TRADE IMPACTS OF THE CHINESE CURRENCY REVALUATION

by

Jenny Lin

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I. Introduction

The People's Republic of China (PRC) removed its currency peg to the dollar in June 2005, after over a decade of the pegged exchange rate policy. This followed significant political pressure from the U.S., international trade organizations and other world countries for China to revalue, particularly in light of its unprecedented trade surplus with the U.S. and competitiveness vis-à-vis many nations. The U.S. was on the verge of imposing import restrictions and other barriers when China made the decision to abandon its currency peg and move to a "managed float" system by which the currency is pegged to a basket of currencies presumed to include the dollar, the euro, the Japanese yen and the Korean won. China appreciated its currency, the yuan or Renminbi (RMB), first by about 2% and by small increments since then, currently achieving a roughly 6.5% appreciation since the peg removal.

Despite this, the U.S. trade deficit with China continues to grow and has achieved unprecedented levels. As of November 2006, the U.S. trade deficit with China stood at a record $213.55 billion, a large portion of which is accounted for by the goods deficit which stands at $157.5 billion. The largest volume of imports from China into the U.S. is manufactured goods, especially the sub-category of electrical components and accessories. Chinese manufactured goods have become competitively dominant in the world marketplace and the manufacturing industry, particularly in the U.S., have led the push for China to revalue, arguing that the competitive advantage China enjoys is largely due to its exchange rate policy.

In this paper, I explore the effects that the RMB exchange rate policy has had since the revaluation on improving the U.S. trade deficit with China. Specifically, I will look at whether significant changes have occurred in: (i) the Chinese import price index for the U.S. and (ii) Chinese input factor prices, specifically for crude oil. In doing so, I hope to examine whether the impacts of the yuan revaluation are leading to the effects the U.S. and other nations had desired in pressing China to revalue and whether China has gained in terms of factor prices following the appreciation. As the timeframe thus far has been relatively short, I will look for effects if only in the desired direction and not any significant magnitude.

In looking at the U.S. import price index for Chinese goods, I want to see the extent by which the yuan appreciation has, if at all, increased the price of Chinese imports into the U.S. A main argument of the U.S. in encouraging China to revalue its currency was that the peg generated an unfair competitive advantage for Chinese products, making them far cheaper than they otherwise would be. In order to gauge whether the exchange rate policy was really a significant driver of low Chinese import prices, I will look at the impact thus far of the currency appreciation and examine whether imports have become relatively more expensive after the policy was implemented, as the U.S. had hoped. Also, I hope to determine whether a Chinese import price trend exists and, if so, how this may be influencing the effect of the appreciation of the RMB on import prices. Finally, I address possible reasons for the observed results.

The results show interesting effects. When the effect of the exchange rate movements on the Chinese import price index is analyzed, the data implies that as the yuan appreciates, Chinese goods have actually become cheaper in the U.S. market. However, a highly significant time trend seems to exist whereby Chinese import prices are generally decreasing over time. Accounting for this trend, import prices do appear to be increasing following the RMB's appreciation, relative to what would have been, though this result is only marginally statistically significant. These results could be due to many reasons. Mostly, this points to the fact that the effect of a downward price trend of Chinese goods over time is greatly overshadowing any price increases achieved by a more favorable exchange rate.

The cause of this may well be the high productivity growth rate China has been experiencing. Productivity is growing and technology is improving so rapidly that the cost of goods, and thereby the price of goods, is falling drastically. With an average annual productivity growth rate of 9% in recent years, a slight increase in the value of the yuan is unlikely to make a large impact in reversing the downward price trend. Production capability and technological advancement are simply growing too fast for the marginally appreciated yuan to balance the effect. This may mean that only after a significant amount of time as well as after a much greater level of yuan appreciation is achieved, can we reasonably expect to see any noticeable effect on Chinese import prices in the U.S. and, by extension, the U.S.-China trade deficit. If this productivity growth is sustainable, it may also mean that the gradual appreciation of the yuan may never catch up and help to level off import prices as the U.S. hopes it will.

By examining the effect of the exchange rate movements on Chinese crude oil prices, I hope to see whether input factor prices are decreasing in China, given the appreciating currency. I specifically focus on crude oil because of the intensive usage of it in many manufactured goods in China and also because it is traded on the world markets in terms of dollars, so that the exchange rate fluctuations vis-à-vis the U.S. may have a more noticeable effect on crude oil prices. Given that factor prices would be expected to decrease in conjunction with an appreciating yuan, I want to see if input factor prices in China have decreased by a significant enough amount so as to render Chinese goods even cheaper and counteract any export price effects that could potentially increase prices of Chinese goods entering into the U.S. In addition, I want to see if there exists any general crude oil price trend and, if so, how this trend is impacting the effect of the revaluation on Chinese oil prices. Finally, I examine potential causes of these results.

When the effect of the exchange rate on Chinese crude oil spot prices is analyzed, the results indicate that as the RMB has been appreciating, crude oil prices have actually gone up. No significant trend appeared to exist for crude oil prices in China. The analysis is likely to be highly affected by omitted variable bias. Including the additional variables of OPEC crude oil production and world crude oil production in addition to the exchange rate, which likely contribute to Chinese crude oil price movements, we obtain: (i) a significant negative coefficient of the exchange rate which indicates still that as the yuan appreciates crude prices appear to be increasing, (ii) an insignificant positive coefficient on OPEC crude oil production and (iii) an insignificant negative coefficient on world crude oil production. In addition to this, including the additional variable of time has the effect of reversing the sign of the coefficient of the exchange rate, making it positive and thus indicative of lowering oil prices as the yuan appreciates, though this result is insignificant. Also, with the inclusion of time as a regressor, we obtain the following: (i) a highly significant positive coefficient of OPEC crude production, strangely indicating that as OPEC production increases so does the price of Chinese crude oil, (ii) a highly significant negative coefficient of world crude production, indicating that greater world production decreases oil prices in

China and (iii) a highly significant positive coefficient for time, indicating that crude oil prices are generally increasing over time.

The results for this part of the analysis remain inconclusive and are still likely affected by omitted variable bias. Though no heteroskedasticity of Chinese crude spot prices was found, the prices remain highly volatile. Looking at a longer period of Chinese crude prices, from 2004-2007, the data appears to reveal a more significant positive trend term, indicating that prices may in fact be generally increasing over time though the trend is difficult to detect at shorter intervals. In general, world oil prices have been increasing over the past few years and short-term oil shocks are likely leading to recent price increases in China. In addition, oil demand has been growing rapidly along with Chinese productivity and development and has peaked in recent years. China's demand for crude oil may be expanding and shifting at such a rapid pace as to drive prices up much faster than an appreciating yuan can help to bring them down. With such a short time interval and many external factors, it is difficult to determine the precise effect the exchange rate is having and will likely have on oil prices in China. If anything, the results point to the fact that exchange rate movements are currently not a significant determinant of Chinese crude prices, though this does not say anything about the future relationship.

The effects of the Chinese peg removal are slight as of yet and it is difficult to attribute any significant impacts to it. So far, it seems that a noticeable relationship can be detected between the appreciating yuan and minutely increasing Chinese import prices. This would seem to support the U.S. rationale for encouraging China to revalue and the desired effect appears to be materializing, though the rate continues to be sluggish. As for any effect of the exchange rate on lowering input factor prices in China, results are still difficult to determine likely due to idiosyncratic effects in recent years of crude price movements worldwide.

II. Chinese currency peg history and current debate

Background and History on the Chinese Peg

Since 1995, the People's Republic of China had pegged its currency, the yuan, to the U.S. dollar. This followed a period of yuan devaluations, notably in 1994 when the yuan lost a third of its value vis-à-vis the dollar, depreciating from about $0.1728 to $0.1152. In large part due to China's dollar peg, other East Asian nations established their own quasi-pegs, buying large reserves of dollars to keep their exports competitive with those of China. Some Asian countries, most notably Japan, had also implemented a dollar peg, though it had dumped it by 1985, well before China's peg. Unlike its neighbors however, China opted for a relatively hard peg, maintained at about 8.28 against the dollar. Though few would argue that China does maintain a fixed-exchange rate with respect to the dollar, many have questioned whether other East Asian nations even did have a dollar peg per se[1]. Nevertheless, the reasons for the Asian dollar pegs were all quite similar: the dollar was stable and Asia wanted monetary stability.

After years of maintaining its peg to the dollar, however, China finally seemingly succumbed to growing political pressure in May 2005 and agreed to gradually remove the peg, beginning with a 2% revaluation. The pressure mostly came from the United States, which continues to come just short of directly branding China a currency manipulator. The U.S. claims that China enjoys an unfair advantage in the world market by keeping the value of its currency at an artificially low level, accomplished by its strict 8.28 exchange rate vis-à-vis the dollar, which has been in place since 1995. Most believe the real value of the Chinese yuan should be higher, some say much higher, than its pegged value and this

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[1] Esaka, T. 2003.

undervaluation has been a huge contributor to the growing U.S. trade deficit. China currently runs the largest trade surplus of any nation with respect to the U.S.

As of November 2006, the U.S. trade deficit with China stood at a record $213.55 billion. The goods trade deficit with China accounted for 25% of the $157.5 billion U.S. total trade deficit in 2004[2], and this proportion continues to grow over time. The deficit has risen dramatically every year since approximately 1988, with the exception of the year 2001 in which it essentially stayed stable. Complaints from U.S. industrial manufacturing firms have greatly pushed the U.S. government to put increasingly more pressure on the Chinese to remove the peg. Manufactured goods are currently the top Chinese import into the U.S. and have displaced a significant amount of domestic manufactured goods as well as labor in industries such as textiles and furniture. Industries have been undercut in price by Chinese imports by as much as 50% and are citing the low currency value as the reason. Firms have at times shut down operations, often harshly criticizing what they believe is China's unfairly begotten competitive edge.

Since 2003, the U.S. Treasury Department has taken a more aggressive role in trying to convince China to adopt a more flexible exchange rate policy. Increasingly direct demands ensued, originating from then U.S. Treasury Secretary John Snow, officials of the International Monetary Fund, as well as Asian countries such as Japan, which want to are seeking to stay competitive with China. In July 2005, the Chinese yuan was finally revaluated by 2.1%. A year later, the yuan had only appreciated by about 1% against the dollar. It is now pegged against a basket of currencies, which remains undisclosed, but is speculated to contain the dollar, the euro, the Japanese yen and the Korean won. The

[2] Cleveland Federal Reserve, 2005. *The Chinese Renminbi*.

central bank maintains a "managed float" exchange regime, allowing the yuan to fluctuate within a tight 0.3% daily band against the dollar. However, it appears that the rate of growth of the yuan is increasing. In addition, the trade-weighted rate of the yuan rose by around 10% by the end of 2005. Estimates of the degree to which the yuan is revalued differ dramatically. The IMF, perhaps surprisingly, does not believe the yuan to be significantly undervalued, while other estimates believe the yuan to be undervalued by as much as 40%. Many investment banks have estimated the yuan's worth at 10-15% higher than its pegged value, which would mean that the yuan has already made a significant move towards being fairly valued as it has currently risen about 4.15% vis-à-vis the dollar since 2005. Many economists believe only until the yuan has appreciated by 20-30% will we see any noticeable effect on the trade imbalance.[3]

A political aspect of this debate has been industry lobbying, especially in 2003 leading up to the presidential election. The National Association of Manufacturers added considerable pressure preceding the election, which ostensibly made a difference in the sudden direct political pressure on China in late 2003 to revaluate. In the past decade, China's steel production has more than doubled, greatly surpassing the steel share of the U.S. and Japan, even overtaking Europe as a whole. U.S. textile and apparel trade groups have cited figures of China capturing 75% of the U.S. market, also encouraging revaluation. Political pressure also led the U.S. Commerce Department to engage in meetings with manufacturers and put strong pressure on China to remove its peg. Rising unemployment in the manufacturing sector is also frequently attributed to Chinese and other East Asian imports. However, the pressure on China was tempered by the need to maintain friendly

[3] *Wall Street Journal* survey of economists, May 2005

terms with China for a large number of other political issues (e.g. terrorist threats) on which we need its allegiance.

The U.S. has been unsatisfied with the rate at which the peg removal is going. Legislation has been proposed, such as the Schumer-Graham bill, which threatens to impose a 27.5% tariff on Chinese imports. Other milder bills have been proposed, but the common goal is undeniable: to strip China of its perceived unfair terms of trade advantage. Yet not only is the extent of this "unfair trade advantage" under serious debate, whether or not this currency peg is really helping, hurting, or not much affecting the U.S. economy is questionable. A large hope of encouraging China to remove its peg lies in the likely possibility that a yuan peg removal would create a domino effect, leading to other East Asian nations to relax their quasi-pegs as well and hold fewer dollars on reserve. Already, China's decision has contributed to influencing the Malaysian government to relax its peg to the dollar, announcing the ringgit revaluation and managed float regime on the same day as China announced the yuan revaluation.

The debate over the pros and cons of revaluation

However, many warn that encouraging China to remove its peg too rapidly could cause global financial catastrophe. As the Euro and even the Japanese yen become increasingly popular reserve currencies and as exchange traders are increasingly favoring those currencies over the dollar, China's large investments in U.S. currency are becoming ever more important. The Chinese government, by actively investing in dollars on international currency markets and buying U.S. treasury bonds, currently finances a significant portion of the federal budget deficit. China remains the second largest holder of

U.S. treasury debt in the world, holding roughly $243.5 billion in U.S. securities as of May 2005.[4] If China holds fewer U.S. government bonds because it simply would not need to hold as much in order to maintain its currency value, prices may fall and yields would increase. Without any fixed-rate system, China may pull its money from the dollar, which may lead to much larger financial problems. Some anti-revaluation proponents have warned that a Chinese revaluation would significantly hurt U.S. economic growth.[5] Others go further, believing that "U.S. interest rates will rise; the housing bubble will probably burst; construction employment and consumer spending will both fall; falling home prices may lead to a wave of bankruptcies… the negative effects of a change in Chinese currency policy will probably be immediate, while the positive effects may take years to materialize."[6]

In addition, some say China's revaluation will not have a significant impact on the U.S. trade deficit. This is because imports from China are comprised of many component parts and materials from other Asian countries. The value added in China of these imports varies, but is estimated at about 20-30% of the imported good. In fact, even as China enjoys a trade surplus with the U.S., it runs a trade deficit with the rest of Asia, because many of the goods that once traveled directly from Asian nations to the U.S. are now passed through China. In other words, Chinese imports into the U.S. are not always actually "Chinese" imports. This could mean that an increase in the value of the yuan itself may not impact the U.S. trade deficit as much as officials hope for. Many analysts believe that the contribution

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[4] Source: U.S. Treasury Department
[5] Kudlow, L. *The China Mess*. April, 2005.
[6] Krugman, P. *The Chinese Connection*. New York Times, 2005.

of the yuan fixed-exchange rate to both China and the U.S.'s trade balances are overstated.[7] In addition, many have pointed out that while appreciation of the yuan may decrease China's terms of trade advantage by making its exports more expensive, it also helps to make its imports and factor inputs cheaper. These cost savings may translate into again cheaper exports, which is exactly what the U.S. and other countries are trying to eliminate. Also, with more expensive Chinese goods, insatiable U.S. consumers may simply shift demand to other cheap importing nations instead. Most agree that only if China's peg removal succeeds in encouraging other East Asian economies to lower their dollar reserves and loosen their pegs, will the yuan's revaluation lead to any significant U.S. trade impact.

Many cite that a continuation of the peg is counterproductive in the long run for China. In 1994, China suffered a drastic rise in inflation. The amount of dollars China's central bank must hold on reserve in order to maintain the peg holds the risk of generating inflation, which will not benefit Chinese trade competitiveness in the long run. Furthermore, China's low value with respect to the dollar makes its imports, especially those traded in terms of the dollar on international markets such as oil, very expensive. Allowing the yuan to rise will help to generate more foreign investment in the yuan, as well as make imports into China, including factor inputs such as crude oil, cheaper.

Some have also blamed the dollar peg for the Asian financial crisis of 1997, citing that the dollar peg minimized exchange rate risk for currency investors and an overabundance of capital inflows helped result in the crisis[8]. Throughout 2006, the Chinese economy was overheating, with annualized export rates of over 30%, an overwhelming trade surplus and a large investment boom. By the second quarter, GDP growth topped

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[7] Cleveland Federal Reserve, 2005. *The Chinese Renminbi*.
[8] Radelet and Sachs, 1998.

11.3% and the Chinese government became increasingly worried about the unsustainable economic growth. The government decided to increase interest rates and impose controls on credit, but the small increases and restrictions did little to rein in the overheating economy. In April 2007, China raised bank reserve requirements by an addition .5%, to 10.5%, in another effort to curb liquidity and investment booms.

In general, it is difficult to predict what a removal of the peg will do and how this will affect the short term versus long term U.S. trade balance. If the Chinese yuan appreciation does have a significant impact on U.S. terms of trade, it would more likely be through the example the revaluation would set for other East Asian nations to consider revaluation. Alone, the Chinese RMB simply may not achieve the effect politicians and industry tradesmen hope for, that is, higher import prices. To adjust its large external imbalances, China must implement broader and more rapid reforms, including encouraging consumption more heavily and clamping down on over-investment.[9] More likely, a rapid removal of the peg could cause short term forex market distress. The type of drastic change politicians and lobbyists call for could lead to a worldwide dumping of dollar reserves that is in no way of benefit to the U.S. However, large banks including JP Morgan, have recently estimated that the yuan will appreciate by up to 17% in the next 12 months.[10]

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[9] Guy DeJonguieres, "Why China's exporters are striking it rich," Financial Times, March 8, 2007, p. 11.
[10] Estimates as of February 24, 2007

III. Chinese productivity growth

China's annual GDP growth rate over the past two decades has hovered around 10% (World Bank 2001).[11] Estimates of annual productivity growth in manufacturing are as high as 15-20%.[12] Not only is China making goods more efficiently and cheaper, it is also increasingly making more skill-intensive goods, moving up market. The country is increasingly exporting goods such as aircraft components and microchips, simultaneously appreciating its currency and even increasing wages. As of 2006, the U.S. had a $40 billion deficit in Advanced Technology Products (ATPs); trade with China accounted for this entire ATP trade deficit in 2006 and increased by $10 billion over the previous year. The U.S. has an ATP trade surplus with the rest of the world, amounting to $14 billion in 2006. The growth of China's labor-intensive sectors has been impressive, but overall its growth has been rather capital-intensive.[13] As of 1996, its capital-intensive goods made up about 34% of manufactured exports according to some estimates.[14] Capital intensity has grown at an average rate of 5.3% per year from 1993-2005, compared to 3.1% between 1978-1993 (NBS Statistical Yearbook 2005).

Many explanations have been introduced, seeking to reveal the primary factors driving China's productivity growth. Two popular papers by Alwyn Young (1995) and Paul Krugman (1994) claim that China is growing fast primarily because of rapid factor input growth. Others attribute productivity growth to information technology (IT) usage, claiming that IT usage in China accounted for 38% of TFP growth and 21% of GDP

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[11] A more recent estimate cites a roughly 9% average annual growth rate over the past two decades (Jefferson, et al., Brookings Institute, 2006)

[12] Guy DeJonguieres, "Why China's exporters are striking it rich," Financial Times, March 8, 2007, p. 11.

[13] Louis Kuijs, World Bank Policy Research Working Paper 3958, July 2006.

[14] Ross Garnaut, *Asia-Pacific Magazine* (1996). Research School of Pacific and Asian Studies, Australian National University, Canberra.

growth.[15] Many believe that Chinese factories and industry have simply become more efficient, likely due to implementation of new technology, and that this is driving productivity growth. Similarly, Ao and Fulginiti (2002) have estimated the contribution of technical change to Chinese GDP growth to be around 21.7%.

Jefferson, et al. (2006) attribute the productivity growth of poorer economies to rapid labor productivity growth, but most importantly to total factor productivity (TFP). Others have also found that TFP growth has led to significant GDP growth in China since the reform period of the late 1970s.[16] TFP growth is estimated at 2-4% per year during the reform period and, in 2004, a McKinsey & Co. study found that TFP in China was just 8% below that of the U.S. Many studies have placed TFP growth in China at around 1.1-1.4% in the two decades leading up to 2000.[17] In addition, TFP growth contributes to labor productivity, which during 1993-2005 rose by about 8.4% per year on average. Some believe the primary sources of Chinese TFP growth are the creation of scale economies and resource allocation.[18] Holz (2006) found that TFP growth in China was highest in the following sectors (ranked in order from highest): 1. industry, 2. agriculture and 3. construction. Interestingly, Jefferson et al. (2006) found that the labor productivity gap between the Chinese industry (including construction) and agricultural sectors to be both large – seven times higher for industry – and growing.

However, China's high productivity and technological growth is hardly evenly distributed throughout its vast geographic area. The industrial coastal region continues to far out-pace the internal regions in terms of productivity and development. Indeed China's

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[15] Information Technology & Innovation Foundation (March 2007)

[16] Heytens and Zebregs (2003) and Wang and Yao (2002)

[17] Ao and Fulginiti, *Productivity Growth in China* (2002)

[18] Jefferson, et al., *The Sources and Sustainability of China's Economic Growth*. Brookings Institute (2006)

growth can be characterized by the productivity gap between its coastal region and the "international technology frontier", as well as the gap between its coastal industry sectors and other sectors and regions. The rapid technological development of the coastal regions within the past decade was spurred by several factors, most likely including: China's entrance into the WTO in 2001, substantial foreign direct investment (FDI) flows into the country and the upsurge in research & development (R&D) expenditure over the past several years. Evidence points to the fact that the productivity gap between China's industrial coast and other international leaders has shrunk. A recent study of 2002 data found that China's coastal industry, on average, exhibited one quarter of the labor productivity of that of the world leader in the industry (either the U.S. or Japan), up from a ratio of one ninth just seven years earlier.[19] Data also suggests that the productivity gap between its coastal and internal regions has decreased between 1995 to 2004, with the Northeastern region even seemingly surpassing the coastal region.

It is difficult to characterize what precisely has been driving China's unprecedented productivity growth over the past two decades. Because of this, it is difficult to predict how long, if at all, the growth can be sustained, as well as whether or not its effect will still be present in the long run. However, this high level of growth is likely driving the general downwards price trend of Chinese imported goods. As coastal regions catch up to the world's production leaders and as other regions catch up to the coast, Chinese goods are becoming both cheaper and more efficient to produce. If the change is a permanent increase in the growth rate of productivity, then we can expect to see this downward import price trend to continue, and also possibly continue eclipsing the effect of an appreciating yuan. If

[19] Based on averages in 27 industries. Jefferson, et al., Brookings Institute (2006)

the change is a non-permanent increase in the level of productivity, the strong yuan may be able to smooth out any trade imbalances faster than can otherwise be achieved. In particular, if Young and Krugman are correct and factor input growth is driving Chinese growth, then the seriously stretched Chinese oil situation may put a near and abrupt end to the sky-high growth, which may in turn allow the appreciating yuan to noticeably correct some of the trade imbalances.

IV. Chinese oil background

In 2005, China became the third-largest net importer of oil in the world, trailing behind the United States and Japan at a net of around 3.1 million barrels per day[20], and the sixth-largest producer of crude oil at 3.8 million barrels per day, trailing Saudi Arabia, Russia, U.S., Iran and Mexico[21]. It also became the second-largest crude oil consumer in the world at about 6.9 million barrels a day, second only to the U.S. In 2005, China imported 127 million tons of crude oil, a 3.3% increase over 2004, but a 31.5% growth rate decrease over that same period[22]. Previously, similar to the United States, the largest source of China's crude oil imports was Saudi Arabia, but in 2006 Angola surpassed Saudi Arabia as its primary crude oil supplier.

China was said to have accounted for over 40% of total world crude oil demand in 2004[23], and the main driver of record oil futures prices in 2004-2005. The U.S. Energy Information Administration (EIA), under the Department of Energy, believes that in 2006, Chinese oil demand growth accounted for 38% of total world oil demand growth.

The Chinese petroleum sector

In 1998, the Chinese government spun off its oil and gas assets into majority state-owned enterprises, the China National Petroleum Corporation (CNPC)/PetroChina, the China Petroleum and Chemical Corporation (Sinopec) and the China National Offshore Oil Corporation (CNOOC). CNPC and Sinopec control almost all of China's refineries and

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[20] Source: Energy Information Administration, Department of Energy. Note: China also trails behind Europe as a whole, which together imports a comparable annual amount to the U.S.
[21] Source: Energy Information Administration, *International Petroleum*. Note: CIA estimates differ, citing China as the 5th largest producer at 3.5 million barrels per day, trailing Saudi Arabia, Russia, U.S. and Iran
[22] Source: China Ministry of Commerce
[23] *China's Shrunken Thirst for Oil*. BusinessWeek , July, 19, 2005.

internal pipelines. Between 2000 and 2002, these state enterprises all made initial public offerings, though they continue to me majority government-owned. China hoped to transform these spin-offs into vertically integrated international oil companies[24], in the spirit of companies such as Chevron and Exxon Mobil, allowing foreign firms minority stakes in the ventures.

Chinese oil production

Around 85% of Chinese oil production is onshore, though these oil reserves are being stretched to the limit and China is now focusing expansion on offshore sources. The principle onshore production sites are located at the Daqing and Shengli oil fields[25], which together account for roughly 65% of Chinese on shore production and 53% of total production. Oil production has peaked at existing oil sites and China is attempting to increase its offshore production holdings. However, the Shengli field alone now produces more, at 535,531 barrels per day, than total offshore source production, at 519,208 barrels a day.

China continually attempts to increase its oil field explorations, especially abroad. Recently, CNOOC initiated several offshore exploration Production Sharing Contracts (PSC) with international oil firms including Kerr-McGee, Chevron and Royal Dutch Shell. The national oil companies will also explore more remote Western onshore areas, though CNOOC and other government oil enterprises are required by law to hold a 51% or more stake in commercial discoveries and have the right to take over most offshore discoveries.

[24] Source: Energy Information Administration, *China Energy Statistics*
[25] Source: Oil & Gas Journal

CNPC asserts that its Tarim basin in Northwestern China alone holds 43.9 billion barrels of untapped reserves.

Chinese oil demand

With average real output growth continually sustained at around 9%, sometimes reaching over 13%, China's industries have been growing at a frantic pace. Chinese oil consumption has been growing in tandem with output, averaging 6.79% year-on-year from 1986-2006.[26] Consumption growth was negative only during one year, 1990, though it has fluctuated significantly from year to year. 1993 marked the year in which China first became a net importer of oil, a position it has increasingly sustained thereon after. In 2004 consumption growth peaked, at 14.73% over the previous year, only to be cut in half by 2005 and even lower in 2006. However, the primary source of energy in China is coal, which accounts for 67-69% of the country's energy needs[27], while oil accounts for about 24%. Coal consumption has been rising rapidly since 2000, following a four year slump. In 2004, coal usage more than doubled its level in 1984 and was 46% greater than the level of 2002, reaching around 2.1 billion short tons a year.

In June 2006, the Chinese government gave an ¥8.48 billion, or $1.05 billion, subsidy to local governments for the rising fuel costs faced by its transport industries, including taxi, forestry, fishery, traffic and rural transport. In 2006, the country also raised gas, diesel and aviation oil prices twice during the year and adjusted transport fares to float with fuel prices. The government continues to control the price of domestic refined oil in order to maintain market stability. However, many have pointed out that high oil prices

[26] Calculated based on EIA China oil consumption statistics
[27] The Chinese Embassy in the U.S. estimates this figure at 67%, while the EIA estimates it at 69%

over the past few years have substantially hurt domestic refiners such as Sinopec, who are paying more for imported crude oil, on which it relies for the majority of its refinement, and receiving artificially lower prices in the refined oil market. In July 2005, the International Energy Agency (IEA) estimated that Chinese domestic market suppliers were losing $20 or more per barrel of gasoil. According to the General Administration of Customs, China paid 40.7% more, at $47.74 billion, for crude oil in 2005 than it did in 2004.

Many wonder at the true extent of the Chinese demand for oil and at the curious fluctuations that occur often counter to what rational market observers would expect. In 2004, as world crude oil prices grew at 35% over the previous year, Chinese oil demand also grew at 17%. Some say the large amount of excess demand generated by government fuel subsidies is exacerbating the problem as world oil prices are inflated, at considerable cost to both Chinese refineries and the government. The country's growing oil demand and consumption have been a singularly important fuel for its economic growth, which many predict cannot be sustained, particularly given pricing mechanism issues surrounding oil.

Shrinking demand?

However, in early to mid-2005, China's demand for oil shrunk considerably, the growth rate of oil demand falling to just 1.4% and dependence on oil imports dropping about 2.2% compared to 2004[28]. This sits in sharp contrast to real output growth, which still hovered at around 9.5% in that same period. In 2005, Chinese crude oil import growth accounted for only 10% of world oil import growth, significantly lower than its 30% share

[28] Source: National Development and Reform Commission

of world oil import growth in 2004[29]. Chinese government institutions assert that this trend is a direct result of the government's energy-saving initiatives begun on July 1, 2005, which called on massive public energy usage reductions. This followed several energy shortages beginning in 2004, highlighting the at-capacity usage of energy in China.

It is also likely that this lowered demand is largely due to Sinopec and PetroChina's substantial cost-cutting measures, necessitated by the very low margins received on oil due to Chinese government regulations that restrict prices to relatively low levels. With the peak in oil prices in 2004 and early 2005, the Chinese refiners faced especially thin margins that led to refineries being shut down for cost purposes, despite a shortage of supply. Non-government affiliated refiners and distributors are even exporting Chinese oil at a time when supply is not sufficient to meet demand. This is because they are not as restricted as Sinopec and PetroChina to selling within China under a relatively inflexible pricing scheme, and have begun to export refined oil in search of higher margins despite China's growing shortage of supply.

The seeming trend towards lower Chinese oil demand continued through 2006, during which time a greater proportion of energy was garnered from coal. The Purchasing Manager Index (PMI) Report on China Manufacturing[30] found in February 2007 that Chinese manufacturing output continues to grow and is fueling increased purchases of inputs overall across sectors. Notably, however, the sectors which had increased input purchases did not include the Oil Refining & Coking industry. The PMI also reports that the input prices index dropped in January 2007, mostly due to lower oil prices, falling to

---

[29] Source: China Ministry of Commerce

[30] Compiled by China Federation of Logistics & Purchasing (CFLP) and China Logistics Information Centre (CLIC), based on data collected by the National Bureau of Statistics (NBS)

about $55 per barrel in January from the previous $60 per barrel high. The Oil Refining & Coking industry, along with other oil-dependent industries, saw lower input prices during this time. This may suggest that Chinese crude oil prices have recently been driven to new heights due primarily to demand. It may also indicate that if oil demand in China begins to cool henceforward, input prices will continue to fall.

V. Regression Analysis & Results

There are several questions I want to address in my analysis of Chinese import prices. How has the appreciation of the yuan affected Chinese import prices in the U.S.? Does the effect conform to what the U.S. and other encouragers of revaluation had hoped for? Is there a time trend of Chinese import prices? If so, how has this impacted the effect of the appreciation of the RMB on import prices?

In looking at crude oil prices since the RMB revaluation, I wanted to focus on other questions. How has the appreciation of the yuan affected Chinese crude oil prices, a major input factor? What is the extent to which crude oil prices have changed after the revaluation? Does the effect on crude prices translate to potentially lower costs of production that may lead to even cheaper Chinese goods? Is there a crude oil price trend? If so, how does accounting for this affect the results?

Monthly Chinese import price index and exchange rate data was used, including only observations since the peg's removal from June 2005 to February 2007 (the most recent date for which all data was available).

The data set for the crude oil input factor analysis included monthly data during the period from June 2005, immediately after the Chinese government relaxed its currency peg to the dollar, to November 2006, the most recent period for which all relevant data exists. Another data set of the same variables, encompassing a much longer period from January 2000 to November 2006, was used for certain trend tests. This was mostly done in order to more accurately examine long-term trends and effects of non-exchange rate variables, which were not as limited in relevance to the specific time period after the revaluation.

Part I – Chinese import price and volume

The regression in **figure 1**, reproduced below, shows a highly significant positive coefficient of the exchange rate regressed against the U.S. import price index for Chinese imports. The coefficient of 3.9226 on the exchange rate indicates that for every 1 unit appreciation of the yuan, the Chinese import price index falls by 3.9226 units beneath the benchmarked December 2003 index value.

```
. reg  CNimportPrice  exchange

      Source |       SS       df       MS              Number of obs =      21
-------------+------------------------------           F(  1,    19) =   75.38
       Model |  5.35348008     1  5.35348008           Prob > F      =  0.0000
    Residual |  1.34937741    19  .071019864           R-squared     =  0.7987
-------------+------------------------------           Adj R-squared =  0.7881
       Total |  6.70285749    20  .335142875           Root MSE      =   .2665

------------------------------------------------------------------------------
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |   3.922624   .4518024     8.68   0.000     2.976991    4.868257
       _cons |   66.46285   3.618064    18.37   0.000     58.89015    74.03554
------------------------------------------------------------------------------
```

A Dickey-Fuller test of the China import price index variable shows a test statistic of about -0.751 and a MacKinnon approximate p-value of 0.8330, indicating a non-stationary series. This means that a trend term may potentially exist and must be tested for.

Figure 2 shows that the Chinese import price index data is not trend stationary. However, it also shows that there is a trend variable significant at the 5% level. The coefficient on the trend term is -.0455, indicating that for every additional month, the import price index tends to fall by -.0455 units.

Figure 3, reproduced below, shows an analysis of the detrended series, with time, in monthly increments, as a regressor. The coefficient on the exchange rate, factoring in the time trend of prices, has become negative, at -1.7, though the coefficient has become less significant, only at the 10% level. This indicates The coefficient on the time variable is highly significant and is negative, at -.1246. This indicates once again that as time progresses, import prices from China are generally trending downwards, at a rate of about -.1246 units per additional month.

```
. reg  CNimportPrice  exchange  time

      Source |       SS       df       MS              Number of obs =      21
-------------+------------------------------           F(  2,    18) =  147.76
       Model |  6.31803819     2  3.15901909           Prob > F      =  0.0000
    Residual |  .384819303    18   .02137885           R-squared     =  0.9426
-------------+------------------------------           Adj R-squared =  0.9362
       Total |  6.70285749    20  .335142875           Root MSE      =  .14622

------------------------------------------------------------------------------
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |   -1.69958   .8729522    -1.95   0.067    -3.533585    .1344242
        time |  -.1246403   .0185561    -6.72   0.000    -.1636252   -.0856554
       _cons |   112.8511   7.185777    15.70   0.000     97.75431    127.9478
```

In **figure 4**, computing Huber-White robust estimates of the standard errors for the initial regression of the exchange rate on the Chinese import price index, we obtain lower standard errors for the exchange rate variable. Though the sample size is fairly small, we can see that the effect of the exchange rate remains significant at 3.9226.

Adjusting for the time trend of Chinese import prices and running the regression with robust standard errors, in **figure 5**, we observe a slightly heightened standard error. The -1.7 coefficient on the exchange rate remains significant at the 10% level and the -.1246 on the time variable also remained highly significant though with a slightly higher standard error.

An analysis of a logarithmic regression of the log exchange rate on log China import prices is shown in **figure 6**. The coefficient of the log exchange rate is highly significant at .3203, indicating that for every 1% appreciation of the exchange rate, there is a .32% decrease in Chinese import prices. **Figure 8** shows the same regression with robust standard errors. The standard error of the log exchange variable improved and the coefficient remains highly significant.

Figure 7 shows the log regression after removing the general downwards trend of import prices. The results show a -.139352 coefficient for the log exchange rate variable, significant at the 10% level. This indicates that for every 1% appreciation of the exchange rate, the price index for Chinese imports increases by about .139%. The coefficient for the time variable, -.00127, is highly significant, confirming that there is likely a downwards price trend of Chinese imported goods over time.

Conducting a Durbin-Watson test on the residuals of the exchange rate regressed on the import price index, **figure 9**, we observe a d-statistic of .5854994, indicating strong signs of positive autocorrelation. A Runs of Signs test confirms the positive autocorrelation. Correcting for the autocorrelation in the initial regression, **figure 10**, using the Cochrane-Orcutt method, we observe 100 iterations and no final convergence. However, the transformed Durbin-Watson statistic is now 2.094984 and the value for rho is .9595661, suggesting that the autocorrelation has been adequately corrected for. The new coefficient for the exchange rate variable is -0.7311, suggesting that for every 1 unit appreciation of the RMB, the import price index from China increases by .7311 units, though this coefficient is statistically insignificant.

A Breusch-Pagan/Cook-Weisberg test of heteroskedasticity on the variables Chinese import price index and Chinese import volume (**figure 21**) show no signs of heteroskedasticity.

A regression of the exchange rate on Chinese import volume into the U.S. (**figure 22**) shows a highly significant coefficient of -15156.51, indicating that for every 1 unit appreciation of the yuan, Chinese imports into the U.S. are increasing by about $15,156.51 million. It appears strange that imports are increasing even as Chinese goods are theoretically becoming more expensive and we must explore further tests.

A test of time trends related to Chinese import volumes in **figure 23** shows an insignificant coefficient of 106.0515, which would indicate a tendency towards higher imports over time. Inclusion of the time variable as a regressor in another regression in **figure 23** confirms that time may not be a significant variable.

Testing the residuals of the regression of exchange rate on Chinese import volume, in **figure 24**, we obtain a Durbin-Watson test statistic (.6533) that indicates positive autocorrelation and we attempt to remove the autocorrelation using the Cochrane-Orcutt method. After only 8 iterations, we arrive at a converged rho of .682719 and a transformed d-statistic of 1.817705. The coefficient on the exchange term is now -12701.03, but is no longer significant.

Regressing Chinese import prices on import volume in **figure 25** we obtain a highly significant (1% level) -3286.524 coefficient on the price term, signifying that for every 1 unit price index increase imports from China fall by about $3.2865 billion. Adding the exchange rate variable into the regression, we obtain insignificant coefficients for both exchange and price index, values of -8164.702 and -1724.554, respectively. Similarly, regressing Chinese import volume on import prices in **figure 28** we obtain a highly significant -.0001216 coefficient, suggesting, not surprisingly, that as import volume increases, prices fall by about .00012 index units for every additional $million worth of imports. However, the significance of the volume variable on prices disappears with the inclusion of the exchange rate and time variables.

Testing the residuals of the regression of the price term on import volume, we detect signs of positive autocorrelation (d-statistic = .5819433), **figure 26**. Correcting for this, we obtain a rho of .7080101 and a transformed d-statistic of 1.725349, after just 2 iterations. The coefficient of the price index term is no longer significant and is now -3295.452.

Part II – Crude oil

Figure 11, reproduced here, shows a regression of the exchange rate (labeled 'value') on crude oil prices in China. The exchange coefficient, -32.22723, is fairly significant at the 10% level. The coefficient implies that for every 1 unit appreciation of the yuan, crude oil prices in China rise by about $32.23 per barrel. This seems highly inflated and a time trend must be tested for on crude prices. Estimating with robust standard errors (**figure 15**) renders the standard error of the exchange rate term notably higher and causes the coefficient to be no longer significant.

```
. reg  crude_oil_price_cn  value

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  1,    16) =    3.89
       Model |  181.994143     1  181.994143           Prob > F      =  0.0660
    Residual |  747.735895    16  46.7334934           R-squared     =  0.1957
-------------+------------------------------           Adj R-squared =  0.1455
       Total |  929.730037    17  54.6900022           Root MSE      =  6.8362

------------------------------------------------------------------------------
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |  -32.22723   16.33083    -1.97   0.066    -66.84705    2.392594
       _cons |   319.8981   131.3715     2.44   0.027       41.403    598.3932
------------------------------------------------------------------------------
```

An analysis of the effect of the variables exchange rate, OPEC crude oil production and world crude production on crude prices in China, **figure 12**, as shown below, gave the following results: (i) a coefficient of -48.85792 on the exchange term, significant at the 5% level, (ii) an insignificant .0085491 on the OPEC production variable and (iii) an insignificant -.0089929 on the world production term. The coefficient term on the exchange rate appears even more inflated with the inclusion of the additional explanatory variables.

```
. reg  crude_oil_price_cn  value  opec_crude_production  total_world_crude_prod
uction

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  3,    14) =    2.37
       Model |  312.889249     3  104.296416           Prob > F      =  0.1148
    Residual |  616.840788    14  44.0600563           R-squared     =  0.3365
-------------+------------------------------           Adj R-squared =  0.1944
       Total |  929.730037    17  54.6900022           Root MSE      =  6.6378

------------------------------------------------------------------------------
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |  -48.85792   22.26147    -2.19   0.046    -96.60402   -1.111822
opec_crude~n |   .0085491   .0066346     1.29   0.218    -.0056807    .0227789
total_worl~n |  -.0089929   .0060825    -1.48   0.161    -.0220385    .0040527
       _cons |   850.6887   427.3368     1.99   0.066    -65.85755    1767.235
------------------------------------------------------------------------------
```

A Dickey-fuller test on Chinese crude oil prices shows non-stationarity. A trend regression, **figure 13**, shows no trend stationarity and a statistically insignificant trend term with a coefficient of -.1671551, which would imply that crude oil prices have generally gone down over time.

Nevertheless, an attempt to detrend by including time as an explanatory variable, **figure 14**, renders the exchange coefficient positive, at 27.32176, though statistically insignificant. The time coefficient is 1.202517 and is also insignificant. These drastically different and ultimately inconclusive results may point to the fact that prices are generally too volatile or the timeframe too short to detect any potential long-term trends. Estimating with robust standard errors (**figure 16**) generates the standard errors that are slightly lower, but still statistically insignificant results.

Figure 17 shows a logarithmic analysis of log exchange rate regressed against log Chinese crude oil prices. The results show a -4.266519 coefficient, significant at the 10%

level, indicating that for every 1% appreciation of the yuan, crude prices in China increase by about 4.27%. Again this appears inflated and other factors must be considered.

Adding the additional regressors log OPEC crude oil production and log world crude production to the regression, **figure 18**, we obtain a highly significant (5% level) -6.615943 on the log exchange variable, which appears even more inflated. The log world production and log OPEC production coefficients are -11.75617 (indicating that for every additional thousand barrels per day produced, Chinese crude prices fall by about $11.76 per barrel) and 4.61975 (indicating that for every additional thousand barrels per day produced, Chinese crude prices increase by about $4.62 per barrel), both statistically insignificant, which is also a strange result. A test for a trend variable found a highly insignificant coefficient of -.0031476.

A regression of log exchange rate, log world production, log OPEC production and time on crude prices (**figure 19**), yielded an insignificant positive coefficient of 5.543234 for logged exchange and significant (5% level) coefficients for the to other variables. The coefficient for log world production (-15.21523) indicates a roughly 15.21% reduction in Chinese crude oil prices for every 1% world production increase, while that of log OPEC production (8.086491) indicates an 8.09% increase in Chinese crude prices for every 1% OPEC production increase.

The Durbin-Watson test on the residuals for the initial regression of exchange rate on crude prices in China yields a statistic of .726916, indicating signs of positive autocorrelation. Correcting for the autocorrelation using the Cochrane-Orcutt iterative method (**figure 20**), we obtain a rho of .7174713 and a transformed d-statistic of 1.589529, only partially eliminating autocorrelative effects after 10 iterations. The coefficient for the exchange term is now positive though statistically insignificant, at 44.10228, which would indicate that for every 1 unit appreciation of the yuan crude prices fall by about $44.10 per barrel. Now the effect appears inflated in the opposite direction from before.

A Breusch-Pagan/Cook-Weisberg test of heteroskedasticity on the variable Chinese crude oil prices (**figure 21**) shows no significant deviation from constant variance.

VI. Results summary explanation

Part I – Import prices and volume

When the effect of the exchange rate movements on the Chinese imports price index was analyzed, a statistically significant positive coefficient was found, implying that as the yuan appreciated, Chinese goods have actually become cheaper in the U.S. market. This effect is exactly the opposite of what U.S. officials had hoped for and also runs counter to the effect that may normally be expected after a currency appreciation. However, this counterintuitive finding may be due to a general downwards time trend of Chinese import prices; that is, Chinese import prices generally fall as time goes on.

Testing for potential trends, it was found that the data show no trend stationarity, though there is a significant (at the 5% level) negative trend factor, suggesting that Chinese import prices are generally decreasing over time. Accounting for the trend term by detrending the series, the coefficient of the exchange rate when regressed on Chinese import prices became negative (-1.70), significant at the 10% level. The same post-detrending change of sign occurred with the exchange coefficient, when running the regression in logarithms. Similarly, removing autocorrelative effects also changed the initial exchange rate coefficient from positive to negative. This translates to the expected and desired outcome that as the RMB appreciates, import prices are becoming higher. The coefficient for the time variable was negative and highly significant, once again pointing to a marked time trend of import prices. The goodness of fit of the regression improved significantly, from an R^2 value of .7987 to .9426.

Adjusting for general price trends, the movements in the exchange rate do appear to be contributing to an increase in prices of Chinese imports relative to what they would have been. However, the original highly significant positive coefficient suggests that the effect of an overall lowering of Chinese import prices over time continues to greatly eclipse any effects of an appreciating yuan. Estimating robust standard errors does not appear to have a significant effect on the standard errors in the detrended regression analysis.

After examining the effect of the exchange rate on U.S. imports in the period after the peg removal, I found that the coefficient was, in fact, negative. This implied that with the appreciation of the yuan, the volume of U.S. imports from China were actually increasing. This result may arise from the presence of a general positive trend, so I tested the data for a significant trend. No statistically significant trend factor was found after using three different tests for trend stationarity. Next, I ran the data taking the logarithm of import volume and exchange rate in order to examine the effects of percent changes. The data still showed that a 1% appreciation of the exchange rate actually led to a roughly 6.61% increase in Chinese imports into the U.S.

Part II – Crude oil

Looking at the effect of the exchange rate on Chinese crude oil prices, after the peg removal, I found that the effect of the exchange rate on crude oil prices in China is slightly significant, at the 10% level. In particular, for every 1% appreciation of the yuan, crude oil prices appear to be increasing by 4.27% (**figure 17**). This is an unexpected result, given that a higher-valued yuan vis-à-vis the dollar should be bringing crude oil prices down, since oil is traded on world markets in terms of the dollar. However, this may have been affected by a general upwards oil price trend.

In testing for the presence of a potential time trend for crude oil prices, however, no significant trend was found. Using a greater number of observations (**figure 27**), from January 2000 to the present, a slightly significant (at the 10% level) positive time trend was found (coefficient .0531408), however this cannot necessarily be applied to the post-peg period. This is because inclusion of the exchange rate variable for the extended time frame may significantly skew results due to the pegged value. This implies that crude prices in China are rising even with a stronger currency and with no discernible upwards price trend. Another factor must be contributing to the fact that prices are increasing with the RMB's appreciation, even though no definitive upwards trend exists.

The analyses including OPEC and world oil production give conflicting results: that crude prices are increasing with increased OPEC production and decreasing with increased world production. In addition, neither of these results were significant, suggesting that crude oil production is not the missing factor leading to the strange result of prices increasing with currency value.

VII. Final thoughts: Chinese import prices and volume

The strong downwards import price trend can be due to many reasons. It is likely that Chinese productivity growth is so high that production costs, and thereby prices of goods, are decreasing very rapidly. So rapidly, in fact, that even the current roughly 6.5% appreciation can do little to curb the fall of Chinese import prices. With an average annual productivity growth rate of about 9%, it is estimated that the yuan must appreciate by some 20-30% over its pegged value before we will observe any noticeable effect on balancing the trade gap. It is no wonder that a barely over 6% appreciation since June 2005 appears to have no observable effect on raising nominal import prices.

Also, with high productivity growth comes skill in producing increasingly up market goods. China is now making more products that require technical skill and it is making these products more efficiently and cheaper. Though importing these more technical products may seem like it should boost the import price index, the fact that these products are now much more plentiful and in such high demand, due to their being cheaper than U.S.-made comparable goods, that sheer import volume may be driving down prices (**figure 28**, table 1). It is unlikely that the volume effect is significant, however it likely is a contributor in falling import prices.

Despite the decreasing import price trend, the Chinese yuan revaluation does seem to be helping, much as the U.S. and other countries had hoped for. Adjusting for generally falling import prices, the appreciation does appear to be contributing to higher import prices. This points to the fact that, though prices are still falling and the trade gap is continuously widening, the circumstances would no doubt be even more unfavorable to the U.S. had the yuan revaluation not occurred. And though the beneficial effect has thus far been small, it no doubt will increase as the RMB continually appreciates vis-à-vis the dollar. The high productivity growth rate in China is unlikely to be sustained indefinitely and when it cools, the appreciation of the yuan will help to adjust the trade balance faster than would otherwise be achieved. We cannot tell when product prices in China will level off, thus we cannot tell at what point a higher valued currency may help to correct the trade imbalance, but at least an appreciating yuan does seem to be helping import prices climb, if ever so slightly.

VIII. Final thoughts: Chinese crude oil

The results of the crude oil analyses exemplify significant departures from expectations. In the case of continually increasingly Chinese imports into the U.S., one possible explanation could be that the U.S. demand curve for Chinese goods has simply shifted out. With many multinational corporations increasingly shifting production into China, the quality of domestic manufactures has improved with time, becoming increasingly undifferentiable from the quality of U.S. produced goods. In addition, technology in China has improved rapidly and the manufacturing production infrastructure is often superior to that of the U.S. This may be due to the fact that, having developed after many U.S. production processes and technology were already set up, China was able to adopt the very latest in technological advancements, while U.S. production plants remained entrenched with near-obsolete equipment. As such, quality improvements in China multiplied rapidly. The heightened U.S. demand for Chinese imports may be so significant as to virtually eclipse the slow and slight strengthening of the RMB. Moreover, demand elasticity may be decreasing as fewer comparably priced, high quality substitutes exist to compete with Chinese goods and this may be contributing to the lack of impact of the RMB appreciation.

Similarly, the rapidly expanding Chinese demand for crude oil may also be both shifting out its demand curve for oil and leading demand to become more inelastic. As Chinese manufacturing has grown, its reliance on crude oil for energy has increased exponentially. Demand may have increased so much as to actually increase oil prices substantially and overcome the more favorable exchange rate for trading crude oil that should be driving prices down. Demand is likely simply a much stronger determinant of crude oil prices than the exchange rate is. Also, several oil price shocks have occurred in the brief period after the revaluation and these may also be contributing to the increasing oil prices. As they were not clearly defined in duration, nor is it clear that the shocks have ended, they were not included in the analysis. Pipeline insecurities in the OPEC region may also be affecting the transport of crude oil and thus have an impact on prices. Given a longer timeframe of observations, it may become more clear what is actually causing the oddly increasing oil prices in China.

The results also run somewhat counter to Chinese price restrictions on oil. However, this can be explained by the fact that price restrictions are mostly on consumer end product gasoline, or refined crude oil, and not on the crude prices seen by Chinese large oil enterprises such as Sinopec and PetroChina/CNPC. In fact, these generally higher prices may help to explain the appearance of Chinese exports of crude oil even when supply is insufficient to meet demand; the costs have become too high for refiners to sell at the slim margins imposed by the government.

Interestingly enough, these results, though counter to what may be expected, serve also to counter-balance each other and point to a potentially negligible effect of the RMB revaluation. The results suggest that the U.S. may not gain any noticeable terms of trade gain vis-à-vis China, though the degree of its terms of trade disadvantage may be lessened. They also suggest that China may not gain any input factor price advantage, particularly in terms of crude oil, though its trade disadvantage may also be reduced.

IX. Conclusion

Overall, the results point to the fact that the Chinese currency revaluation has not had notable effects in any direction, thus far. In terms of Chinese import prices, the degree of yuan appreciation is still too small to observe any substantial effect and it is too soon to see whether the revaluation can succeed in counteracting the rapid downwards import price trend. In terms of Chinese input factor prices, specifically crude oil prices, the data show strange results implying increasing prices even after the revaluation. However we cannot determine whether this is due to idiosyncratic price shocks which may be causing temporary price increases covering up the effect of an appreciating yuan, or due to a change in overall oil demand which may result in more long-term upwards price trends. Mostly, the results imply that a roughly 6.5% yuan appreciation is definitely not enough to achieve the lowered prices the U.S. and other nations hoped for, nor is it enough for China to enjoy any decreases in input factor prices.

This analysis was severely hampered by the short timeframe of the post-revaluation period. The amount of appreciation has been relatively slight during this time and oil price shock factors were also difficult to account for, given the brief time span. Looking at the data some length of time from now, when the yuan has appreciated by perhaps 20% or more, would likely give a clearer picture of underlying effects of the peg removal, as well as the drivers of those effects. If given the opportunity to look at results for a more extensive period after the revaluation, I would be able to remove idiosyncratic oil price shocks and likely find more accurate trend factors. It is also highly likely that a longer period of time would help to reveal crude oil price trends more clearly, especially given that looking back a longer period of time than we were able to in this analysis already gives strong signs of an upwards trend. Having used monthly data, a longer timeframe would also have helped increase the number of observations, thereby rendering the results more reliable.

In terms of data, many variables were omitted from this analysis. This was due primarily to lack of sufficient data. I had hoped to also analyze the effect of Chinese crude oil consumption on crude prices, as consumption is a good indicator of demand, so as to see whether my hypothesis was true of heightened demand being the primary driver of the strange result of increasing crude prices in China. This consumption data was not available in monthly intervals and disaggregating the data was not possible. In addition, a look at the prices of other input factors in China, post-revaluation, would have been ideal. Much of this data, as well as that of other variables relating to the Chinese economy, was either not available or not official and the analysis was limited by the exclusion of variables that likely could have shed light on causal relationships and effects. Also, given more time and data, I would like to have examined the value added in China of goods originating from other, especially Asian, countries. I could then use this to determine how much the yuan alone must appreciate in order to raise import prices from China, given that the production and cost of the goods are not influenced by China alone.

At present, we must wait for a longer period to pass and for a greater degree of RMB appreciation to occur in order to obtain more insightful results. Given that a 6.5% appreciation has seemingly done very little for import prices and nothing at all for the crude oil input factor prices, it seems reasonable to believe that it would take a much more rapid and drastic increase in yuan value to make a substantial impact on trade. The degree of appreciation required to achieve significant changes satisfactory to Chinese competitors and trading partners may never occur, but if and when it does, we will be able to truly observe the impact of the Chinese yuan revaluation.

Appendix

Figure 1

```
. reg  CNimportPrice  exchange

      Source |       SS       df       MS              Number of obs =      21
-------------+------------------------------           F(  1,    19) =   75.38
       Model |  5.35348008     1  5.35348008           Prob > F      =  0.0000
    Residual |  1.34937741    19  .071019864           R-squared     =  0.7987
-------------+------------------------------           Adj R-squared =  0.7881
       Total |  6.70285749    20  .335142875           Root MSE      =   .2665

------------------------------------------------------------------------------
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |   3.922624   .4518024     8.68   0.000     2.976991    4.868257
       _cons |   66.46285   3.618064    18.37   0.000     58.89015    74.03554
------------------------------------------------------------------------------
```

Figure 2

```
. dfuller  CNimportPrice, trend regress

Dickey-Fuller test for unit root                   Number of obs   =        20

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.423            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3672

------------------------------------------------------------------------------
D.CNimport~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
CNimportPr~e |
         L1. |   -.513546   .2119048    -2.42   0.027    -.9606261   -.0664659
      _trend |  -.0455485   .0199691    -2.28   0.036    -.0876796   -.0034174
       _cons |   50.67211   20.95002     2.42   0.027     6.471434     94.8728
------------------------------------------------------------------------------
```

Figure 3

```
. reg  CNimportPrice  exchange  time

      Source |       SS       df       MS              Number of obs =      21
-------------+------------------------------           F(  2,    18) =  147.76
       Model |  6.31803819     2  3.15901909           Prob > F      =  0.0000
    Residual |  .384819303    18   .02137885           R-squared     =  0.9426
-------------+------------------------------           Adj R-squared =  0.9362
       Total |  6.70285749    20  .335142875           Root MSE      =  .14622

------------------------------------------------------------------------------
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |   -1.69958   .8729522    -1.95   0.067    -3.533585    .1344242
        time |  -.1246403   .0185561    -6.72   0.000    -.1636252   -.0856554
```

```
       _cons |   112.8511   7.185777    15.70   0.000     97.75431    127.9478
```

Figure 4

```
. reg  CNimportPrice  exchange, robust

Linear regression                                      Number of obs =      21
                                                       F(  1,    19) =  132.02
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.7987
                                                       Root MSE      =   .2665

------------------------------------------------------------------------------
             |               Robust
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |   3.922624   .3413954    11.49   0.000     3.208075    4.637173
       _cons |   66.46285   2.716516    24.47   0.000     60.77712    72.14858
------------------------------------------------------------------------------
```

Figure 5

```
. reg  CNimportPrice  exchange time, robust

Linear regression                                      Number of obs =      21
                                                       F(  2,    18) =  184.06
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.9426
                                                       Root MSE      =  .14622

------------------------------------------------------------------------------
             |               Robust
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |   -1.69958   .8935234    -1.90   0.073    -3.576803    .1776426
        time |  -.1246403   .0201435    -6.19   0.000    -.1669603   -.0823204
       _cons |   112.8511   7.371802    15.31   0.000     97.36349    128.3386
```

Figure 6

```
. reg  lnCNimportPrice  lnexchange

      Source |       SS       df       MS              Number of obs =      21
-------------+------------------------------           F(  1,    19) =   75.25
       Model |  .000558136     1  .000558136           Prob > F      =  0.0000
    Residual |  .000140915    19  7.4166e-06           R-squared     =  0.7984
-------------+------------------------------           Adj R-squared =  0.7878
       Total |  .000699051    20  .000034953           Root MSE      =  .00272

------------------------------------------------------------------------------
lnCNimport~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  lnexchange |   .3203007   .0369224     8.67   0.000     .2430212    .3975803
       _cons |   3.917351    .076808    51.00   0.000      3.75659    4.078112
------------------------------------------------------------------------------
```

Figure 7

```
. reg  lnCNimportPrice  lnexchange  time

      Source |       SS       df       MS              Number of obs =      21
-------------+------------------------------           F(  2,    18) =  149.11
       Model |  .000659258     2  .000329629           Prob > F      =  0.0000
    Residual |  .000039793    18  2.2107e-06           R-squared     =  0.9431
-------------+------------------------------           Adj R-squared =  0.9368
       Total |  .000699051    20  .000034953           Root MSE      =  .00149

------------------------------------------------------------------------------
lnCNimport~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  lnexchange |   -.139352   .0708895    -1.97   0.065    -.2882853    .0095813
        time |  -.0012744   .0001884    -6.76   0.000    -.0016703   -.0008785
       _cons |   4.887535   .1494524    32.70   0.000     4.573547    5.201523
------------------------------------------------------------------------------
```

Figure 8

```
. reg  lnCNimportPrice  lnexchange, robust

Linear regression                                      Number of obs =      21
                                                       F(  1,    19) =  133.21
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.7984
                                                       Root MSE      =  .00272

------------------------------------------------------------------------------
             |               Robust
lnCNimport~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  lnexchange |   .3203007    .027752    11.54   0.000     .2622151    .3783864
       _cons |   3.917351   .0575669    68.05   0.000     3.796862     4.03784
------------------------------------------------------------------------------
```

Figure 9

```
. dwstat

Durbin-Watson d-statistic(  2,    21) =  .5854994

. runtest res
 N(res <= -.0032979736570269) = 10
 N(res >  -.0032979736570269) = 11
        obs = 21
     N(runs) = 4
          z  = -3.36
    Prob>|z| = 0
```

Figure 10

```
. prais  CNimportPrice  exchange, corc

Iteration 0:  rho = 0.0000
Iteration 1:  rho = 0.7039
Iteration 2:  rho = 0.8282
Iteration 3:  rho = 0.8860
Iteration 4:  rho = 0.9065
```

```
Iteration 5:  rho = 0.9175
Iteration 6:  rho = 0.9246
Iteration 7:  rho = 0.9298
Iteration 8:  rho = 0.9336
Iteration 9:  rho = 0.9367
Iteration 10:  rho = 0.9392
Iteration 11:  rho = 0.9412
Iteration 12:  rho = 0.9430
Iteration 13:  rho = 0.9445
Iteration 14:  rho = 0.9458
Iteration 15:  rho = 0.9469
Iteration 16:  rho = 0.9479
Iteration 17:  rho = 0.9488
Iteration 18:  rho = 0.9496
Iteration 19:  rho = 0.9503
Iteration 20:  rho = 0.9510
Iteration 21:  rho = 0.9516
Iteration 22:  rho = 0.9521
Iteration 23:  rho = 0.9526
Iteration 24:  rho = 0.9531
Iteration 25:  rho = 0.9535
Iteration 26:  rho = 0.9539
Iteration 27:  rho = 0.9542
Iteration 28:  rho = 0.9545
Iteration 29:  rho = 0.9548
Iteration 30:  rho = 0.9551
Iteration 31:  rho = 0.9554
Iteration 32:  rho = 0.9556
Iteration 33:  rho = 0.9559
Iteration 34:  rho = 0.9561
Iteration 35:  rho = 0.9563
Iteration 36:  rho = 0.9565
Iteration 37:  rho = 0.9566
Iteration 38:  rho = 0.9568
Iteration 39:  rho = 0.9570
Iteration 40:  rho = 0.9571
Iteration 41:  rho = 0.9572
Iteration 42:  rho = 0.9574
Iteration 43:  rho = 0.9575
Iteration 44:  rho = 0.9576
Iteration 45:  rho = 0.9577
Iteration 46:  rho = 0.9578
Iteration 47:  rho = 0.9579
Iteration 48:  rho = 0.9580
Iteration 49:  rho = 0.9581
Iteration 50:  rho = 0.9582
Iteration 51:  rho = 0.9583
Iteration 52:  rho = 0.9583
Iteration 53:  rho = 0.9584
Iteration 54:  rho = 0.9585
Iteration 55:  rho = 0.9585
Iteration 56:  rho = 0.9586
Iteration 57:  rho = 0.9586
Iteration 58:  rho = 0.9587
Iteration 59:  rho = 0.9587
Iteration 60:  rho = 0.9588
Iteration 61:  rho = 0.9588
Iteration 62:  rho = 0.9589
Iteration 63:  rho = 0.9589
Iteration 64:  rho = 0.9589
```

```
Iteration 65:  rho = 0.9590
Iteration 66:  rho = 0.9590
Iteration 67:  rho = 0.9591
Iteration 68:  rho = 0.9591
Iteration 69:  rho = 0.9591
Iteration 70:  rho = 0.9591
Iteration 71:  rho = 0.9592
Iteration 72:  rho = 0.9592
Iteration 73:  rho = 0.9592
Iteration 74:  rho = 0.9592
Iteration 75:  rho = 0.9593
Iteration 76:  rho = 0.9593
Iteration 77:  rho = 0.9593
Iteration 78:  rho = 0.9593
Iteration 79:  rho = 0.9593
Iteration 80:  rho = 0.9594
Iteration 81:  rho = 0.9594
Iteration 82:  rho = 0.9594
Iteration 83:  rho = 0.9594
Iteration 84:  rho = 0.9594
Iteration 85:  rho = 0.9594
Iteration 86:  rho = 0.9594
Iteration 87:  rho = 0.9595
Iteration 88:  rho = 0.9595
Iteration 89:  rho = 0.9595
Iteration 90:  rho = 0.9595
Iteration 91:  rho = 0.9595
Iteration 92:  rho = 0.9595
Iteration 93:  rho = 0.9595
Iteration 94:  rho = 0.9595
Iteration 95:  rho = 0.9595
Iteration 96:  rho = 0.9595
Iteration 97:  rho = 0.9595
Iteration 98:  rho = 0.9596
Iteration 99:  rho = 0.9596
Iteration 100:  rho = 0.9596

Cochrane-Orcutt AR(1) regression -- iterated estimates

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  1,    18) =    0.29
       Model |  .00741588     1  .00741588             Prob > F      =  0.5953
    Residual |  .45654425    18  .025363569            R-squared     =  0.0160
-------------+------------------------------           Adj R-squared = -0.0387
       Total |  .46396013    19  .024418954            Root MSE      =  .15926

------------------------------------------------------------------------------
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |  -.7311036   1.352081    -0.54   0.595    -3.571721    2.109514
       _cons |   101.0767   10.00242    10.11   0.000     80.06239     122.091
-------------+----------------------------------------------------------------
         rho |   .9595661
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    0.585499
Durbin-Watson statistic (transformed) 2.094984
Convergence not achieved
r(430);
```

Figure 11

```
. reg  crude_oil_price_cn  value

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  1,    16) =    3.89
       Model |  181.994143     1  181.994143           Prob > F      =  0.0660
    Residual |  747.735895    16  46.7334934           R-squared     =  0.1957
-------------+------------------------------           Adj R-squared =  0.1455
       Total |  929.730037    17  54.6900022           Root MSE      =  6.8362

------------------------------------------------------------------------------
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |  -32.22723   16.33083    -1.97   0.066    -66.84705    2.392594
       _cons |   319.8981   131.3715     2.44   0.027       41.403    598.3932
------------------------------------------------------------------------------
```

Figure 12

```
. reg  crude_oil_price_cn  value  opec_crude_production  total_world_crude_prod
> uction

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  3,    14) =    2.37
       Model |  312.889249     3  104.296416           Prob > F      =  0.1148
    Residual |  616.840788    14  44.0600563           R-squared     =  0.3365
-------------+------------------------------           Adj R-squared =  0.1944
       Total |  929.730037    17  54.6900022           Root MSE      =  6.6378

------------------------------------------------------------------------------
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |  -48.85792   22.26147    -2.19   0.046    -96.60402   -1.111822
opec_crude~n |   .0085491   .0066346     1.29   0.218    -.0056807    .0227789
total_worl~n |  -.0089929   .0060825    -1.48   0.161    -.0220385    .0040527
       _cons |   850.6887   427.3368     1.99   0.066    -65.85755    1767.235
------------------------------------------------------------------------------

. dfuller  crude_oil_price_cn

Dickey-Fuller test for unit root                   Number of obs   =        17

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.795            -3.750            -3.000            -2.630
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3828
```

Figure 13

```
. dfuller  crude_oil_price_cn, trend regress

Dickey-Fuller test for unit root                   Number of obs   =        17

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
```

```
------------------------------------------------------------------------------
 Z(t)             -0.911            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9550

------------------------------------------------------------------------------
D.crude_oi~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
crude_oil_~n |
         L1. |  -.2451119    .269041    -0.91   0.378    -.8221475    .3319238
      _trend |  -.1671551   .3889434    -0.43   0.674    -1.001356    .6670455
       _cons |     16.617   14.22607     1.17   0.262    -13.89489    47.12889
------------------------------------------------------------------------------
```

Figure 14

```
. reg  crude_oil_price_cn  value  time

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  2,    15) =    2.93
       Model |  261.219879     2  130.60994            Prob > F      =  0.0843
    Residual |  668.510158    15  44.5673439           R-squared     =  0.2810
-------------+------------------------------           Adj R-squared =  0.1851
       Total |  929.730037    17  54.6900022           Root MSE      =  6.6759

------------------------------------------------------------------------------
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |   27.32176   47.42503     0.58   0.573     -73.7623    128.4058
        time |   1.202517   .9019168     1.33   0.202    -.7198731    3.124907
       _cons |  -170.5246   389.5595    -0.44   0.668    -1000.851    659.8018
------------------------------------------------------------------------------
```

Figure 15

```
. reg   crude_oil_price_cn  value, robust

Linear regression                                      Number of obs =      18
                                                       F(  1,    16) =    2.75
                                                       Prob > F      =  0.1167
                                                       R-squared     =  0.1957
                                                       Root MSE      =  6.8362

------------------------------------------------------------------------------
             |               Robust
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |  -32.22723    19.4335    -1.66   0.117    -73.42442    8.969963
       _cons |   319.8981   157.4163     2.03   0.059    -13.80953    653.6057
------------------------------------------------------------------------------
```

Figure 16

```
. reg  crude_oil_price_cn  value  time, robust

Linear regression                                      Number of obs =      18
                                                       F(  2,    15) =    2.80
                                                       Prob > F      =  0.0926
                                                       R-squared     =  0.2810
                                                       Root MSE      =  6.6759
```

```
------------------------------------------------------------------------------
             |               Robust
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |   27.32176   46.44918     0.59   0.565    -71.68233    126.3258
        time |   1.202517   .7668705     1.57   0.138    -.4320287    2.837063
       _cons |  -170.5246   380.2252    -0.45   0.660    -980.9553    639.9061
------------------------------------------------------------------------------
```

Figure 17

```
. reg  logcrude  logvalue

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  1,    16) =    3.89
       Model |  .049027264     1  .049027264           Prob > F      =  0.0660
    Residual |  .201440797    16   .01259005           R-squared     =  0.1957
-------------+------------------------------           Adj R-squared =  0.1455
       Total |  .250468061    17  .014733415           Root MSE      =  .11221

------------------------------------------------------------------------------
    logcrude |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    logvalue |  -4.266519   2.162064    -1.97   0.066    -8.849891    .3168523
       _cons |   12.99341   4.507601     2.88   0.011      3.43772    22.54909
------------------------------------------------------------------------------
```

Figure 18

```
. reg  logcrude  logvalue  lnworldprod  lnopecprod

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  3,    14) =    2.59
       Model |  .089474855     3  .029824952           Prob > F      =  0.0939
    Residual |  .160993206    14  .011499515           R-squared     =  0.3572
-------------+------------------------------           Adj R-squared =  0.2195
       Total |  .250468061    17  .014733415           Root MSE      =  .10724

------------------------------------------------------------------------------
    logcrude |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    logvalue |  -6.615943   2.911772    -2.27   0.039    -12.86107   -.3708117
 lnworldprod |  -11.75617   7.238577    -1.62   0.127    -27.28138    3.769029
  lnopecprod |    4.61975   3.328167     1.39   0.187    -2.518459    11.75796
       _cons |   101.8625   76.82527     1.33   0.206    -62.91127    266.6363
------------------------------------------------------------------------------
```

Figure 19

```
. reg  logcrude  logvalue  time

      Source |       SS       df       MS              Number of obs =      18
-------------+------------------------------           F(  2,    15) =    2.78
       Model |  .067815959     2  .033907979           Prob > F      =  0.0937
    Residual |  .182652102    15  .012176807           R-squared     =  0.2708
-------------+------------------------------           Adj R-squared =  0.1735
       Total |  .250468061    17  .014733415           Root MSE      =  .11035

------------------------------------------------------------------------------
```

```
    logcrude |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    logvalue |   3.227419   6.396669     0.50   0.621    -10.40676     16.8616
        time |   .0187341   .0150818     1.24   0.233    -.0134119    .0508802
       _cons |  -2.808109   13.47117    -0.21   0.838    -31.52122      25.905
------------------------------------------------------------------------------

. predict res, r

. dwstat

Durbin-Watson d-statistic(  2,    18) =   .726916
```

Figure 20

```
. prais  crude_oil_price_cn  value, corc

Iteration 0:  rho = 0.0000
Iteration 1:  rho = 0.6802
Iteration 2:  rho = 0.7087
Iteration 3:  rho = 0.7153
Iteration 4:  rho = 0.7169
Iteration 5:  rho = 0.7173
Iteration 6:  rho = 0.7174
Iteration 7:  rho = 0.7175
Iteration 8:  rho = 0.7175
Iteration 9:  rho = 0.7175
Iteration 10:  rho = 0.7175

Cochrane-Orcutt AR(1) regression -- iterated estimates

      Source |       SS       df       MS              Number of obs =      17
-------------+------------------------------           F(  1,    15) =    1.08
       Model |  28.7588103     1  28.7588103           Prob > F      =  0.3153
    Residual |  399.703937    15  26.6469291           R-squared     =  0.0671
-------------+------------------------------           Adj R-squared =  0.0049
       Total |  428.462747    16  26.7789217           Root MSE      =  5.1621

------------------------------------------------------------------------------
crude_oil_~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       value |   44.10228    42.4521     1.04   0.315    -46.38223    134.5868
       _cons |  -289.8241   338.2958    -0.86   0.405    -1010.885    431.2365
-------------+----------------------------------------------------------------
         rho |   .7174713
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    0.726916
Durbin-Watson statistic (transformed) 1.589529
```

Figure 21

```
. hettest  CNimportPrice

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: CNimportPrice

         chi2(1)      =     1.16
         Prob > chi2  =   0.2807
```

```
. hettest  CNimportVol

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: CNimportVol

         chi2(1)      =     0.11
         Prob > chi2  =   0.7355

. hettest  crudeprice

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: crudeprice

         chi2(1)      =     0.01
         Prob > chi2  =   0.9087
```

Figure 22

```
. reg  CNimportVol  exchange

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  1,    18) =   12.05
       Model |  64013971.9     1  64013971.9           Prob > F      =  0.0027
    Residual |  95627807.9    18  5312655.99           R-squared     =  0.4010
-------------+------------------------------           Adj R-squared =  0.3677
       Total |   159641780    19  8402198.93           Root MSE      =  2304.9

------------------------------------------------------------------------------
 CNimportVol |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |  -15156.51   4366.341    -3.47   0.003    -24329.85   -5983.167
       _cons |   144986.7    35021.3     4.14   0.001     71409.68    218563.7
```

Figure 23

```
. dfuller  CNimportVol, trend regress

Dickey-Fuller test for unit root                   Number of obs   =        19

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.768            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7202

------------------------------------------------------------------------------
D.CNimport~l |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 CNimportVol |
         L1. |  -.3292301   .1862554    -1.77   0.096    -.7240739    .0656136
      _trend |   106.0515   96.98204     1.09   0.290    -99.54123    311.6442
       _cons |   6861.491   3812.605     1.80   0.091    -1220.872    14943.85
------------------------------------------------------------------------------

. reg  CNimportVol  exchange  time
```

```
      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  2,    17) =    6.40
       Model |  68578064.3     2  34289032.2           Prob > F      =  0.0085
    Residual |  91063715.4    17  5356689.14           R-squared     =  0.4296
-------------+------------------------------           Adj R-squared =  0.3625
       Total |   159641780    19  8402198.93           Root MSE      =  2314.5

------------------------------------------------------------------------------
 CNimportVol |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |  -2161.396   14745.24    -0.15   0.885    -33271.14    28948.35
        time |   278.6175   301.8418     0.92   0.369     -358.213     915.448
       _cons |   37842.04   121285.8     0.31   0.759    -218048.6    293732.7
------------------------------------------------------------------------------
```

Figure 24

```
. dwstat

Durbin-Watson d-statistic(  2,    20) =  .6533058

. prais  CNimportVol  exchange, corc

Iteration 0:  rho = 0.0000
Iteration 1:  rho = 0.6656
Iteration 2:  rho = 0.6794
Iteration 3:  rho = 0.6820
Iteration 4:  rho = 0.6826
Iteration 5:  rho = 0.6827
Iteration 6:  rho = 0.6827
Iteration 7:  rho = 0.6827
Iteration 8:  rho = 0.6827

Cochrane-Orcutt AR(1) regression -- iterated estimates

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    1.49
       Model |  4519879.09     1  4519879.09           Prob > F      =  0.2388
    Residual |  51548845.6    17  3032285.04           R-squared     =  0.0806
-------------+------------------------------           Adj R-squared =  0.0265
       Total |  56068724.7    18  3114929.15           Root MSE      =  1741.3

------------------------------------------------------------------------------
 CNimportVol |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |  -12701.03   10403.05    -1.22   0.239    -34649.55    9247.482
       _cons |   125076.2   82724.22     1.51   0.149    -49456.69      299609
-------------+----------------------------------------------------------------
         rho |    .682719
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    0.653306
Durbin-Watson statistic (transformed) 1.817705
```

Figure 25

```
. reg  CNimportVol  CNimportPrice

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  1,    18) =   11.98
```

```
       Model |  63786725.5     1  63786725.5           Prob > F      =  0.0028
    Residual |  95855054.2    18  5325280.79           R-squared     =  0.3996
-------------+------------------------------           Adj R-squared =  0.3662
       Total |   159641780    19  8402198.93           Root MSE      =  2307.7

------------------------------------------------------------------------------
 CNimportVol |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
CNimportPr~e |  -3286.524   949.6048    -3.46   0.003    -5281.569   -1291.478
       _cons |   345233.4   92981.98     3.71   0.002     149885.5    540581.3
------------------------------------------------------------------------------


. reg  CNimportVol  exchange  CNimportPrice

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  2,    17) =    6.30
       Model |    67954986     2    33977493           Prob > F      =  0.0090
    Residual |  91686793.7    17   5393340.8           R-squared     =  0.4257
-------------+------------------------------           Adj R-squared =  0.3581
       Total |   159641780    19  8402198.93           Root MSE      =  2322.4

------------------------------------------------------------------------------
 CNimportVol |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    exchange |  -8164.702    9287.35    -0.88   0.392     -27759.3    11429.89
CNimportPr~e |  -1724.554   2017.445    -0.85   0.405     -5980.99    2531.883
       _cons |     257773   136578.4     1.89   0.076    -30382.25    545928.2
------------------------------------------------------------------------------
```

Figure 26

```
. predict rres, r (residuals for reg  CNimportVol  CNimportPrice)

. dwstat

Durbin-Watson d-statistic(  2,    20) =  .5819433

. prais  CNimportVol  CNimportPrice, corc

Iteration 0:  rho = 0.0000
Iteration 1:  rho = 0.7080
Iteration 2:  rho = 0.7080

Cochrane-Orcutt AR(1) regression -- iterated estimates

      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  1,    17) =    2.73
       Model |  7639154.86     1  7639154.86           Prob > F      =  0.1169
    Residual |  47595329.5    17  2799725.26           R-squared     =  0.1383
-------------+------------------------------           Adj R-squared =  0.0876
       Total |  55234484.3    18  3068582.46           Root MSE      =  1673.2

------------------------------------------------------------------------------
 CNimportVol |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
CNimportPr~e |  -3295.452   1995.033    -1.65   0.117    -7504.604    913.6993
       _cons |     346005   194847.8     1.78   0.094     -65087.9    757097.9
-------------+----------------------------------------------------------------
         rho |   .7080101
```

```
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    0.581943
Durbin-Watson statistic (transformed) 1.725349
```

Figure 27

```
. dfuller  crude_oil_price_cn, trend regress

Dickey-Fuller test for unit root                   Number of obs   =        82

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.058            -4.080            -3.468            -3.161
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.5695

------------------------------------------------------------------------------
D.crude_oi~n |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
crude_oil_~n |
         L1. |  -.0991932       .0482    -2.06   0.043    -.1951328   -.0032535
      _trend |   .0531408    .0298508     1.78   0.079    -.0062758    .1125573
       _cons |   1.770374    1.064589     1.66   0.100    -.3486381    3.889386
------------------------------------------------------------------------------
```

Figure 28

```
. reg  CNimportPrice  CNimportVol

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  1,    18) =   11.98
       Model |  2.35961135     1  2.35961135           Prob > F      =  0.0028
    Residual |   3.5458894    18  .196993856           R-squared     =  0.3996
-------------+------------------------------           Adj R-squared =  0.3662
       Total |  5.90550075    19  .310815829           Root MSE      =  .44384

------------------------------------------------------------------------------
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 CNimportVol |  -.0001216    .0000351    -3.46   0.003    -.0001954   -.0000478
       _cons |   100.7639     .829129   121.53   0.000       99.022    102.5059
------------------------------------------------------------------------------

. reg  CNimportPrice  CNimportVol  exchange  time

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  3,    16) =   77.75
       Model |  5.52639793     3  1.84213264           Prob > F      =  0.0000
    Residual |  .379102814    16  .023693926           R-squared     =  0.9358
-------------+------------------------------           Adj R-squared =  0.9238
       Total |  5.90550075    19  .310815829           Root MSE      =  .15393

------------------------------------------------------------------------------
CNimportPr~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 CNimportVol |  -2.28e-06    .0000161    -0.14   0.889    -.0000365    .0000319
    exchange |  -1.865502    .9812881    -1.90   0.075     -3.94574    .2147358
        time |  -.1261792    .0205716    -6.13   0.000    -.1697892   -.0825693
       _cons |   114.2545     8.08947    14.12   0.000     97.10555    131.4034
```