20-1 To What Extent Are Tariffs Offset by Exchange Rates?

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ABSTRACT
In theory, tariffs are partially offset by a currency appreciation in the tariff-imposing country or by a depreciation in the country on which the tariff is imposed. Based on a calibrated model, this paper finds that US tariffs imposed in 2018 should not have had a large impact on the dollar but may have significantly depreciated the renminbi. This prediction is consistent with a high-frequency event analysis looking at the impact of tariff-related news on the dollar and the renminbi. Tariff-related news explains about one-third of the renminbi depreciation observed in 2018.

JEL Codes: F31, F42
Keywords: Tariffs, Exchange Rates, Dollar, Renminbi

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1 INTRODUCTION

In 2018 the United States imposed new tariffs of 6.8 percent on average on its imports from China,\(^1\) but the renminbi depreciated by 5.5 percent against the dollar. Indeed, a common argument against tariffs is that their effect is likely to be mitigated by endogenous movements in exchange rates (Stiglitz 2016). Of course, the appreciation of the dollar and the weakness of the renminbi could have resulted from other factors, such as the lift-off of the Fed policy rate in the United States and slowing growth in China.

The question addressed in this paper is the extent to which tariffs are offset by countervailing movements in exchange rates. The answer is based on both theory and evidence. I first present a simple model of an open economy applying a tariff on its imports. The authorities have domestic objectives in terms of inflation and employment and pursue these objectives through a Taylor rule. Introducing a tariff stimulates demand for home labor, leading to a currency appreciation. Importantly, the appreciation results from the fact that the central bank pursues domestic objectives in terms of inflation and employment and not that it tries to offset the tariff per se (the central bank does not target the exchange rate or the trade balance). I call the fraction of the tariff that is offset by currency appreciation the “exchange rate offset.” Similarly, I derive an expression for the exchange rate offset in response to a tariff imposed by foreign countries on home exports.

The model explains how the exchange rate offset depends on the circumstances—the currencies in which exports and imports are invoiced, whether the tariff is implemented immediately or announced for a future date, and whether the economy is at full employment.

A calibrated version of the model shows that the exchange rate offset is about 0.3 for an economy at full employment and may be much smaller if there is slack in the home labor market. Even if one assumes that the US economy was at full employment, the model cannot attribute to tariffs the substantial appreciation of the dollar observed in 2018 (7.9 percent according to the Federal Reserve Broad Index). One reason is that the increase in the average tariff over total US imports was not that large. Another reason is that a currency is more sensitive to tariffs on exports than to those on imports so that the dollar appreciation caused by the US tariffs may have been more than offset by the countertariffs imposed in the rest of the world.

By contrast, the model predicts a larger response of the renminbi to the US tariffs, mostly because of those targeted at Chinese exports. A calibrated version of the model predicts an effective depreciation of the renminbi of more than 1 percent, one third to one half of the multilateral renminbi depreciation observed in 2018.

I compare the model predictions with the results of a high-frequency study looking at how the dollar and renminbi responded to tariff-related news in 2018. The sample of news is constructed using the timeline reported by Chad P. Bown and Melina Kolb (2018) for US tariffs on imports from China. I look at

\(^1\) The United States imposed a 25 percent tariff on $50 billion of Chinese imports in July 2018, and 10 percent on $200 billion in September. With total US goods imports from China at $481 billion, this amounts to an average tariff of 6.8 percent on them.
whether there is an impact of tariff news on the renminbi-dollar exchange rate at time horizons of a few hours. I find no impact of tariff news on the dollar effective exchange rate; by contrast, the renminbi depreciates in response to US tariff news. The cumulative impact of the tariff news may have amounted to a depreciation of the renminbi of 1 percent.

The paper is related to several lines of literature. On the theoretical side, studies in the 1980s examined the macroeconomic impact of tariffs (Eichengreen 1981, Krugman 1982, Dornbusch 1987). More recent papers have followed a resurgence of interest in that topic (e.g., Erceg, Prestipino, and Raffo 2018, Lindé and Pescatori 2018). The main difference between the earlier and more recent studies is that in the new models, demand is determined by the intertemporal optimization of rational agents rather than an old-style Keynesian IS curve.

On the empirical side, some recent papers have compared the impact of exchange rates and of tariffs on trade flows. There is evidence that trade flows are more responsive to tariffs than to exchange rate movements (e.g., Fontagné, Martin, and Orefice 2018, for France). Agnès Bénassy-Quéré, Matthieu Bussière, and Pauline Wibaux (2018) find that exports are more responsive to a tariff cut in the destination country than to a real depreciation of the same amount in the source country. Using impulse response functions estimated over a large sample of countries, Davide Furceri and colleagues (2018) find that tariffs result in real exchange rate appreciations. There is evidence that the United States experienced complete passthrough of the recent tariffs into domestic prices of imported goods (Amiti, Redding and Weinstein, 2019; Faigelbaum et al. 2019). Finally, there is a large literature on the impact of news on exchange rates (e.g., Faust et al. 2006). In a closely related study, Gloria Li (2019) finds evidence that the offshore yuan depreciated relative to the dollar when the United States imposed or announced tariffs and appreciated when trade talks resulted in the delay of tariffs.

2 THEORY

This section presents a simple model of the exchange rate offset. The model assumptions, which are standard in modern international macroeconomic theory, are summarized here and presented in more detail in appendix A. The model features a small open economy whose domestic demand results from intertemporal optimization by domestic consumers. Wages are sticky in the short run and there is a Phillips curve linking home production to wage inflation. The domestic monetary authorities implement a Taylor rule to achieve an inflation target consistent with full employment. The monetary authorities thus care about the exchange rate or the trade balance only to the extent that these variables affect domestic inflation and employment. The prices of exports are set in the currency of the exporter (the so-called producer currency pricing assumption).

The question is by how much the currency appreciates when a tariff on imports is introduced. I define the exchange rate offset as the amount by which the domestic currency appreciates following the imposition of a 1 percent tariff on all imports. For example, an offset of 1 means that the exchange rate

2 See Eichengreen (2019) for a review.
appreciates one-for-one in response to the tariff. Similarly, one can define the exchange rate offset for a tariff on all exports as the fraction of the tariff that is offset by a depreciation of the home currency. Assuming linearity, the impact of a uniform tariff covering all imports on the exchange rate can be estimated simply by multiplying the change in the tariff by the offset coefficient. If the tariff is not uniform and applies only to some imports, one multiplies the change in the average tariff by the offset coefficient.

The value of the exchange rate offset depends on several ancillary assumptions about the state of the economy and the nature of the tariff: Is the home economy at full employment when the tariff is imposed? Is the tariff implemented immediately or in the future? I start with the case where the economy is at full employment and the tariff is permanent, and then discuss different circumstances.

2.1 Permanent Tariff under Full Employment

The benchmark case is that of a permanent tariff on imports unexpectedly introduced in a steady-state equilibrium with full employment. Other things equal, the tariff raises the demand for home labor (by shifting home demand away from imports), which generates inflationary pressures. The monetary authorities respond to the inflation, if it materializes, by raising the interest rate. With rational expectations, the interest rate does not need to increase in equilibrium: the home currency immediately appreciates to a level such that the economy stays at full employment and inflation remains equal to the target. The exchange rate adjusts to a new level that ensures that the total demand for the home good is unchanged after the introduction of the tariff.

Denoting the (log) value of the home currency in terms of foreign currency by \( e \), so that an appreciation of the home currency corresponds to an increase in \( e \), it is possible to show (see appendix A) that the exchange rate offset is given by

\[
\frac{de}{d\tau} = \varphi \frac{1}{1 + (e_x/\omega_H - 1)/e_m}. \tag{1}
\]

where \( \varphi \) is the share of imports on which the tariff is imposed, \( \omega_H \) is the share of the home good in home expenditure, \( e_m \) is the elasticity of substitution between the home good and foreign goods in home markets (the import elasticity), and \( e_x \) is the elasticity of substitution between the home good and foreign goods in foreign markets (the export elasticity).\(^3\)

If \( e_x > \omega_H \) (which I argue is the most plausible assumption) the exchange rate offset is between zero and one.\(^4\) The offset is less than one for the following reasons. If the domestic currency appreciated by the same amount as the tariff,

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\(^3\) New Keynesian open economy macroeconomic models generally assume that these elasticities are different (see, e.g., Galí 2015, chapter 8). As discussed in the next section, recent empirical literature has found the export elasticity to be significantly larger than the import elasticity (Feenstra et al. 2018).

\(^4\) An appreciation of the home currency raises home income in terms of foreign goods. The condition \( e_x > \omega_H \) ensures that this income channel is dominated by expenditure switching, so that the steady-state demand for the home good does not increase when the home currency appreciates.
the home goods would lose all the competitiveness gain from the tariff in home markets. On top of this, home goods would lose competitiveness in export markets so that on balance domestic employment would decrease. Thus to keep the home economy at full employment, the currency appreciation must be smaller than the tariff.

Another implication of equation (1) is that the exchange rate offset increases with import elasticity but decreases with export elasticity. A larger import elasticity magnifies the impact of the tariff on employment and requires a larger offsetting appreciation. Conversely, a larger export elasticity means that a smaller currency appreciation is required to offset the increase in domestic employment induced by the tariff.

Similarly, one can look at the endogenous response of the exchange rate to a tariff imposed on the country’s exports. Because the tariff reduces foreign demand for the home goods, it is offset by a depreciation (rather than an appreciation) of the home currency. As shown in appendix A, the offset coefficient is now given by

$$\frac{de}{d\tau^*} = -\phi^* \frac{1}{1-\omega_H(1-e_m)/e_x},$$

where $\phi^*$ is the share of the country’s exports that is subject to the tariff. The offset coefficient decreases with $e_m$ and is lower than one in absolute value if and only if $e_m$ is larger than one.

Depreciating the home currency has two opposite effects on the steady-state home demand for the home good. On one hand, it reduces home demand by reducing the country’s purchasing power, but on the other hand it shifts home demand toward the home good. If $e_m = 1$ these two effects cancel each other so that home demand for the home good does not depend on the terms of trade. In this case, a tariff on exports must be offset one-for-one by a currency depreciation to keep the volume of exports constant (an offset coefficient of one). If $e_m > 1$ the demand-switching effect dominates so that the offset coefficient is smaller than 1 in absolute value, and conversely, the offset coefficient is larger than 1 if $e_m < 1$.

### 2.2 Calibration

Table 1 reports the baseline calibration of the elasticities that appear in equations (1) and (2). The elasticities for imports and exports are from Robert Feenstra and colleagues (2018), who find that the price elasticity between goods exported by different countries is significantly higher than between home goods and imports in a given country. Their estimates for the import elasticity are close to 1 whereas those for the export elasticity are close to 3. I assume that $\omega_H = 0.85$, which is approximately equal to one minus the share of imports in GDP in the United States. With these values, the exchange rate offset implied by equation (1) for a uniform tariff on all imports is 0.28, i.e., a 10 percent tariff appreciates the currency by 2.8 percent.

The last parameter to estimate in equation (1) is $\phi$, the share of imports on which the tariff is imposed. For this I looked at “trade battles” in which the United States was involved (described in Bown and Kolb 2018). The results are
reported in table 2 (and the underlying computations are in appendix B). The table reports, for each trade battle, the average tariff applied ($\tau$), the share of US imports affected ($\phi$), and the dollar appreciation predicted by equation (1).\(^5\)

The first trade battle involved solar panels and washing machines. In January 2018, President Trump approved global safeguard tariffs on all imports of solar panels and washing machines. The tariff applied to solar panels was 30 percent, as reported in table 2.\(^6\) The second trade battle concerns steel and aluminum. In March 2018, the Trump administration announced tariffs of 25 percent on steel and 10 percent on aluminum on national security grounds. The average tariff on steel and aluminum, weighted by the 2018 value of imports, was 18.4 percent.\(^7\)

Table 1

**Calibration of elasticities**

<table>
<thead>
<tr>
<th>$\varepsilon_m$</th>
<th>$\varepsilon_x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>[0.5,1.5]</td>
<td>[2,4]</td>
</tr>
</tbody>
</table>

Note: The table reports the benchmark calibration of import elasticity ($\varepsilon_m$) and export elasticity ($\varepsilon_x$). Ranges of admissible values are indicated in brackets.

Table 2

**Estimated dollar appreciation in various US trade battles**

<table>
<thead>
<tr>
<th></th>
<th>Solar panels and washing machines</th>
<th>Steel and aluminum</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average tariff, $\tau$</td>
<td>30%</td>
<td>18.40%</td>
<td>6.80%</td>
</tr>
<tr>
<td>Share of imports, $\phi$</td>
<td>0.30%</td>
<td>2.20%</td>
<td>19.50%</td>
</tr>
<tr>
<td>Resulting dollar appreciation</td>
<td>0.02%</td>
<td>0.12%</td>
<td>0.37%</td>
</tr>
<tr>
<td></td>
<td>[0.01, 0.04]</td>
<td>[0.05, 0.22]</td>
<td>[0.16, 0.69]</td>
</tr>
</tbody>
</table>

Note: The table reports the average tariff and share of US imports for the first three “trade battles” described in Bown and Kolb (2018). The bottom line reports the resulting dollar appreciation predicted by equation (1) under the benchmark calibration as well as the calibration intervals (in brackets).

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\(^5\) The table shows only the tariffs that were effectively introduced in 2018. Thus, it does not include a fourth trade battle over autos and auto parts.

\(^6\) The tariff schedule, for this trade battle and the others, is more complicated than reported in the table. The tariff on solar panels is scheduled to fall to 15 percent after four years. The first 1.2 million washing machines imported each year face a 20 percent tariff, with additional imports facing a 50 percent tax. For simplicity, I assume a uniform tariff of 30 percent.

\(^7\) Exemptions of various durations were granted to selected countries. The tariff on Turkish steel was increased in August 2018 in response to the depreciation of the Turkish lira. For simplicity, I assume that the tariffs announced in March 2018 apply to all US imports of steel and aluminum.
Trump administration imposed a 25 percent tariff on $50 billion of Chinese goods in the summer of 2018, followed by a 10 percent tariff on an additional $200 billion worth of Chinese goods in September. The average increase in tariff for total US imports from China (which amounted to $481 billion) weighted by import value was 6.8 percent, and those imports amounted to 19.5 percent of US imports.

As shown in the bottom line of table 2, the model-predicted impact of these tariffs on the dollar effective exchange rate is negligible in the case of the solar panels, washing machines, and steel and aluminum. The reason is simply that the share of these goods in US imports is too small to make the tariffs macroeconomically significant. The trade war with China involves larger trade flows but even so explains a multilateral dollar appreciation of less than 0.4 percent. Taken together, the tariffs implemented in 2018 can explain a 0.5 percent effective appreciation of the dollar, about one fifteenth of the dollar appreciation observed in 2018.

Against this, US exports were subject to new or increased tariffs, which should have depreciated the dollar according to the model. In 2018, China increased the tariff rate on its imports from the United States by 10 percent (from about 8 percent to about 18 percent; see Bown, Jung, and Zhang 2019). Given our assumption that the import elasticity is one, the exchange rate offset coefficient on tariffs on exports is also equal to one according to equation (2). Since China represents a share of about 7 percent of US exports of goods, the Chinese tariffs may explain a 0.7 percent effective depreciation of the dollar. This dominates the impact of the US tariffs on imports so that it is not clear, on balance, that the US dollar should have appreciated as a result of the trade war.

One can apply the same approach to the Chinese currency instead of the dollar. About 6.4 percent of Chinese imports of goods come from the United States, so the Chinese tariffs should have appreciated the renminbi by 0.2 percent according to equation (1). At the same time, 19.2 percent of Chinese exports go to the United States, so the US tariffs should have depreciated the renminbi by 1.3 percent according to equation (2). On balance, the trade war should have depreciated the renminbi by more than 1 percent, according to the model.

The results are summarized in table 3, which reports the model-based estimates of the impact of the US tariffs imposed on China and Chinese tariffs imposed on the United States on the effective exchange rates of the dollar and renminbi. The impact on a country’s currency is estimated using equation (1) for its own tariff and equation (2) for the foreign tariff. The upshot is that the tariff war between the United States and China had a larger net impact on the renminbi than on the dollar. This is because, under my benchmark calibration, a country’s currency is more sensitive to a tariff on the country’s exports than a tariff on its imports, and a substantial share of Chinese exports goes to the United States.

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8 A 15 percent increase in the second tariff, initially announced for January 2019, was later postponed to June 15, 2019.

9 I set the value of \( a_2 \) to 0.81, which is approximately equal to one minus the share of imports in Chinese GDP. The values of \( \varphi \) and \( \varphi^* \) used in the computations are explained in appendix B.
2.3 Alternative Assumptions

The baseline model assumes producer currency pricing (PCP), i.e., that the price of an exported good is fixed in the currency of the exporter. Gita Gopinath (2016) argues that a more realistic assumption for many countries is that the price of imports and exports is fixed in terms of foreign currency (dollar or euro), which she calls dominant currency pricing (DCP). If the home economy is the United States, DCP implies that the dollar price of imports (net of tariff) does not change when the United States introduces a tariff. As a result, the gross price of imports increases by the full amount of the tariff. DCP implies that foreign exporters do not take advantage of the depreciation of their currency to mitigate the impact of the tariff on their competitiveness in the United States. This behavior may seem puzzling, especially if it were to persist in the long run, but there is evidence that it fits the facts. Gopinath and colleagues (2019) show that the US tariffs were almost totally passed through to the total prices of US imports from China.

How does DCP change the results of the exchange rate offset? I first consider the case of an economy that does not use the dollar as its currency. With DCP the dollar price and quantity of exports are fixed for a given foreign tariff. In steady state, therefore, a tariff on imports must be offset one-for-one by an appreciation of the home currency in order to keep the relative price of the home and foreign goods the same in the home market. That is, the exchangerate offset is equal to one for a uniform tariff on all imports, and equal to $\phi$ for a tariff that applies to a fraction $\phi$ of imports:

$$\frac{de}{d\tau} = \phi.$$  (3)

A foreign tariff reduces exports by an amount that is independent of the home exchange rate. To maintain full employment in steady state, the home currency must depreciate in order to stimulate the home demand for the home good. As shown in appendix A, the exchange rate offset for a foreign tariff applying to a fraction $\phi^*$ of home exports is given by

$$\frac{de}{d\tau^*} = -\phi^* \frac{\varepsilon_x}{\omega_H \varepsilon_m}.$$  (4)
The required exchange rate adjustment increases with the export elasticity and decreases with the import elasticity.

Equations (3) and (4) are the analogs of equations (1) and (2) in the case of DCP. Comparing these equations (and using the assumption \( c_x > w_H \)) it is easy to see that the exchange rate offsets are larger in absolute value under DCP than under PCP. Intuitively, the exchange rate needs to move more with DCP because there is no expenditure switching on the side of exports.

The analysis of DCP is different for the United States because the prices of both the home good and the foreign good are fixed in terms of dollars. This implies that the impact of a tariff on home employment cannot be instantaneously offset by a change in the exchange rate. US authorities must accept that inflation deviates from the target for some time after the imposition of a tariff on imports or exports.

What is the impact of an expected tariff? The model can be used to analyze the impact of announcing the introduction of a permanent tariff in the future. In the long run the currency appreciates, but how does it respond in the short run (at the time of the announcement)? This depends on the impact of the tariff announcement on output. If output is depressed by the announcement, the central bank lowers the interest rate, which tends to mitigate the appreciation of the currency. Conversely, if output is increased by the announcement, the central bank raises the interest rate, which tends to amplify the appreciation of the currency.

In general, the announcement of a future tariff on imports could increase or decrease output. There are two countervailing effects to consider. On one hand, the announcement of the tariff appreciates the currency prematurely (before the tariff is introduced), which tends to depress output. On the other hand, the announcement of a tariff, like the announcement of any tax on consumption, stimulates domestic consumption before the tariff is introduced. Which effect dominates depends on how the price elasticity of imports compares with the elasticity of intertemporal substitution of consumption.

Finally, the exchange rate offset also depends on how close the home economy is to full employment. In the baseline model, a tariff induces the monetary authority to raise the interest rate because the economy is at full employment. If it is not, the exchange rate offset could be much smaller. For example, assume that the economy is initially below full employment and employment cannot be increased using monetary policy because the interest rate is at the zero lower bound. By imposing a tariff, the country shifts demand toward the home good and increases the demand for home labor. Thus, the country can raise employment and inflation toward their respective targets by imposing a tariff if the economy is in a liquidity trap. In this case, there is no reason for the home currency to appreciate so that the exchange rate offset would be close to zero.10

10 The tariff is an effective tool to increase employment in a liquidity trap from a unilateral perspective, not from a multilateral one. In this type of model, tariffs reduce global demand and employment if they are used by all countries (Jeanne 2019).

11 The home currency may appreciate slightly because the country’s trade balance increases, which raises the country’s level of net foreign assets and appreciates the home currency in the long run, when the economy is back to full employment.
In conclusion, the imposition of a tariff generally leads to an appreciation of the currency of the tariff-imposing country. The exchange rate offset is partial and equal to about 0.3 under full employment in the calibrated model. The offset could be larger under different assumptions about pricing or the parameter values. It is likely to be smaller, possibly close to zero, if there is slack in the domestic labor market.

3 TARIFF NEWS, THE DOLLAR, AND THE RENMINBI

In this section I attempt to identify the impact of tariffs on the dollar and renminbi exchange rates using high-frequency news about tariffs. In principle, the news could have had a larger impact than predicted by the model to the extent that it affected expectations of tariffs to be introduced after 2018. The US administration announced increases in existing tariffs and entertained proposals to introduce new tariffs on macroeconomically significant imports, such as autos. The legal basis for the tariffs on steel and aluminum (that these imports threatened US national security) was unusual and constituted a radical departure from previous practices. Thus, market participants may have interpreted the 2018 tariffs as a signal about the trading partners’ willingness to engage in a wider trade war. As shown by the model, the impact of expected tariffs may be as large as that of actual ones.

I present the results of an event study showing a high-frequency impact of tariff news on the dollar-renminbi exchange rate as well as the multilateral effective exchange rates of the dollar and renminbi. For the renminbi I use the offshore exchange rate because it is traded during the day in US time, when most of the news took place. Data for the CNH/USD exchange rate were downloaded at 10-minute frequencies from Bloomberg.

Tariff news was identified from the Bown and Kolb (2018) timeline of events. The authors report days when major news or events related to US tariffs occurred. These events are heterogeneous in several ways. Some involved the imposition, announcement, or consideration of new tariffs by the United States. Others concerned the removal, announcement, or consideration of lower US tariffs. Still others related to tariffs imposed by the rest of the world. Some tariffs apply to specific categories of goods, others to specific countries or regions. I considered only news items in which the United States imposed or considered imposing higher tariffs on imports from China. I identified 12 news items in 2018, shown in table B3. As in Li (2019), Bloomberg News Search was used to determine the exact time of these announcements, which are usually reported within two minutes after being released by an official source.

The impact of the tariff news on the exchange rate was then measured first by regressing the change in the CNH/USD exchange rate on a dummy variable capturing the occurrence of tariff news in nonoverlapping time windows of different lengths (one, two, three, four, and five hours). The regression specification is

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12 I used the offshore CNH/USD exchange rate rather than its onshore counterpart (CNY/USD) because the latter is not traded at night in Chinese time, which is when most of the tariff-related news occurred.
\[
\frac{E_t - E_{t-k}}{E_{t-k}} = a + b D_t + \varepsilon_t
\]  

(5)

where \( E_t \) is the CNH/USD exchange rate at time \( t \), \( k \) is the length of the time window, and \( D_t \) is a dummy variable taking the value of 1 if tariff news occurred between \( t-k \) and \( t \).

The results are reported in figure 1, which shows the point estimate of coefficient \( b \) in regression (5). The solid line reports the estimated coefficient when the length of the time windows (reported on the horizontal axis) increases from one to five hours; it shows that the CNH depreciated by about 0.05 percent against the dollar on average following tariff news. The dashed lines show the 95 percent confidence interval: The impact of tariff news on the exchange rate is statistically significant for two hours but loses its significance for longer time windows.

**Figure 1**

**Impact of tariff news on the renminbi/dollar exchange rate**

![Graph showing the impact of tariff news on the renminbi/dollar exchange rate.](image)

*Note: The solid line shows the impact of tariff news on the CNH/USD exchange rate in percentage points over a time window of length indicated on the horizontal axis (in hours). The dashed lines report the 95 percent confidence interval. Source: Bloomberg and author’s computations.*

Do these results indicate that the dollar appreciated or that the renminbi depreciated in response to US tariff news? To answer this question we must look separately at the multilateral effective exchange rates of the dollar and renminbi. This is also more consistent with the model presented in section 2, which makes predictions about the multilateral exchange rate of a small open economy rather than bilateral exchange rates.

The US dollar effective exchange rate can be found on Bloomberg at the required frequency. For the renminbi, the effective exchange rate series must be constructed, which was done using the currencies of China’s eight most
Regression (5) was then run separately on dollar and renminbi effective exchange rates. The results are reported in figures 2 and 3 for the same time windows as in figure 1. The effective exchange rate is computed in such a way that a positive response means a depreciation of the currency.

Figure 2 shows that tariff news led to an effective appreciation of the dollar, as predicted by theory. This response built up over time but is statistically insignificant at all horizons. Figure 3 shows that the renminbi depreciated following US tariff news, also consistent with theory. This time, though, the impact of tariff news is statistically significant at all time horizons and seems permanent. The response of the bilateral exchange rate shown in figure 1, thus, reflects a depreciation of the renminbi rather than an appreciation of the dollar. This is consistent with the calibrated model, which predicted a larger impact of tariffs on the renminbi than on the dollar.

A crude way of estimating the impact of tariff news on the renminbi in 2018 would be to add the impact of all the news reported during that year. Since there were 12 news items and each depreciated the renminbi by about 0.1 percent (see figure 3) one could estimate the total impact of tariff news over 2018 to be about 1 percent. This impact is not negligible if one compares it with the multilateral

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Figure 2

Impact of tariff news on the dollar effective exchange rate

<table>
<thead>
<tr>
<th>Percentage point</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
</tr>
<tr>
<td>0.05</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>-0.05</td>
</tr>
<tr>
<td>-0.10</td>
</tr>
<tr>
<td>-0.15</td>
</tr>
<tr>
<td>-0.20</td>
</tr>
</tbody>
</table>

Note: The solid line shows the impact of tariff news on the US dollar effective exchange rate in percentage points over a time window of length indicated on the horizontal axis (in hours). The dashed lines report the 95 percent confidence interval.

Source: Bloomberg and author’s computations.

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13 The currency basket used to construct the renminbi effective exchange rate includes the US dollar (28.7 percent), euro (22.5 percent), Japanese yen (14.9 percent), Hong Kong dollar (14.1 percent), Australian dollar (6.7 percent), Malaysian ringitt (4.7 percent), Brazilian real (4.3 percent), and Indian rupee (4.1 percent). The weights are based on the sum of exports and imports using 2017 data from the World Bank’s WITS database. The Korean won and Vietnamese dong were omitted because of data limitations.
depreciation of the renminbi, which amounted to about 3 percent in 2018. According to this computation, the US tariffs explain about one third of the renminbi depreciation observed in 2018.

Of course, there are several reasons that this back-of-the-envelope computation might under- or overestimate the impact of tariffs on the dollar and the renminbi. The news reported in table B3 might miss a number of relevant events. It does not include the news related to decreases in US tariffs, or the announcement of tariffs imposed by China. And it does not account for Chinese attempts to resist depreciation at horizons longer than a few hours.

Notwithstanding these caveats, it is interesting to observe that this news-based analysis provides an estimate that is of the same order of magnitude as that predicted by the model: a small impact of tariffs on the dollar, and a larger impact on the renminbi, with a depreciation of about 1 percent.

4 CONCLUSIONS

This paper started with the observation that the US tariffs implemented in 2018 were largely offset by concomitant appreciation of the dollar and depreciation of the renminbi. In theory, however, there is no “theorem” to the effect that tariffs should be offset exactly by currency movements. If the home economy is not at full employment, the exchange rate offset on a tariff on imports could be very low.

The simple textbook model on which these conclusions are based does not incorporate all the relevant channels (e.g., the global supply chain disruption induced by the tariffs). It is not clear, however, how the inclusion of these other

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14 As noted in the introduction, the renminbi depreciated by 5.5 percent against the dollar, but this reflected mostly an effective appreciation of the dollar.
channels would change the results. Tariffs are similar to a negative productivity shock for the firms involved in the global supply chain. Other things equal, tariffs should depreciate the currencies of the countries that own the production factors (both capital and labor) used in the global supply chain.

On the empirical side, I looked for evidence of an impact of tariff news on the dollar and renminbi using high-frequency analysis. I found no impact of tariffs on the dollar. The dollar appreciation observed in 2018, thus, did not result from the tariffs (at least through the channels considered in this paper). By contrast, I found that tariffs had a significant impact on the renminbi. This impact was not large enough to offset the tariff but can explain about one third of the renminbi depreciation observed in 2018.
APPENDIX A
MODEL ASSUMPTIONS

The assumptions on the goods structure are similar to those in Jeanne (2019). I consider a small open economy populated by identical consumers who consume home goods as well as foreign goods. Time is discrete and infinite. The representative consumer’s utility is given by

\[ U = E[\sum \beta^t u(C_t)]. \tag{A1} \]

Consumption is a Constant Elasticity of Substitution (CES) index of the consumption of a home good \( H \) and a foreign good \( F \),

\[ C = \left[ \omega_H^{1/\varepsilon_m} C_H^{(\varepsilon_m-1)/\varepsilon_m} + \omega_F^{1/\varepsilon_m} C_F^{(\varepsilon_m-1)/\varepsilon_m} \right]^{\varepsilon_m/(\varepsilon_m-1)}, \tag{A2} \]

where \( \varepsilon_m \) is the import elasticity and \( \omega_H + \omega_F = 1 \). The foreign good is a CES aggregate of a large number of goods imported from foreign countries.

The home good is produced with home labor using a linear production function, \( Y = L \). Hence, the home currency price of the home good is equal to the nominal wage \( W \). The home currency price of the foreign good is \( (1 + \tau)P^* / E \), where \( \tau \) is the tariff on imports, \( P^* \) is the foreign currency price of the foreign good, and \( E \) is the price of the home currency in terms of foreign currency. To simplify the algebra the tariffs are assumed to apply to all imports and exports \( (\phi = \phi^* = 1) \).

With these assumptions, the home currency price of consumption is given by the CES price index

\[ P_C = \left[ \omega_H W^{1-\varepsilon_m} + \omega_F \left( (1 + \tau)P^* / E \right)^{1-\varepsilon_m} \right]^{1/(1-\varepsilon_m)}. \]

The home terms of trade are the price of exports in terms of imports, \( S = EW/P^* \). The home demands for the home and foreign good can then be written

\[ C_H = \omega_H \left( \frac{W}{P_C} \right)^{-\varepsilon_m} C = \omega_H \left[ \frac{p(S/(1+t))}{S/(1+t)} \right]^{\varepsilon_m} C, \]

\[ C_F = \omega_F \left( \frac{(1+t)P^* / \varepsilon}{P_C} \right)^{-\varepsilon_m} C = \omega_F p \left( \frac{S}{1+t} \right)^{\varepsilon_m} C, \]

where \( p(S/(1+t)) = (\omega_H S/(1+t) + \omega_F)^{1-\varepsilon_m} \) is the price of home consumption in terms of after-tax imports.

The foreign currency price of the home good in foreign markets is \( (1 + \tau^*)EW \), where \( \tau^* \) is the foreign tariff on home exports. The home good competes in export markets with foreign goods that are priced at \( P^* \) and are not subject to tariff \( \tau^* \). The demand for the home goods in foreign markets is \( M^*[S/(1 + \tau^*)]^{-\varepsilon_m} \), where \( M^* \) is total foreign imports and \( \varepsilon_e \) is the export elasticity. Under these assumptions the demand for home output, and the country’s next exports in terms of foreign good, can be written, in any period \( t \),

\[ Y_t = \omega_H \left[ \frac{p(S_t/(1+t))}{S_t/(1+t)} \right]^{\varepsilon_m} C_t + [(1 + \tau^*)S_t]^{-\varepsilon_m} M_t^*, \tag{A3} \]
\[ NX_t = S_t[(1 + r^t)S_t]^{-\varepsilon_x}M_t^* - \omega_F p(S_t/(1 + \tau_t))^{\varepsilon_m}C_t. \]  

(A4)

The two terms on the right-hand side of (A3) are respectively the home demand \( \phi_t \) and foreign demand for the home good. The right-hand side of equation (A4) is the difference between home exports and home imports \( C_t \) expressed in terms of the foreign good.

There is free capital mobility, implying the interest parity relationship

\[ 1 + i_t = (1 + r)(1 + \pi_{t+1}) \frac{S_t}{S_{t+1}}, \]  

(A5)

where \( i_t \) is the home nominal interest rate, \( \pi_t = \frac{w_t}{w_{t-1}} - 1 \) is home wage inflation, and \( r \) is the global interest rate in terms of the foreign good.

I assume that the relationship between home wage inflation and home output is characterized by the following Phillips curve,

\[ \pi_t = \pi(Y_t), \]  

(A6)

where \( \pi(\cdot) \) is an increasing function. Finally, I assume that the home monetary authorities follow a Taylor rule,

\[ 1 + i_t = (1 + r)(1 + \hat{\pi})^{-a}(1 + \pi_t)^{1+a}, \]  

(A7)

where \( \hat{\pi} \) is the inflation target. I denote with \( \hat{Y} \) the output level associated with the inflation target resulting from the Phillips curve (A7), the “output target.”

Let us consider a steady-state equilibrium with constant tariffs \( r \) and \( r^* \), constant foreign imports \( M^* \), and zero home foreign assets. Interest parity, the Phillips curve, and the Taylor rule—equations (A5), (A6), and (A7)—imply that inflation and output are equal to their respective target levels. The home net exports are equal to zero in a steady state with zero foreign assets. Using \( NX = 0 \) and equation (A4) to substitute out \( C_t \) from (A3) one obtains

\[ \hat{Y} = [(1 + \tau^*)S]^{-\varepsilon_x} \left[ 1 + \frac{\omega_N}{\omega_F} \left( \frac{S}{1+t} \right)^{-\varepsilon_m} \right] M^*. \]  

(A8)

The wage level does not change with the tariff and under PCP, \( P^* \) is fixed so that \( ds/dr = de/dr \) and \( ds/d\tau^* = de/d\tau^* \) where \( e = \log E \) and \( s = \log S \). Differentiating (A8) around a steady state with \( r = r^* = 0 \) and \( S = 1 \) gives equations (1) and (2) in the text.

Under DCP, the dollar price of exports is fixed so that the quantity and dollar value of exports can be moved only by the foreign tariff \( \tau^* \). As a result, equations (A3) and (A4) become

\[ Y_t = \omega_N p \left[ \frac{(S_t/(1+\tau_t))^\varepsilon_x}{S_t} \right]^{\varepsilon_m} C_t + (1 + \tau^*)^{-\varepsilon_x}M_t^*, \]  

(A9)

\[ NX_t = (1 + \tau^*)^{-\varepsilon_x}M_t^* - \omega_F p \left( \frac{S_t}{1 + \tau_t} \right)^{\varepsilon_m} C_t. \]  

(A10)
Hence, a steady state with $NX = 0$ and $Y = \dot{Y}$ must satisfy

$$\dot{Y} = (1 + \tau^*)^{-\varepsilon_x} \left[ 1 + \frac{\omega_H}{\omega_F} \left( \frac{S}{1+\tau} \right)^{-\varepsilon_m} \right] M^*,$$

which replaces equation (A8). Differentiating (A11) around a steady state with $\tau = \tau^* = 0$ and $S = 1$ gives equations (3) and (4) in the text.
APPENDIX B
DATA

The data in table 2 were constructed using data from UN Comtrade and the IMF Direction of Trade Statistics (DOTS). Table B1 reports the trade flows for goods (not services) between the United States, China, and the rest of the world in billions of US dollars, based on the 2018 DOTS free on board (FOB) exports data. The table shows the flow of exports from the column entity to the row entity. For example, the flow of exports from the United States to the rest of the world amounted to $1,664 billion whereas the flow of exports from the rest of the world to the United States (i.e., US imports) amounted to $2,468 billion.

Based on table B1 the shares of Chinese goods in US imports and exports are respectively $481/2,468 = 19.5 percent and $120/1,664 = 7.2 percent. The shares of US goods in Chinese imports and exports are respectively $120/1,872 = 6.4 percent and $481/2,501 = 19.2 percent.

Table B2 reports the US imports of the goods that were taxed in the context of the non-China trade wars from UN Comtrade.

The list of tariff news used in section 3 is shown in table B3. (The identification of the news is explained in the main text.)

Table B1
Trade flows between the United States, China, and the rest of the world, 2018 (billions of US dollars)

<table>
<thead>
<tr>
<th>Rest of world</th>
<th>United States</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest of world</td>
<td>—</td>
<td>1,664</td>
</tr>
<tr>
<td>United States</td>
<td>2,468</td>
<td>—</td>
</tr>
<tr>
<td>China</td>
<td>1,872</td>
<td>120</td>
</tr>
</tbody>
</table>

Table B2
US imports of selected goods, 2018

<table>
<thead>
<tr>
<th>Solar panels (HS 854140)</th>
<th>Washing machines (HS 8450)</th>
<th>Steel (HS 72)</th>
<th>Aluminum (HS 76)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value (billions of US dollars)</td>
<td>5.6</td>
<td>1.4</td>
<td>31.1</td>
</tr>
<tr>
<td>Share of US imports (percent)</td>
<td>0.2</td>
<td>0.1</td>
<td>1.3</td>
</tr>
</tbody>
</table>
The data in table 2 were constructed using data from UN Comtrade and the IMF Direction of Trade Statistics (DOTS). Table B1 reports the trade flows for goods (not services) between the United States, China, and the rest of the world in billions of US dollars, based on the 2018 DOTS free on board (FOB) exports data. The table shows the flow of exports from the column entity to the row entity. For example, the flow of exports from the United States to the rest of the world amounted to $1,664 billion whereas the flow of exports from the rest of the world to the United States (i.e., US imports) amounted to $2,468 billion.

Based on table B1 the shares of Chinese goods in US imports and exports are respectively $1,872 / $2,468 = 7.2 percent and $120 / $1,664 = 7.2 percent. The shares of US goods in Chinese imports and exports are respectively $120 / $1,872 = 6.4 percent and $481 / $2,501 = 19.2 percent.

Table B2 reports the US imports of the goods that were taxed in the context of the non-China trade wars from UN Comtrade. The list of tariff news used in section 3 is shown in table B3. (The identification of the news is explained in the main text.)

### Table B3
**US tariff news, March 22–September 17, 2018**

<table>
<thead>
<tr>
<th>Date</th>
<th>News</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>March 22, 2018</strong></td>
<td>Trump administration releases report finding China is conducting unfair trade practices related to technology transfer, indicates forthcoming remedies of tariffs on up to $60 billion of Chinese products.</td>
</tr>
<tr>
<td><strong>April 3, 2018</strong></td>
<td>Trump administration releases $50 billion list of 1,333 Chinese products under consideration for 25 percent tariffs.</td>
</tr>
<tr>
<td><strong>April 5, 2018</strong></td>
<td>US considers additional tariffs on $100 billion of US imports from China.</td>
</tr>
<tr>
<td><strong>May 29, 2018</strong></td>
<td>White House releases statement stating intention to impose tariffs on $50 billion of goods from China shortly after announcing the final list on June 15, 2018.</td>
</tr>
<tr>
<td><strong>June 15, 2018</strong></td>
<td>USTR releases revised list of tariffs on almost $50 billion of Chinese product starting July 6, 2018.</td>
</tr>
<tr>
<td><strong>June 18, 2018</strong></td>
<td>Trump directs USTR to identify $200 billion worth of Chinese goods for additional tariffs at 10 percent.</td>
</tr>
<tr>
<td><strong>July 6, 2018</strong></td>
<td>US and China impose first phase of June 15 tariff lists.</td>
</tr>
<tr>
<td><strong>July 10, 2018</strong></td>
<td>USTR releases a list of $200 billion of imports from China to be subject to new 10 percent tariffs.</td>
</tr>
<tr>
<td><strong>July 20, 2018</strong></td>
<td>Trump threatens tariffs on all imports from China in interview.</td>
</tr>
<tr>
<td><strong>August 1, 2018</strong></td>
<td>Trump wants 25 percent tariff, instead of 10 percent, on $200 billion list of imports released in July.</td>
</tr>
<tr>
<td><strong>August 7, 2018</strong></td>
<td>USTR finalizes second tranche of tariffs on $16 billion of Chinese goods.</td>
</tr>
<tr>
<td><strong>September 17, 2018</strong></td>
<td>Trump announces tariffs on $200 billion of Chinese imports taking effect on September 24. The rate is 10 percent to the end of 2018 but will rise to 25 percent.</td>
</tr>
</tbody>
</table>

*Sources: Bown and Kolb (2018), Bloomberg News Search.*
REFERENCES


