# **EXCHANGE RATE OFFER CURVES: TWO EXAMPLES FROM THE HEADLINES**

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## ABSTRACT

The paper introduces an innovative graph for teaching bilateral exchange rates called currency offer curves. The currency quantities are on the axes, and the exchange rate is the ratio between them, i.e., the slope of a ray from the origin. The paper uses the model to address two issues from the headlines (1) China's export led growth strategy, i.e., its policy of undervaluing the yuan, (2) the current euro-zone fiscal crisis' effect on the pound-euro market.

## **INTRODUCTION**

Many observers believe that the economic relationship between the U.S. and China is a major factor contributing to the recent economic crisis (*The Economist*, 2009; Highfill, 2008). Well before the crisis the large current account deficit of the U.S. with China has been a subject of concern which inevitably raises questions about the dollar-yuan exchange rate. China fixed its exchange rate at 8.2765 yuan per dollar until July 2005. The value of the dollar against the yuan as of June 2010 is 6.8306, virtually unchanged over the last year, and about a 17% depreciation since 2005. Although there are always dissenting voices, many observers believe that this rate has been fixed by China in pursuit of an export-led growth strategy. As evidence, Derrick (BBC News, 2010) notes that "since the start of 2002, China has sold an astonishing \$2.187tn worth of its own currency, in an attempt to stop it gaining in value."

While there has been ongoing attention paid to the yuan-dollar relationship, recently the euro has been at the center of attention. "The issue," according to the head of the European Central Bank, Jean-Claude Trichet, "is that of financial stability within the euro area on account of bad fiscal policy in certain countries" (Trichet, 2010). The euro and the pound have both depreciated against the dollar over the December 2009 to June 2010 window, but the fiscal crisis has caused the value of the pound to appreciate relative to the euro. The value of the pound against the euro was about 1.1052 on December 4, 2009 while on June 4, 2010 it had increased to 1.2085. The second section of the paper helps students see that this can be explained by focusing on capital flows, primarily between Europe and Britain. If British investors are less interested in buying European bonds in June than they were in December, and European investors are more interested in buying British bonds, then the pound should have appreciated against the euro. J. Bradford DeLong describes this as "The Flight to Quality" (DeLong, 2010).

Although there is much more to the story than what can be explained in the classroom, our method allows students to see how such behavior affects the exchange rate.

When teaching exchange rates, we often ask students to imagine standing at a teller window at an airport kiosk trying to change money either before they get on an international flight, or even better, a little flustered after getting off an eight or eighteen hour flight. The point is that on one hand exchange rates are rather simple: you lay down one currency and pick up the other. On the other hand, if laying down a dollar is supplying and picking up a yuan, for example, is demanding, then you are always both demanding and supplying at the same time—unlike almost any other market you can think of. The pedagogical problem is that in every other market we emphasize that demand and supply are completely separate concepts. In the market for pizza demand comes from consumers and supply from firms.

The "currency offer curve" methodology presented here makes use of the fact that there are really only two quantities to keep track of—the exchange rate being the ratio of the quantities—and eliminates the problematical "demand for pounds and supply of euros" curves of the textbook supply and demand treatment of the foreign exchange market.

## THE YUAN-DOLLAR MARKET FOR FOREIGN EXCHANGE: AN UNDERVALUED CURRENCY

Denoting the quantity of yuan by  $Q^{*}$  and the quantity of dollars by  $Q^{\$}$ , the dollar-yuan market is drawn with  $Q^{*}$  on the vertical axis and  $Q^{\$}$  on the horizontal axis. Notice first that picking any point in the graph, the value of the dollar ( $=Q^{*}/Q^{\$}$ ) associated with that point is the slope of the ray from the origin going through it. For example, in Figure 1, at the point where  $Q^{*} = 10$  and  $Q^{\$} = 20$  the value of (one) dollar is one half (yuan). (Notice as well that we have sacrificed accuracy for teachability—as mentioned previously, the value of the dollar against the yuan is nothing like one or a half.)

## The Dollar-Yuan Offer Curve

Figure 1 shows the dollar-yuan offer curve, denoted  $\$ \rightarrow \$$ , which reflects the desires of all the private agents holding dollars that would like to exchange them for yuan at the various exchange rates. The reasons agents have for wanting to exchange dollars for yuan can be organized in a number of ways; equation (1) gives the version we find most useful:



Figure 1: Dollar-Yuan Offer Curve

Exports includes the usual toys, cars, and software, but also includes such items in the current account as investment income and private remittances. The term "Inflows" refers to the traditional capital transactions; buying a stock or bond, making a "green-field" investment, and the like. We will use the term "Hot Money" to refer to any other capital transaction where holders of dollars want to exchange them for yuan. Although virtually all observers believe hot money flows exist the exact definition is often in the eye of the beholder. One person's speculative transaction is another's investment. As defined, all terms are positive.

The initial presentation of the model may by aided by a table. (The values in the table are derived from the equation (A.1) in the appendix assuming m = 2 and  $a_{\pm} = 40$ .)

As students will probably expect, as the value of the yuan falls the quantity of yuan desired by dollar holders rises. Since exchange rates are ratios of currency quantities, the information in the first two columns is equivalent to the information in the center two columns, and for that matter in the last two columns. The traditional supply and demand approach maps the first two columns and/or the last two columns. The approach of the present paper maps the middle two columns.

 $Q^{4} = ChineseExports + InflowsIntoChina + HotMoneyIntoChina$ (1)

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| Table 1<br>DOLLAR-YUAN OFFER CURVE DATA |                  |                     |                             |  |  |
|---|------------------|---------------------|-----------------------------|--|--|
| Value of Yuan                           | Quantity of Yuan | Quantity of Dollars | Value of Dollar             |  |  |
| $(=Q^{\$}/Q^{\intercal})$               | $Q^{*}$          | $Q^{\$}$            | $(=Q^{\mathcal{V}}/Q^{\$})$ |  |  |
| 4                                       | $\frac{5}{2}$    | 10                  | $\frac{1}{4}$               |  |  |
| 2                                       | 10               | 20                  | $\frac{1}{2}$               |  |  |
| $\frac{4}{3}$                           | $\frac{45}{2}$   | 30                  | $\frac{3}{4}$               |  |  |
| 1                                       | 40               | 40                  | 1                           |  |  |

Looking at Table 1, reading from the right, when the value of the dollar is one half agents offer 20 dollars hoping to obtain 10 yuan. When the value of the dollar is one agents offer 40 dollars hoping to obtain 40 yuan. In general, as the value of the dollar increases (rays from the origin get steeper and reading down the right-most column of Table 1), agents desire more yuan and are willing to put more dollars on the table to get them. The offer curve is thus upward sloping.

The intuition behind the convexity of the offer curve is perhaps best understood by asking students to think of what happens as the value of the dollar increases to a very high level. For any increase in the value of the dollar both the quantity of yuan demanded and the quantity of dollars offered increase. But as the value of the dollar goes higher and higher, each dollar offered gets a larger and larger number of yuan in return. Thus the curve becomes more and more vertical as the value of the dollar increases. (The equations for the offer curves are found in the appendix.)

## The Yuan-Dollar Offer Curve

Figure 2 shows the yuan-dollar offer curve, denoted  $\cong \Rightarrow$ , which reflects the desires of all the private agents holding dollars that would like to exchange them for yuan at the various exchange rates as shown in equation (2).

$$Q^{s} = USExports + InflowsIntoUS + HotMoneyIntoUS .$$
<sup>(2)</sup>

The discussion of these terms is similar to that above and will be omitted. Table 2 is similar to Table 1, but the yuan-dollar offer curve is being illustrated. (The values in the table are derived from the equation (A.2) in the appendix assuming n = 2 and  $a_s = 5$ .)

| Table 2<br>YUAN-DOLLAR OFFER CURVE DATA |                     |                          |                           |  |  |
|---|---------------------|--------------------------|---------------------------|--|--|
| Value of Dollar                         | Quantity of Dollars | Quantity of Yuan         | Value of Yuan             |  |  |
| $(=Q^{\mathcal{V}}/Q^{\$})$             | $Q^{s}$             | $\mathcal{Q}^{arphi}$    | $(=Q^{\$}/Q^{\intercal})$ |  |  |
| 1                                       | 5                   | 5                        | 1                         |  |  |
| $\frac{1}{\sqrt{2}} \approx 0.71$       | 10                  | $5\sqrt{2} \approx 7.07$ | $\sqrt{2} \approx 1.41$   |  |  |
| $\frac{1}{2}$                           | 20                  | 10                       | 2                         |  |  |

The first two columns show that as the value of the dollar decreases the quantity of dollars desired by yuan-holders increases. Again the figure is based on the middle two columns.





The rays from the origin in Figure 2 are the same as in Figure 1. In this case when the value of the yuan is one agents desire five dollars and offer five yuan in exchange. When the value of the yuan goes up to two (i.e., the value of the dollar falls to one half) agents desire 20 dollars and are willing to offer 10 yuan for them. The intuition for the concavity is similar to that above, noting of course, that the currency desired is now on the horizontal axis. Briefly, as the

value of the yuan gets higher and higher (the value of the dollar smaller and smaller and the rays from the origin flatter and flatter) the number of dollars received for each yuan supplied gets larger as well.

## **Equilibrium in the Dollar-Yuan Market**

Equilibrium in the foreign exchange market is defined simply as quantity of dollars desired equal to quantity of dollars offered, which is equivalent to quantity of yuan desired equal to quantity of yuan offered; see Figure 3.



Figure 3: Equilibrium in the Dollar-Yuan Market

As the alert student will have noticed by now, the equilibrium value of the dollar is one half; in equilibrium the quantity of dollars traded is 20 and the quantity of yuan traded is 10. The analytical solution is found in the appendix for students interested in working through the formal derivation.

### **China's Undervalued Currency**

Suppose now that China sets a dollar-yuan exchange rate of one—that is, the yuan is undervalued and the dollar is overvalued. This is shown in Figure 4. In this example, when the value of the dollar is one, the quantity of yuan desired is 40 and the quantity of yuan offered is 5. The quantity of dollars offered is 50 and the quantity of dollars desired is 5.

#### Figure 4: China's Undervalued Yuan



The Chinese government, which controls the supply of yuan is in a position to support this non-equilibrium exchange rate. It simply supplies 35 yuan and accumulates 35 dollars.

The number of dollars put into the market by private agents (40) is clearly larger than the number of dollars desired by private agents (5) at the fixed (disequilibrium) value of the dollar of one. We would argue that our method helps students "see" that an export-led growth strategy leaves the supporting country awash in its competitor's currency. Export-led growth only works when consumers in the U.S. are buying, and it requires that the Chinese government find assets in which to hold their dollars, making them vulnerable to forces in the U.S. economy that weaken those dollars. China can bluster all it wants, but it cannot both dump its holdings of U.S. assets and undervalue its currency.

One reason that has been mentioned for China's policy is that it can use its Sovereign Wealth fund for precautionary purposes, perhaps taking a lesson from its neighbors' troubles during the Asian Crisis. To the extent that China has been a destination for global financial capital, it might be the case that, for whatever reason, those global investors decide to take their funds out of China. Hot money can flee as fast as it enters. If the Chinese government were willing to accept a devaluation in the yuan, then it would not need to intervene in the foreign exchange market. But it is not, and again, it must absorb the dollars required to support its currency.

### THE POUND-EURO MARKET: CAPITAL FLOWS

If students have just finished the dollar-yuan discussion above, we need only to explain how this example differs from the previous one. On the other hand, if this section is presented on its own, then a few introductory comments are required. First, the slope of any ray from the origin is the value of the pound relative to the euro because the pound is on the horizontal axis and the euro is on the vertical axis. The dark solid convex offer curve in Figure 5 labeled  $\pounds_0 \rightarrow \bigoplus_0$  reflects the wishes of agents holding pounds that want to exchange them for euros. The dark solid concave offer curve labeled  $\pounds_0 \rightarrow \pounds_0$  reflects the wishes of agents holding euros that want to exchange them for pounds. The equilibrium value of the pound is found where the offer curves intersect. The value of the pound is 1.1 corresponding roughly to its value in December 2009. The equilibrium number of pounds traded is 100 and the number of euros is 110.



Figure 5: Decrease in the Pound-Euro Offer Curve

Although we are still simplifying the real world greatly for classroom presentation (notice the whole numbers for quantities and parameters in the appendix) we have attempted to show relatively realistic exchange rates. This is the reason why we moved the origin to (70,70) and omitted the portion of the offer curves near the axes.

It goes without saying that the pound/euro exchange rate affects agents in many ways: travel, imports and exports, remittances, and a whole host of other things. To simplify the presentation we will focus on capital flows. The original offer curve  $\pounds_0 \rightarrow \emptyset_0$  includes the agents wanting to purchase euro-denominated assets. The key point is that the fiscal crisis in Europe might prompt some agents who otherwise would have been buying euro-denominated assets to forgo those purchases. In that case, other things being equal, the quantity of euros desired would decrease. In this context "other things being equal" means along any ray from the origin because the exchange rate is constant for points along any such ray. The shift in the

pound-euro offer curve to the dark dashed curve labeled  $\pounds_1 \rightarrow \pounds_1$  reflects this shift. The value of the pound rises to about 1.15, while the quantity of pounds traded falls to a little over 90 and the quantity of euros traded falls to about 105. (Although students may not be aware of it, the shift in Figure 5 is designed to produce a "clean" example when combined with the shift in Figure 6 to produce Figure 7.)

If the only goal were to illustrate the direction of the effect of the fiscal crisis on exchange rates, then Figure 6 would be sufficient. But, in fact, we expect the crisis would increase the number of agents holding euros that wish to purchase pound- denominated assets. This is shown in Figure 6 as a shift from  $\mathcal{E}_0 \rightarrow \mathcal{E}_0$  to  $\mathcal{E}_1 \rightarrow \mathcal{E}_1$ . The latter reflects higher quantities of both pounds and euros along any ray from the origin.



#### Figure 6: Increase in Euro-Pound Offer Curve

In this case the value of the pound again increases to about 1.15, while the quantity of pounds increases to about 104 and the quantity of euros increases to almost 120. The exchange rate prediction is similar to that of the previous figure, but notice that while the quantity of euros goes up in both figures, the quantity of pounds goes up here and down in the previous case.

Figure 7 combines the shifts of Figures 5 and 6 in the same space. The effect of both shifts together on the value of the pound is to increase it from 1.1 to 1.2. Thus it roughly captures the actual behavior of the pound in the six month window under consideration.



Figure 7: Net Capital Outflows from Europe to the U.K.

The quantity of euros traded increases from 110 (December) to 114 (June) while the quantity of pounds traded decreases from 100 (December) to 95 (June). It might be noted that the figure could have been drawn in such a way that the quantity of pounds could be held constant or increase. But we have shown a decrease in pounds because it could be the case that the fiscal crisis prompts some agents to switch from euro-denominated assets to assets denominated in, for example, dollars. It goes without saying that the relationship between Britain and the euro zone is a complex one (*The Economist*, 2010), but the fiscal crisis shows that exchange rates matter.

## CONCLUSION

The primary argument of the present paper is that currency offer curves are a simpler more efficient way of teaching exchange rates than traditional supply and demand. On the other hand, they offer more rigor than a simple verbal treatment. We have chosen to illustrate two issues from the headlines, but the method could be used to do any of the standard examples in an exchange rate unit. For example, Figures 5-7 could as easily be used to illustrate a world in which U.K. income is falling while euro-zone income is rising. In our classes we would spend a significant amount of time discussing the fact that the fiscal crisis we illustrated would have a qualitatively similar effect on exchange rates as a U.K. recession coupled with expansion in Europe. Students are aware that the first is seen in the popular media as reflecting well on the U.K. while the latter would be most definitely problematic. Students enjoy a certain irony. As for future work, we speculate that India would provide an excellent case study to the extent that

it is accused of a one-sided exchange rate policy, i.e., tolerating depreciations but not appreciations.

#### REFERENCES

- DeLong, J. B. (2010, May 27). The Flight To Quality. Retrieved June 7, 2010, <u>http://www.project-syndicate.org/commentary/delong102/English</u>
- Derrick, S. (2010). When will China Change Yuan Policy. BBC News. Retrieved June 7, 2010, http://news.bbc.co.uk/2/hi/business/8609007.stm
- Highfill, J. (2008). The Economic Crisis as of December 2008: The Global Economy Journal Weighs In. *Global Economy Journal*, 8(4), Article . Retrieved June 7, 2010, http://www.bepress.com/gej/vol8/iss4/4/
- Krugman, P.R., & M. Obstfeld (2009). *International Economics: Theory and Policy (Eighth Edition)*. Boston, MA: Pearson.

Perfidious Albion Again (2010, May 22). The Economist 395(8683): 58.

The Spend is Nigh (2009, August 1). The Economist 392(8642): 65-66.

Trichet, J.-C. (2010, May 31). European Central Bank. Retrieved June 7, 2010, http://www.ecb.int/press/key/date/2010/html/sp100531\_1.en.html

#### APPENDIX

The offer curve analysis of the present paper assumes isoelastic demand functions for both currencies, specifically,

$$Q_D^{\Psi} = a_{\Psi} \left(\frac{\$}{\Psi}\right)^{-m}$$

$$Q_D^{\$} = a_{\$} \left(\frac{\Psi}{\$}\right)^{-n}$$
(A.1)
(A.2)

where all parameters are positive. This is equivalent to assuming an elasticity of -m for the demand for yuan and -n for the demand for dollars. Using the identity

$$\frac{\$}{\$} = \frac{Q_S^{\$}}{Q_D^{\$}}$$

these can be rewritten

$$Q_D^{\Psi} = (a_{\Psi})^{\frac{1}{1-m}} (Q_S^{\$})^{\frac{m}{m-1}}$$

$$Q_S^{\Psi} = a_{\$}^{1/n} (Q_D^{\$})^{n-1/n}.$$
(A.3)
(A.4)

Equation (A.3) is the dollar-yuan offer curve where  $Q_D^{\sharp}$  is the quantity of yuan desired and  $Q_s^{\$}$  is the quantity of dollars offered or supplied. Similarly, (A.4) is the yuan-dollar offer curve.

The equilibrium condition is  $Q_D^{\sharp} = Q_S^{\sharp}$  so that

$$a_{\pm}\left(\frac{\$}{\pm}\right)^{-m} = Q_{D}^{\mp} = Q_{S}^{\mp} = a_{\$}\left(\frac{\$}{\pm}\right)^{n-1}$$

so that

$$a_{\$} \left(\frac{\$}{\$}\right)^{m} = a_{\$} \left(\frac{\$}{\$}\right)^{1-n}$$

$$\left(\frac{\$}{\$}\right)_{EQ} = \left(\frac{a_{\$}}{a_{\$}}\right)^{\frac{1}{m+n-1}} = \left(\frac{5}{40}\right)^{\frac{1}{2+2-1}} = \frac{1}{2}.$$
(A.5)

The quantities, which this approach is designed to highlight, are

$$Q_{EQ}^{\$} = a_{\$} \left(\frac{\Psi}{\$}\right)^{-n} = a_{\$} \left(\frac{a_{\$}}{a_{\$}}\right)^{\frac{-n}{m+n-1}} = (a_{\$})^{\frac{m-1}{m+n-1}} (a_{\$})^{\frac{n}{m+n-1}} = (5)^{\frac{2}{2+2-1}} (40)^{\frac{2}{2+2-1}} = (5)^{\frac{1}{3}} (40)^{\frac{2}{3}} = 20$$
(A.6)

and

$$Q_{EQ}^{\Psi} = a_{\$} \left(\frac{\$}{\Psi}\right)^{n-1} = a_{\$} \left(\frac{\Psi}{\$}\right)^{1-n} = a_{\$} \left(\frac{a_{\$}}{a_{\Psi}}\right)^{\frac{1-n}{m+n-1}} = (a_{\$})^{\frac{m}{m+n-1}} (a_{\Psi})^{\frac{n-1}{m+n-1}} = (5)^{\frac{2}{2+2-1}} (40)^{\frac{2-1}{2+2-1}} = 10.$$
(A.7)

Notice the latter substitutions in each equation assume the parameters of the present paper, namely, m = n = 2,  $a_x = 40$ , and  $a_s = 5$ .

The derivations for the pound/euro example are similar with an initial (December 2009) parameter set of m = n = 2,  $a_e = 90.9091$ , and  $a_f = 121$ . The second (June 2010) parameter set is m = n = 2,  $a_e = 79.1667$ , and  $a_f = 136.8$ .

Finally, it should be mentioned that although the analysis has relied on numerical examples, the qualitative results are similar as long as the currency demand functions are elastic. The model permits inelastic demand functions, but resulting curves are downward sloping rather than upward sloping. Further, stability still requires that the Marshall-Lerner condition be satisfied (Krugman and Obstfeld, 2009, 457-459).

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