPLS. However, Leightner [8] did check to see how different truncation rules affected the RTPLS results. He found that using different truncation rules did not affect the basic shape of the line drawn between RTPLS estimates and time; however, different truncation rules did affect the amplitude and average height of that line. In this paper, we use the rules recommended in the existing literature.

4 In traditional regression analysis, error comes from three sources: omitted variables, imprecise measurement, and rounding off. It is important to realize that the “e” in equations 2 through 8 is due solely to imprecise measurement and rounding off – it does not include the influence of omitted variables. Omitted variables enter these equations through “q.” Since “e” is due solely to imprecise measurement and rounding off, it is extremely reasonable to assume that it is random and unrelated to X1. The fact that e1/X1i is at the end of equation 5 might lead someone to believe that White heteroskedasticity-consistent standard errors should be used instead of the basic OLS standard errors when estimating. However, this is not the case: when 1/X1 is used as a regressor in equation 8, it will pick up any correlation between e/X1 and 1/X1 and the remaining error (e2) will not be correlated with X1. Remember that any correlation between e/X1 and 1/X1 is due solely to multiplying a non-correlated e by 1/X1. It also should be noted that any correlation between e1/X1i and 1/X1 should be relatively small because a random variable divided by X1 is still a random variable.

5 If a negative relationship is found, Leightner and Inoue [14] recommend multiplying the included independent variable by negative one, and then adding a sufficiently large constant so that all resulting numbers are positive. Adding the same constant to every observation does not change the slope estimate. Multiplying an independent variable that is negatively correlated to the dependent variable by negative one, makes it possible to estimate a positive relationship.

6 The yuan is undervalued by “as much as 40 per cent” [18].

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