MEASURING THE EFFECTS OF DOLLAR APPRECIATION ON ASIA: A FAVAR APPROACH

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Abstract. Exchange rate shocks have mixed effects on economic activity in both theory and empirical VAR models. In this paper, we extend the empirical literature by considering the implications of a positive shock to the U.S. dollar in a factor-augmented vector autoregression (FAVAR) model for the U.S. and three large Asian economies: Korea, Japan and China. The FAVAR framework allows us to represent a country's aggregate economic activity by a latent factor, generated from a broad set of underlying observable economic indicators. In addition, to control for global conditions in our specification, we introduce a "global conditions index," an additional latent factor generated from the economic indicators of major trading partners. Our results suggest that a dollar appreciation shock has a negative impact on not only the U.S. economy, but also on all three Asian economies. This finding suggests that despite their disparate economic structures and policy regimes, the primary impact of dollar movements for the Asian economies we consider is through its effect on U.S. aggregate demand, rather than their export competitiveness.

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I. Introduction

With the expected onset of policy normalization in the United States in the second half of 2014 through the first half of 2015, the U.S. dollar appreciated significantly. This appreciation is an important channel for the transmission of monetary policy normalization, as the exchange rate appreciation in the United States would be expected to result in expenditure-switching in favor of foreign goods and thereby reduce U.S. economic activity, holding all else equal.[1] Simulations from calibrated DSGE models, such as Mendoza (1995) have found that terms of trade shocks can result in large temporary disruptions from the steady state.

Holding all else constant, this expenditure-switching effect would be expected to result in an improvement in the trade balance, and ceteris paribus of the income, of U.S. trading partners. However, the implications of terms of trade depreciation for even a country's trade balance has been recognized to be ambiguous for some time. In particular, the well-known Harberger-Laursen-Metzler effect implies that a transitory deterioration in a country's terms of trade will reduce domestic savings, holding all else equal, and therefore reduce a country's current account balance (Svensson and Razin, 1983). If the terms of trade deterioration is permanent, however, Obstfeld (1982) shows that there is a negative wealth effect that may increase savings, rendering the general effects of a terms-of-trade shock ambiguous.[2]

In addition to the terms of trade effect, the reduction in U.S. activity following a dollar appreciation shock implies a reduction in overall demand in the United States, including demand for foreign goods. This may in turn depress an Asian country's exports to the U.S., and thereby its eocnomic activity. This possibility has been stressed by U.S. monetary policymakers in their assessment of the global implications of U.S. monetary policy during the global financial crisis and the subsequent recovery. For example, Ben Bernanke (Bernanke, 2014) recognized the possibility that appropriate monetary policy for the United States may have undesirable consequences for its trading partners, particularly for emerging market

[1]The presence of global monetary policy spillovers raises the question of the scope for international policy coordination. Most studies find that the effective scope for policy coordination is limited, although it has been argued that in exceptional circumstances, such as the global financial crisis, the potential gains from such coordination can be quite large [e.g. Coeuré (2016)].

[2]This ambiguity can be resolved for a variety of special cases. For example, Kraay and Ventura (2000) demonstrate that in the case where investors allocate a marginal change in wealth in the same proportion as their existing asset holdings, a positive shock to income in a debtor country will increase its current account deficit. It has also been shown that the magnitude of the so-called expenditure-switching effect of an exchange rate change can be mitigated by firms pricing their goods to market [e.g. Devereux and Engel (2003)]. Alternatively, Agénor and Aizenman (2004) demonstrate that countries that face borrowing constraints may disproportionately save the proceeds of positive terms of trade shocks, improving their current account.

economies that are vulnerable to abrupt changes in the pace of capital movements. But he stressed that any "costs" of these policies to those countries must be assessed against the benefits of supporting recovery in the advanced economies. Similarly, Federal Reserve Vice Chair Stanley Fischer (Fischer, 2014) noted that while the onset of policy tightening in the United States in 2015 may have put pressure on some emerging market assets, one reason for optimism was again that the policy tightening was taking place "... against the backdrop of a strengthening U.S. economy and in an environment of improved household and business confidence." The implications of both of these speeches is that the strength of U.S. demand is of important concern for emerging market countries that rely on the U.S. as a market for their exports.

Sensitivity to external shocks, including those from the United States, has also been shown to depend on a country's domestic policy regime. In particular, exchange rate regimes have been shown to play an important role in the determination of sensitivity to external exchange rate shocks. The well-known "trilemma" argument implies that emerging market economies will enjoy superior monetary independence with floating rates. To the extent that these countries resist accommodative interest rate changes in response to external shocks, they are likely to experience real depreciations in the wake of positive shocks to the dollar. For countries with rigid or slowly moving pegs against the dollar, however, the dynamics can be quite different. Countries pegged to the dollar will experience an appreciation along with that currency vis-a-vis the rest of the world. As such, the adverse implications of potential declining U.S. demand from a dollar appreciation shock for countries with dollar pegs are likely exacerbated by positive terms of trade movements against the rest of the world, leaving those country's exports less competitive.

One notable example of the latter case is China, whose currency, the renminbi, closely followed the dollar over this period. The result can be seen in Figure 1. As the dollar appreciated in anticipation of policy normalization since the middle of 2014, the trade-weighted renminbi moved along with it. By the end of our sample, the real effective exchange rate (REER) of the U.S. dollar had appreciated 2.77 percent, while that of the renminbi had appreciated a close-to-equivalent 3.21 percent. In contrast, both the trade-weighted South Korean won and the trade-weighted Japanese yen depreciated over the same period, although less than one might expect because the United States is the destination for only a modest share of these countries' exports relative to their trade with the rest of Asia and Europe.[3]

Most of the empirical work done on the implications of external monetary or exchange rate rate shocks finds international policy spillovers. For example, Calderon et al. (2002) find that real exchange depreciations are negatively related to current account deficits for a

[3]The Korean won REER depreciated by 0.40 percent, while the yen REER depreciated by 1.85 percent.

broad panel of countries, suggestive of expenditure-switching effects. However, it has also been shown that a significant role exists for exchange rate and capital account regimes to influence a nation's sensitivity to monetary shocks. Shambaugh (2004) finds that pegged countries largely follow the interest rates of their base currencies. As a result, di Giovanni and Shambaugh (2008) find that high interest rates in industrial countries result in contractionary responses in pegged countries, but little identifiable relationship in floating countries. Broda (2004) also finds that flexible exchange rate regimes are more insulated from terms of trade shocks.[4] Similarly, Kim (2001) finds that expansionary U.S. monetary policy shocks from 1974 through 1996 tended to increase economic activity in the non-U.S. G6, primarily due to the implications of U.S. monetary shocks for global interest rates.[5]

In contrast to the exchange rate regime, there is less evidence that capital controls have a systematic impact on a nation's sensitivity to external monetary shocks [e.g. Miniane and Rogers (2007)]. The failure of capital controls to viably insulate a country from external monetary shocks has been associated with outstanding stocks of foreign currency debt [Towbin and Weber (2000)], which can result in national balance sheet deterioration in the wake of exchange rate depreciations, or changes in global risk tolerance [e.g. Rey (2015)].

There has also been work done on the Asian countries featured in this study. Kim and Yang (2012) examine the impact of U.S. monetary policy shocks on a number of East Asian countries, including Korea, Japan and China, using monthly data from June 1999 through June 2007. Their study characterizes China as pursuing a de facto crawling peg against the dollar, while Korea and Japan appear to be more flexible. However, they find that the Korean exchange rate regime is more mixed in practice, despite its status as an inflation targeter over much of the period, as at times it tolerated deviations from its inflation target to achieve exchange rate smoothing goals.

In this paper, we evaluate the implications of dollar appreciation on conditions in both the United States and in three major U.S. Asian trading partners: Korea, Japan, and China. In addition to bringing the responses to exchange rate shocks to bear on the long-standing questions of the impacts of monetary and terms of trade shocks, we also make a methodological extension to the literature through the use of a factor-augmented vector autoregression, or FAVAR, representation as used by (Bernanke and Boivin, 2003) and (Bernanke et al., 2003). To our knowledge, our paper is the first use a FAVAR framework approach to evaluate other countries' sensitivities to external exchange rate shocks. We estimate separate FAVAR representations for the United States, as well as each of the other Asian countries. In addition

[4]In a recent paper, Schmitt-Grohé and Uribe (2013) find little impact of terms of trade shocks for a mixed group of poor and emerging market economies in VAR framework.

[5]There is also evidence of spillovers from the unconventional U.S. policies pursued during the global financial crisis [e.g. Bowman et al. (2015) and Chen et al. (2016)].

to using a FAVAR approach for the representation of a local activity index, we also estimate a latent index of foreign activity, individually weighted by trade volumes for each country, as described below. This country-specific "global conditions index" provides a novel way of conditioning for changes in relevant foreign activity and should assist in isolating the dollar appreciation effects in which we are interested.

As discussed by Bernanke and Boivin (2003), a FAVAR approach is particularly suited to the analysis of concepts that are imperfectly observed latent variables [e.g. As these authors note, a FAVAR approach may even be beneficial for evaluation of economic conditions in the United States, as "economic activity" is a concept that is not directly observable. A number of alternative measures of these concepts may be useful, and the FAVAR approach provides one coherent approach for mixing these series, namely through the use of factor analysis. (Bernanke et al., 2003) argue that combining the data in this manner may provide superior estimates to using a single data series for each concept. Moreover, a FAVAR model has the advantage over a standard vector autoregressive (VAR) framework in mitigating the need for ad hoc specification decisions. As discussed in (Fernald et al., 2014), the use of a FAVAR framework suggests that these estimated latent activity factors are likely to be more accurate measures of activity than any individual reported data series. Moreover, they may also better reflect the information sets relevant to policymakers or used by economic agents to make decisions.

The FAVAR approach should be particularly useful for assessing economic activity in China. Skepticism about the accuracy of Chinese data is well-known [e.g. (Fernald et al., 2015)], both due to the extensive structural changes that have taken place recently in that country and also to systematic distortions aimed at reaching output targets.[6]

We include two activity factors: The first is a local conditions index (LCI), designed to reflect domestic economy activity. We load nine indicators of domestic economic activity, described in more detail below, and estimate the first principal component as our measure of local conditions. We also estimate a country-specific global conditions index (GCI) to control for the effects of changes in external conditions faced by each country. To estimate each country's GCI, we gather 11 monthly times series for the top 9 individual trading partners of each country. We then weigh each of these by the trade share of each country, constructing a trade-weighted series for each measured indicator. We extract the first principal component of these 11 trade-weighted indicators along with 4 common series capturing global financial conditions to construct our GCI. We confirm that these activity indices are plausible, capturing well global cyclical fluctuations over the course of our sample.

[6]Lescaroux and Mignon (2009) also construct a FAVAR model of the Chinese economy, concentrating on the implications for China of oil price shocks.

We then include these activity factors in a six variable VAR. We examine the responses of domestic economic activity to changes in the broad dollar, including our GCI to capture global economic activity. Our U.S. VAR results confirm that an appreciation in the dollar results in reduced economic activity and inflation in the United States. Our results for the three Asian countries we consider also demonstrate that an appreciation in the broad dollar is associated with a decline in both local activity and inflation in those countries. This result suggests that the adverse impacts on U.S. demand from dollar appreciation dominate the positive expenditure-switching terms of trade effects for these countries.

Finally, our analysis allows us to consider the counterfactual question of how much this region was adversely impacted by the most recent dollar appreciation episode. The recent appreciation of the dollar was accompanied by notable renminbi appreciation vis-a-vis the rest of the world, so China suffered due to its pegged regime. Japan and Korea's exchange rates were more flexible, Japan's much more so, but these countries not only experienced the adverse implications of reduced demand in the United States, but also in a major trading partner in China due to its slowdown. Of course, these countries' exports also enjoyed a terms of trade decline against China. Our counterfactual results suggest that for all of these countries, the net effect was a notable decline in economic activity, but only a modest reduction in inflation.

The remainder of this paper is organized into 5 sections. Section 2 discusses our empirical methodology and our construction of the local and global activity indices for the four countries in our study. Section 3 discusses our results. Section 4 conducts counterfactual exercises for the case where the dollar did not appreciate since the middle of 2014. Lastly, section5 concludes.

II. Empirical methods

We estimate the macro effects of dollar appreciation on economic activity using a FAVAR approach in the spirit of Bernanke and Boivin (2003) and Bernanke et al. (2003). Observed individual time series such as industrial production and the unemployment rate are in general imperfect measures of economic activity. This concern is particularly relevant for a country like China, where data availability is limited and official data are not completely reliable [e.g. Fernald et al. (2014)]. We measure activity by as a latent variable extracted from a wide range of published time-series data, including industrial production, electricity use, rail cargo shipments, loan disbursements, and others. The FAVAR framework has the additional advantage relative to a simple VAR in that activity is summarized by a small number of factors, so that the parameters to be estimated in our VAR representation are limited to a small number, which helps improve the accuracy of our estimates.

For each country, we generate two indices, a local conditions index (LCI) and a global conditions index (GCI). These indices are generated by combining information from a wide range of observable data series. The local conditions index is generated from local observable economic indicators, while the GCI is generated from indicators collected from each country's major trading partners, weighted by trade volume. We then put these activity indicators along with several observable variables into a VAR and estimate that VAR model using the Bayesian approach of Sims and Zha (1998).

II.1. **Data and activity indicators.** To construct the LCI for each country, we extract the first principal component of a number of domestic economic indicators in that country. Denote by X_t those observable indicators and by F_t the underlying factors. The observables are related to the factors through

$$X_t = \Lambda F_t + u_t, \tag{1}$$

where u_t denotes idiosyncratic noises and Λ is the matrix of factor loading parameters. For each country, the observable data X_t is a vector of nine domestic variables, including industrial production, unemployment, housing starts or permits, stock prices, 1-year government bond yields, 2-year government bond yields, M1, M2, and the producer price index (see the Appendix for a description of the data).[7]

To construct the GCI for each country, we gather data for 11 time series for the top nine trading partners of that country. Indicator variables included are industrial production, unemployment, the consumer price index, housing starts or permits, equity prices, 1-year government bond yields, 2-year government bond yields, 3-month government bond yields, M1, M2, and the producer price index.[8] We then compute the principal components of trade-weighted averages of those 11 time series plus four common series that include oil prices, emerging market bond yield index (EMBI), the economic sentiment indicator of the euro zone, and the economic sentiment indicator of the European Union. The GCI is measured as the first principal component.[9]

Figure 2 displays the LCI and GCI for each of the four countries for the appropriate sample periods. The grey areas represent U.S. recession periods. All of the countries' LCI' and GCIs

[7]Some of the variables included in the construction of the GCI, such as the consumer price index, are not included in the LCI because they are introduced as separate arguments in our final VAR specification.

[8]The Appendix describes the time series data used and provides a list of the largest trading partners for each country.

[9]We get substantive The first principal component of the LCI accounts for 49% of the variance of the LCI for the US, 34% for Korea and Japan, and 39% for China. The first principal component of the GCI accounts for about 40% of the variance of the GCI for each country. The explanatory powers of the 2nd principal components are substantially smaller, approximately 21% for the US, 20% for Japan, 19% for Korea and 20% for China.

appear to be plausible, and in particular all reflect the impact of the global financial crisis and the different experiences of these countries during that crisis and afterwards.

The US LCI is highly correlated with its GCI, reflecting the dominant role of the US in the global economy, and particularly among its primary trading partners. Both the LCI and GCI are procyclical: they rise in booms and fall in recessions. However, in the more recent periods from 2013 through the end of 2015, the US LCI recovered more rapidly than the GCI, reflecting the relative slow recovery of the major trading partners of the US, in particular the sluggish recoveries of the euro area and Japan.

Korea's LCI and GCI are also highly correlated, both rising in booms and falling in recessions. However, the Korean LCI seems to be far less volatile than its GCI, particularly during the boom years preceding the global financial crisis, as Korean growth rates fell short of those of their major trading partners, particularly the U.S., during this period. The Korean LCI also declined less precipitously than its GCI during the global financial crisis, suggesting that Korea was relatively more successful than its primary trading partners at stabilizing the impact of that event. Of course, others have found that growth experiences prior to the crisis were negatively correlated with growth experiences during the crisis [e.g.Rose and Spiegel (2012)], which is consistent with this result for Korea. In addition, we see that Korea's LCI also recovered more rapidly than its GCI from the global financial crisis.

Japan's LCI and GCI are also closely correlated. The drop in the Japanese GCI is notably steep during the great recession, while the falloff in the Japanese activity indicator during that period is surprisingly tranquil relative to the steep drops in trade and GDP experienced by Japan during that episode. Both Japan's LCI and GCI appear to pick up at the end of 2012, presumably in response to optimism surrounding the election of Shinzo Abe as Prime Minister and the launching of his "Abenomics" economic reforms. However, the pickup in Japan's LCI in particular is almost completely reversed by the end of our sample.

Finally, China's LCI does not seem to co-move closely with its GCI. In particular, the LCI and GCI diverge after 2009. This divergence likely reflects the effects of China's large-scale fiscal stimulus, which accelerated that country's economic recovery subsequent to the global financial crisis. It can be seen that China's recovery commenced prior to those of its trading partners, as reflected in the earlier trough to China's LCI series relative to its GCI series. However, since 2010, China's LCI has declined steadily, consistent with the country's growth slowdown.

III. The FAVAR model and the estimation results

In this section, we discuss the estimated impulse responses to a dollar exchange rate shock in our FAVAR specification for each of the four countries in our sample.

III.0.1. *The US.* We begin with the US FAVAR model. The US model includes the local conditions index, the inflation rate (measured by year-over-year changes in the consumer price index), the short-term nominal interest rate (the three-month Treasury bills rate), the global conditions index, and the broad trade-weighted US dollar index, in that order. This ordering of the variables reflects our Choleski identification restriction that the latent factors (LCI and GCI) and the observables (inflation and the interest rate) do not respond to a dollar exchange rate shock in the impact period, while the dollar index is allowed to respond to the other shocks in the VAR. We estimate the impulse responses using Bayesian methods with the Sims and Zha (1998) priors. [10]

Figure 3 shows the estimated impulse responses in the US FAVAR model. The solid lines represent the median impulse responses and the dashed lines show the range of the 68% confidence bands.

Our estimation shows that a nominal appreciation of the dollar leads to an initial decline in both local activity and inflation. The decline in local activity suggests dominance by the expenditure-switching effect of the dollar appreciation. As foreign goods are relatively cheaper, net demand for foreign goods rises and demand for US goods falls. This reduction in aggregate demand for US goods leads to declines in US local activity and inflation. Furthermore, the declines in relative import prices associated with exchange rate appreciation directly contribute to declines in overall inflation.

The appreciation shock modestly pushes down the US nominal interest rate, although our point estimate of this effect is close to zero. Note that the dollar does not return to its initial value over the course of our simulation, but instead continues to appreciate modestly. The expected modest appreciation in the exchange rate pushes down the local nominal interest rate over this period. In addition, the decline in aggregate demand also motivates monetary easing in the form of reduced local interest rates. However, this response is muted during the latter period of our sample because of the zero bound limitation on monetary policy easing through conventional channels.

The dollar appreciation also leads to a notable decline in the GCI, suggesting that the contraction in the US also leads to a contraction in the economic activity of its trading partners. This supports the notion that the demand effect of dollar appreciation dominates the expenditure-switching effect for the U.S. trading partners as a group.

These impulse responses are all statistically significant over some portion of the forecast period.

[10] An advantage of using the Bayesian priors proposed by Sims and Zha (1998) is that it helps improve the accuracy of the estimates when the time series dimension of the sample is relatively short, as they are in our samples in this paper.

III.0.2. *Korea.* We next turn to the case of Korea. Figure 4 shows the impulse responses and the 68% confidence bands in the estimated Korean FAVAR model. This is a six-variable model that includes Korea's LCI, CPI inflation rate, short-term nominal interest rate, GCI, the real effective exchange rate (REER) , and the nominal broad dollar index. A main difference with the US FAVAR is the inclusion of Korea's REER, which captures potential effects of changes in Korea's terms of trade relative to its trading partners other than the US.

As shown in Figure 4, a dollar appreciation shock reduces the GCI for Korea, reflecting weakened demand from the US. The shock also leads to a real depreciation of Korea's currency, as expected. Given this depreciation in the real value of the Korean won, the expnditure switching effect would act towards raising Korean export demand and increasing its aggregate activity.

However, our impulse responses show that Korea's LCI and inflation both fall in response to the dollar appreciation shock, suggesting that declines in demand for Korean exports dominate the stimulus provided by real depreciation in Korea. This is somewhat surprising, as Korea has the lowest trade share for the U.S. relative to GDP among the Asian countries we consider.[11] It is therefore likely that the Korean data picks up the adverse impact of dollar appreciation on Chinese activity through its appreciation of that country's currency as well.

Furthermore, the real depreciation corresponds to a deteriorated terms of trade for Korea and thus reduces income. To the extent that terms-of-trade deterioration is transitory, households choose to smooth consumption by reducing their savings or by borrowing from abroad, as predicted by the Harberger-Laursen-Metzler effect. This would act towards reducing the current account balance and adding to the recessionary effects from weakened global demand following the dollar appreciation shock.

Overall, the Korean impulse responses appear to well-represent a relatively small open economy that is dependent on the U.S. as an export market. While the appreciation in the dollar may enhance the relative competitivenss of Korean to US exports in third countries, which would ceteris paribus tend to stimulate Korean activity, this benign outcome is overshadowed by the adverse implications of demand for import in the U.S. due to the reduction in its global demand. Moreover, the adverse implications on demand for Korean goods in China seem to also be playing a role in the determination of our observed impulse responses.

III.0.3. *Japan.* We next consider Japan. Figure 5 shows the impulse responses and the 68% confidence bands in the Japanese FAVAR model. The VAR model specification is identical

[11]Our sample averages for the U.S. trade share for Korea is around 15.4%, while for Japan and China, it is 20% and 22.6% respectively.

to that for Korea. The patterns of impulse responses are also similar to those in Korea. There is also a decline in Japan's GCI, reflecting reduced activity among Japan's primary trading partners. This reduced activity seems to drage on domestic conditions, as we observe declines in both Japanese local activity and inflation.

The decline in domestic demand leads to a decline in Japanese short-term nominal interest rates. However, Japanese nominal rates were constrained by the zero lower bound over much of our estimation period, only most recently going negative. This reduces the degree to which declines in nominal interest rates can be interpreted as monetary easing in response to weak domestic conditions, which makes it likely that the bulk of our observed responses are driven by the portions of our sample when these Japanese rates were above the zero bound. In addition, the movements in interest rates probably reflects the effects of unconventional monetary policies pursued by the Bank of Japan at the zero bound.

In contrast to the case of Korea, however, the Japanese REER appreciates following the dollar appreciation shock. This is surprising, as the yen is commonly considered a freely-floating currency which would be expected to depreciate in response to a positive shock to the dollar. The real appreciation of the yen therefore likely reflects that currency's safe-haven status during and around the global financial crisis period. As shown in Figure 1, in the crisis period of 2008-2009, both the dollar and the yen appreciated substantially.

III.0.4. *China.* Finally, we turn to the case of China. The VAR specification for China is again identical to those for Korea and Japan. Figure 6 shows the impulse responses and the 68% confidence banks estimated from the Chinese FAVAR model.

Our results for China differ from those for Korea and Japan for at least two reasons: First, China has tightly managed its bilateral exchange rate with the dollar over the course of our sample. When the dollar appreciates, the RMB usually follows suit, and vice versa. While there was some exchange rate smoothing in Korea over the course of our sample, it was much more freely floating than the renminbi over this period. Moreover, China is a large importer of commodities. To the extent that the renminbi follows the dollar, dollar appreciation reduces the real costs of commodity inputs.

China's exchange rate regime was changed following the global financial crisis, as the RMB was allowed to appreciate modestly but persistently (see Figure 1). This response reflected the policy responses of the People's Bank of China to unconventional monetary policy in the United States and other advanced economies that lowered yields on foreign interest rates. The decline in foreign interest rates raised the cost of sterilization to the PBOC under China's capital controls. To avoid a run up of domestic inflation from reduced sterilization activity, the PBOC allowed the RMB to appreciate. The PBOC also raised the reserve requirements numerous times. As discussed in Chang et al. (2015), despite these policy interventions, the

PBOC still faced a tradeoff between sterilization costs and inflation stability under capital controls, and inflation surged from 2009 to 2012.

These considerations demonstrate that despite China's closed capital account, it still felt the impact of foreign exchange rate shocks. As such, we obtain interesting dynamics in our estimated Chinese impulse responses to dollar appreciation shocks for China in Figure 6. In particular, a dollar appreciation shock reduces China's global conditions index. This likely reflects not only the decline in U.S. demand, but also the declining activity in Japan and Korea that we observed above, as both of these countries are important Chinese trading partners.

This results in declines in both Chinese economic activity and inflation. The decline in local activity likely reflects the weakened global demand for Chinese goods following the dollar appreciation (in particular, demand from the U.S. and other large trading partners of China, including the cases of Japan and Korea observed above). This result is intuitive as direct competition between the U.S. and China is modest compared to the importance of the US as a market for Chinese final goods, so expenditure-switching effects from dollar appreciation would be expected to be modest.

Despite its exchange rate management, China's real effective exchange rate also falls slightly. These real exchange rate movements are likely attributable to movements in its inflation. The drop in inflation combined with a relatively fixed dollar peg can explain the modest observed decline in China's REER in our impulse responses.

The observed reduction in inflation reflects the opposite case from that where a negative interest rate shock in the U.S. raises the Chinese cost of sterilization and induces the Chinese government to sterilize less and monetize more, which increases realized inflation. All else equal, dollar appreciation reduces the costs of sterilization, and the PBOC would rationally respond by sterilizing more, reducing inflationary pressure. Inflation is also directly reduced by China's reduced demand and declines in the relative price of commodities following the dollar appreciation.

The reduction in China's interest rate reflects monetary policy easing in response to the recessionary effects of the shock. Note that Chinese monetary policy independence is sustained despite its pegged exchange rate due to its capital control policies.

IV. Counterfactual exercise

To assess the quantitative importance of the dollar appreciation from July 2014 through the end of our sample in December 2015, we conduct a counterfactual experiment by fixing the value of the broad dollar index during this period to its actual value in June 2014. In other words, we turn off the shock to the dollar index between July 2014 and December

2015, but keep all the other shocks and parameters at their estimated values in the FAVAR. We then simulate the time series of the variables in the FAVAR for this treatment period. The difference between the simulated counterfactual path of a variable and its actual path in the data captures the contribution of the dollar shock during the treatment period.

Figure 7 displays the actual time series of the LCI for each of the four countries from July 2014 to December 2015 (the solid lines) and the counterfactual simulated path of the LCI when the dollar shock is turned off (the dashed lines). We normalize the LCIs (both actual and counterfactual) so that the value in July 2014 for each country is set to 0.

Figure 7 shows that the dollar appreciation since mid-2014 has substantially depressed US local activity. In particular, absent the dollar shock, the US local activity index would have been about one standard deviation higher than its observed value. Thus, we find that dollar appreciation has been a significant drag on the US economy. We also find that the dollar appreciation has affected all of our three Asian economies, although to different extents. In particular, it has substantially reduced local activity in Korea. Absent the dollar shocks, Korea's local activity index by the end of our sample would have been close to that in mid-2014. But the actual LCI for Korea is substantially lower (about 0.7 standard deviation lower at the end of our sample than in mid-2014). The effects of dollar appreciation on Japan's and China's LCIs are much smaller.

Similarly, Figure 8 displays the actual times series of inflation (solid lines) along with the counterfactual series (dashed lines) from July 2014 to December 2015. For the US, the dollar appreciation has contributed significantly to the low CPI inflation in this period. In the counterfactual without dollar shocks, the US inflation rate would have been on average about one percentage point higher than the actual inflation rate.

The dollar appreciation since July 2014 has also contributed to low inflation in Korea. Absent dollar shocks in this period, Korea's CPI inflation would have been half a percentage point higher than the actual value. The effects of dollar shocks on Japan's and China's inflation are again relatively small.

It is unsurprising that Korea stands out among our three Asian economies as the most exposed to a positive dollar shock. China manages its exchange rate closely, but it also closely restricts capital movements, limiting the opportunities for any arbitrage activity that could increase sensitivity to dollar movements. Japan has floating regime, leaving it free to pursue desired domestic monetary policy. Still, the zero bound limited this monetary policy freedom during our sample period.

V. Conclusion

We evaluate the implications of a dollar appreciation shock on U.S. economic conditions and also on three major Asian economies: Korea, Japan, and China. We use a FAVAR framework to estimate country specific local and global condition indices as latent variables. To our knowledge, our paper is the first to apply the FAVAR methodology to the question of the implications of exchange rate shocks.

Our results demonstrate that dollar appreciation results in decreased economic activity for all of countries in our study. The decline in U.S. activity is a direct effect of reduced competitiveness through the standard expenditure-switching channel. For the Asian trading partners in our study, in contrast, our results demonstrate that the expansionary expenditure-switching effects of dollar appreciation are more than offset by, among other things, the reduction in demand of the U.S. and other Asian trading partners.

Finally, we use our estimated FAVAR model to evaluate the implications of the recent dollar appreciation since 2014. We run counterfactuals, asking what activity and inflation would have been, were there no dollar appreciation since July 2014. Our findings suggest that all of the countries in our study would have experienced greater activity in the absence of the appreciation, but that the Korean economy was particularly exposed. Our point estimates suggest that the Korean economy's local conditions index would have been about 0.7 standard deviations higher than it was at the end of our sample in the absence of the dollar appreciation shock. The changes predicted for both Japan and China are substantially smaller.

Our findings suggest that Asian economic conditions are closely tied to U.S. monetary policy, despite the apparent differences in economic structures and policy regimes in those countries. Moreover, they favor the contention made by monetary policymakers during the crisis, such as Federal Reserve Chair Ben Bernanke, that the paramount interest of emerging market economies durnig the crisis was the recovery of the advanced economies. Expenditure-switching consequences of dollar movements, at least, appear to have been second-order over the course of our sample.

Appendix A. Data descriptions

A.1. **Local conditions index.** We construct local conditions indices (LCI) for the United States, South Korea, Japan and China based on a number of monthly time series data. In particular, each country's LCI is the first principal component of the following series:

(1) Industrial production (log growth)
(2) Unemployment rate
(3) Housing starts/permits (log unit)
(4) Stock price index (log growth)
(5) One-year government bond yields
(6) Two-year government bond yields
(7) M1 (log growth)
(8) M2 (log growth)
(9) Producer price index (log growth).

For China, the samples for the two-year and one-year government bond yields are very short. We replace them by China's interbank loan rates.

A.2. **Global conditions index.** We construct global conditions indices (GCI) for each country based on trade-weighted averages of 11 time series variables in that country's major trading partners along with four common series.

The 11 country-specific variables include

(1) Industrial production (log growth)
(2) Unemployment rate
(3) Consumer price index (log growth)
(4) Housing starts/permits (log)
(5) Stock price index (log growth)
(6) One-year government bond yields
(7) Two-year government bond yields
(8) Three-month government bond yields
(9) M1 (log growth)
(10) M2 (log growth)
(11) Producer price index (log growth)

The four common series include

(1) Brent crude oil price (log)
(2) Emerging market bond yield index, EMBI
(3) European Commission Economic SentiMent Indicator Eurozone
(4) European Commission Economic SentiMent Indicator EU

Table A1. Major trading partners

Trade rank	United States	China	Korea	Japan
1	Canada	United States	China	China
2	China	Euro area	United States	United States
3	Euro area	Japan	Japan	Euro area
4	Mexico	Korea	Euro area	Korea
5	Japan	Taiwan	Singapore	Australia
6	Korea	Australia	Taiwan	Australia
7	United Kingdom	Singapore	Australia	Thailand
8	Brazil	Malaysia	Vietnam	Malaysia
9	Taiwan	Russia	Russia	Indonesia

Table A2. VAR sample dates

Country	Start	End
United States	1997m12	2015m12
Korea	1999m10	2015m12
Japan	1997m12	2015m11
China	2002m1	2015m5

To construct the GCI for a country, we compute the first principal component of the 11 trade-weighted series plus the four common series. We focus on the 9 largest trading partners determined by total trade (imports plus exports) in 2014, so that the composition of the trading partners remain constant over time. All trade data are taken from the IMF Direction of Trade Statistics database. Table A1 shows the top 9 major trading partners of each country in our sample.

A.3. **VAR samples.** We run the VARs on the sample allowed by data availability through 2015. Table A2 shows the dates for each VAR.

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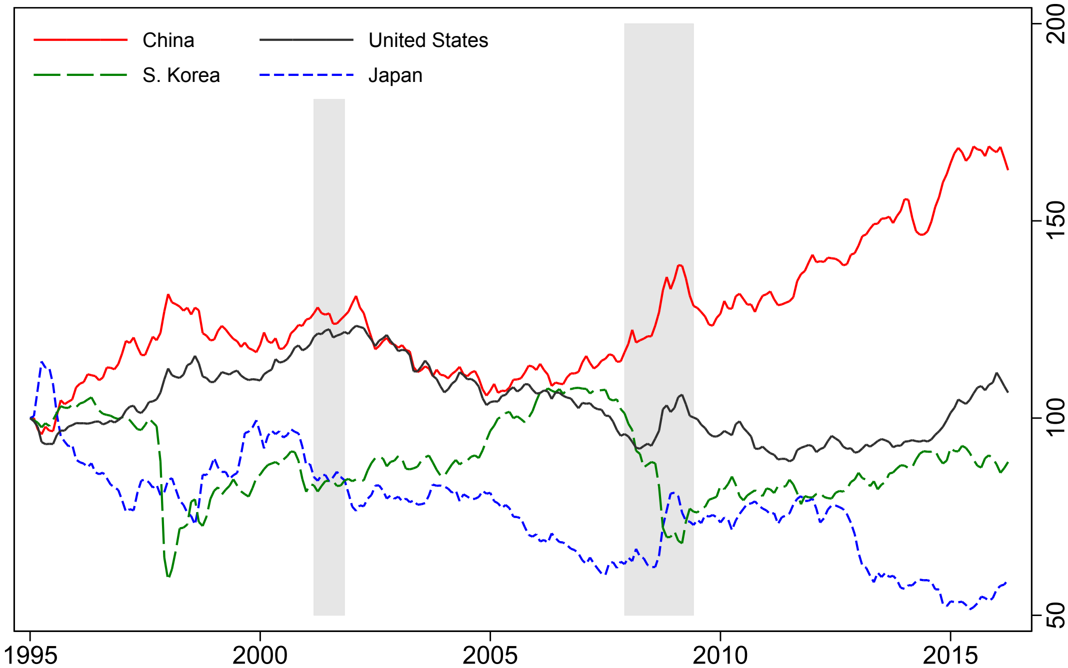

FIGURE 1. Real effective exchange rates, indexed to 100 in January 1995.

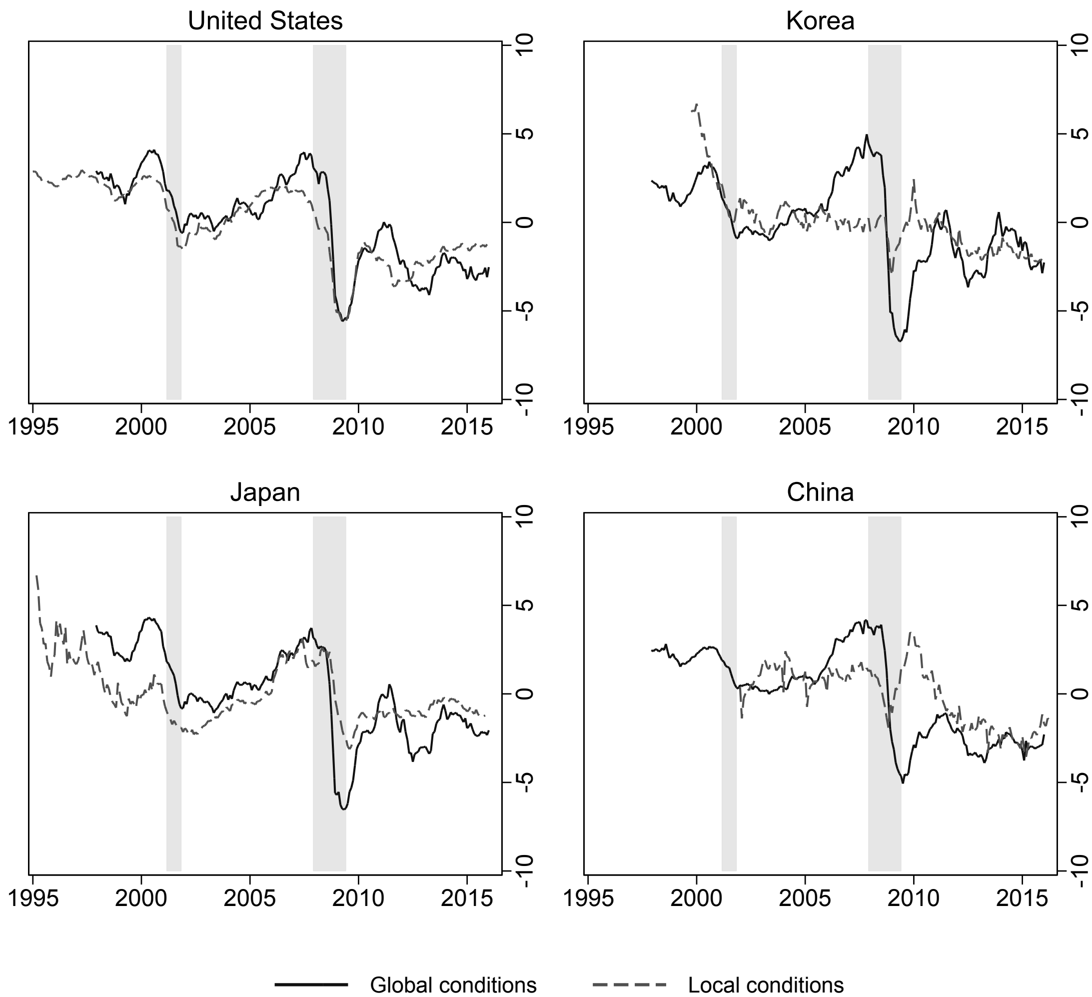

FIGURE 2. Global conditions index and local conditions index for the four countries in our sample.

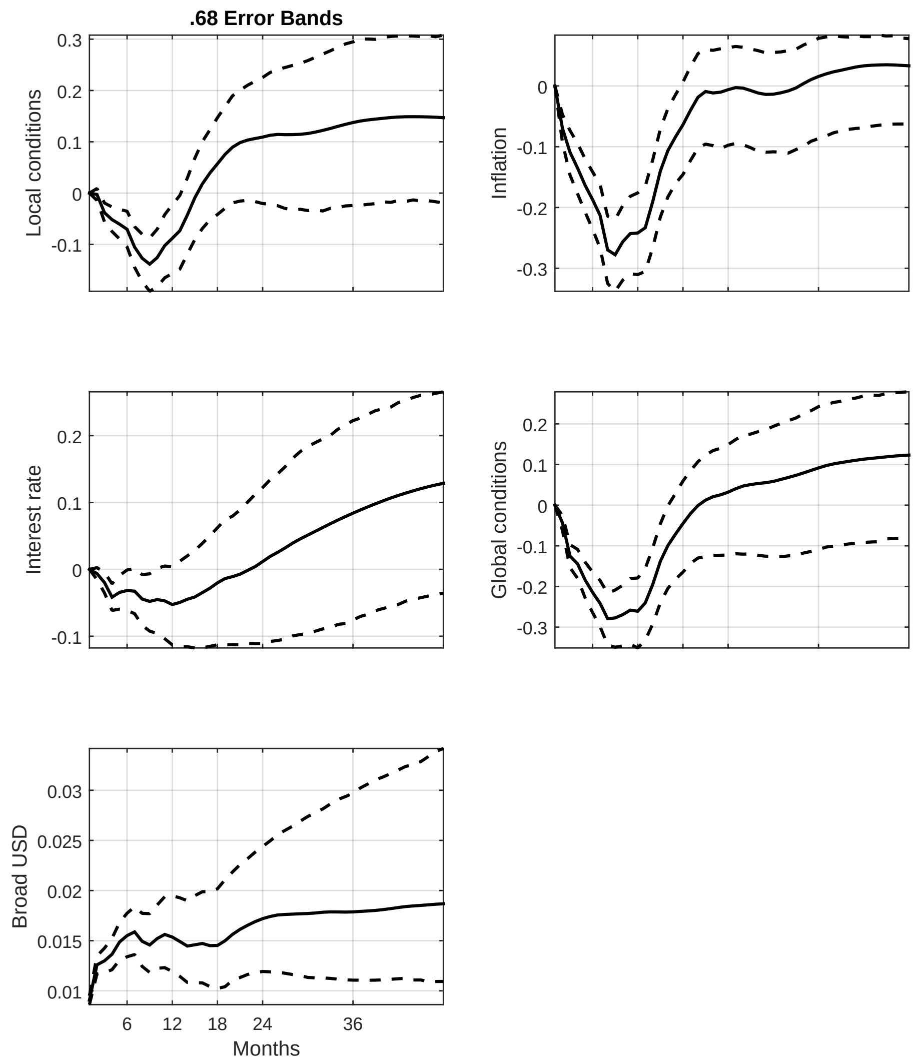

FIGURE 3. Impulse responses to a positive shock to the broad dollar index in the estimated FAVAR model for the US. The solid lines represent the median impulse responses. The dashed lines indicate the 68% confidence bands.

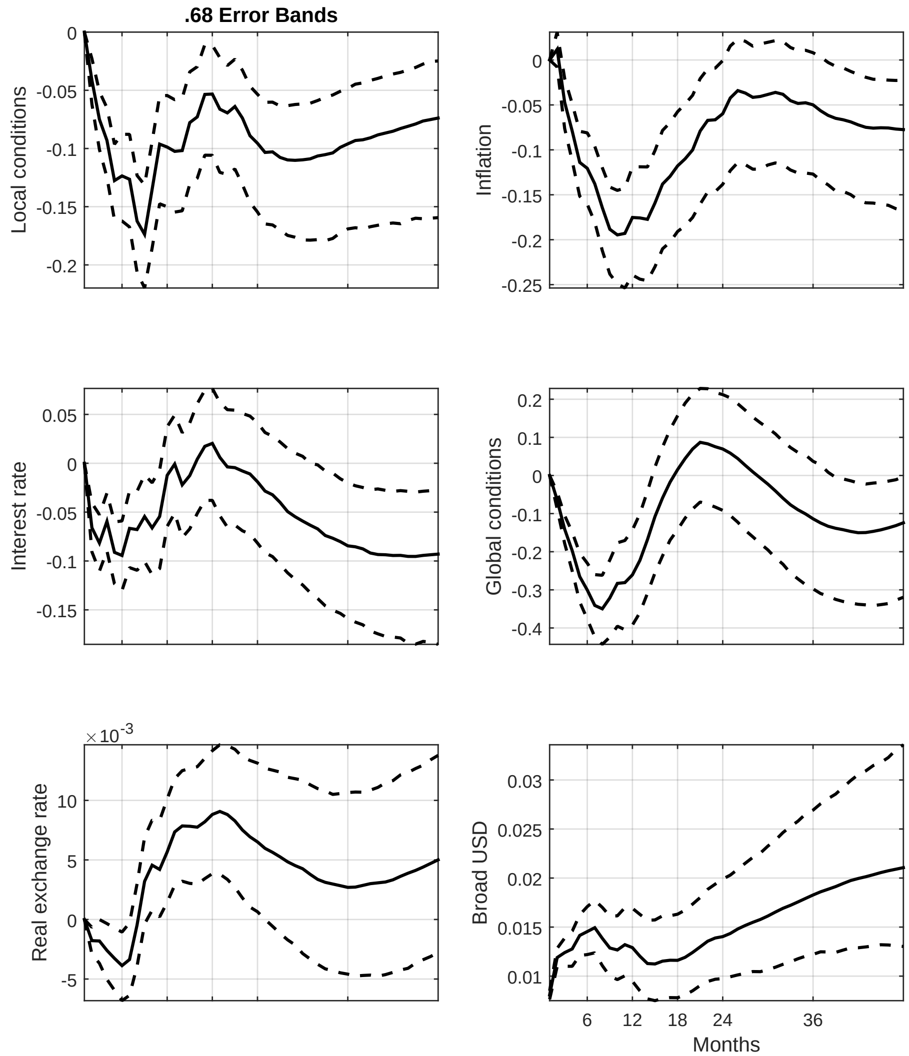

FIGURE 4. Impulse responses to a positive shock to the broad dollar index in the estimated FAVAR model for Korea. The solid lines represent the median impulse responses. The dashed lines indicate the 68% confidence bands.

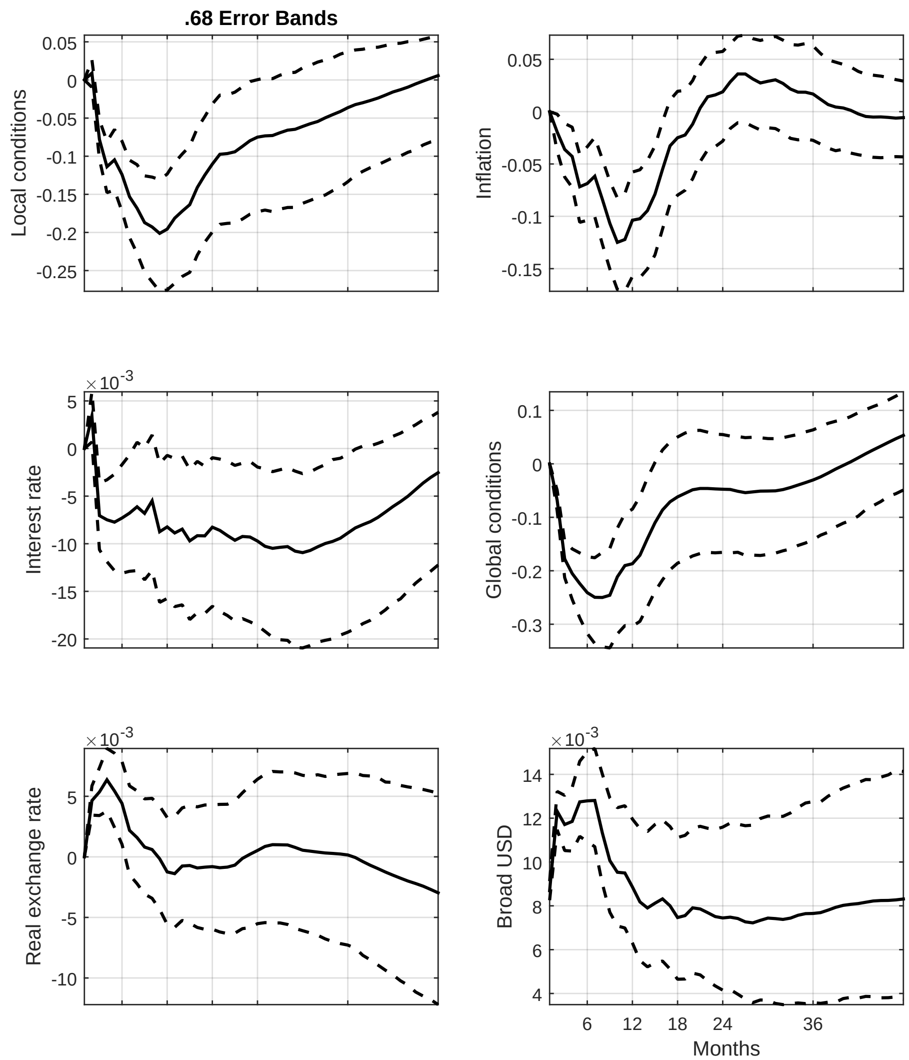

FIGURE 5. Impulse responses to a positive shock to the broad dollar index in the estimated FAVAR model for Japan. The solid lines represent the median impulse responses. The dashed lines indicate the 68% confidence bands.

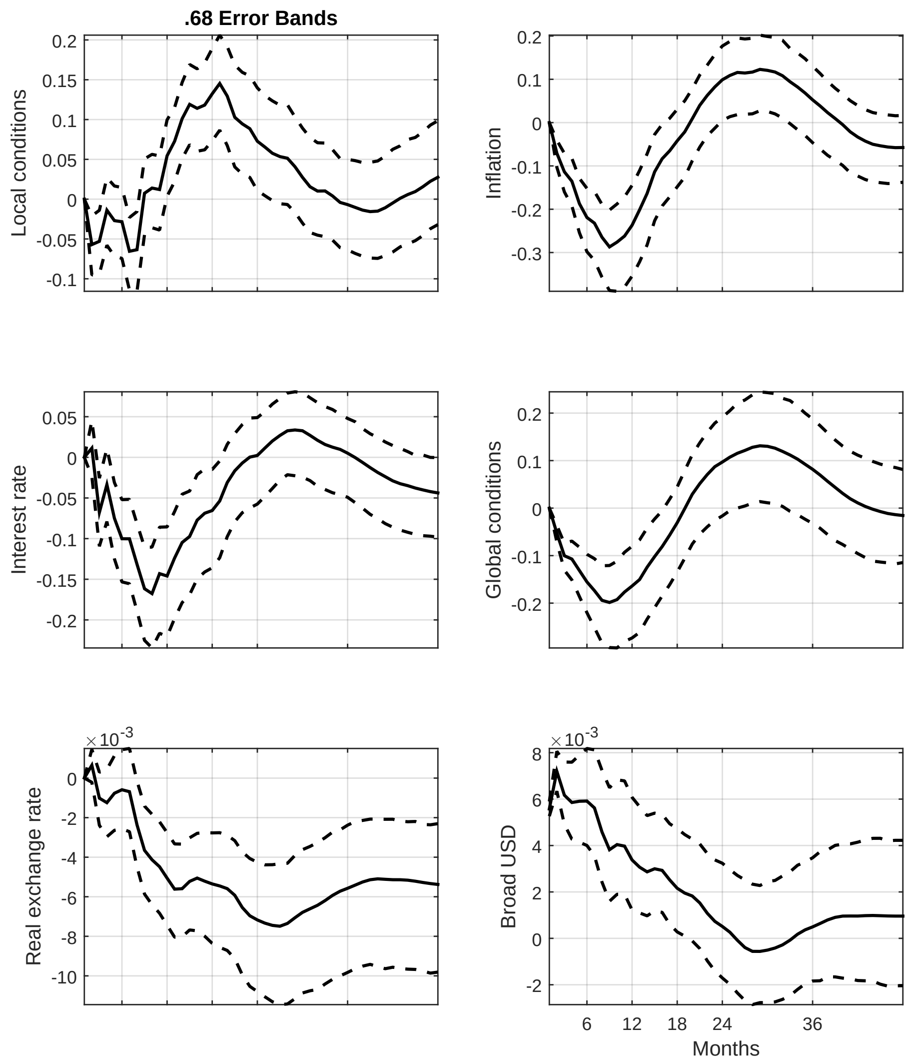

FIGURE 6. Impulse responses to a positive shock to the broad dollar index in the estimated FAVAR model for China. The solid lines represent the median impulse responses. The dashed lines indicate the 68% confidence bands.

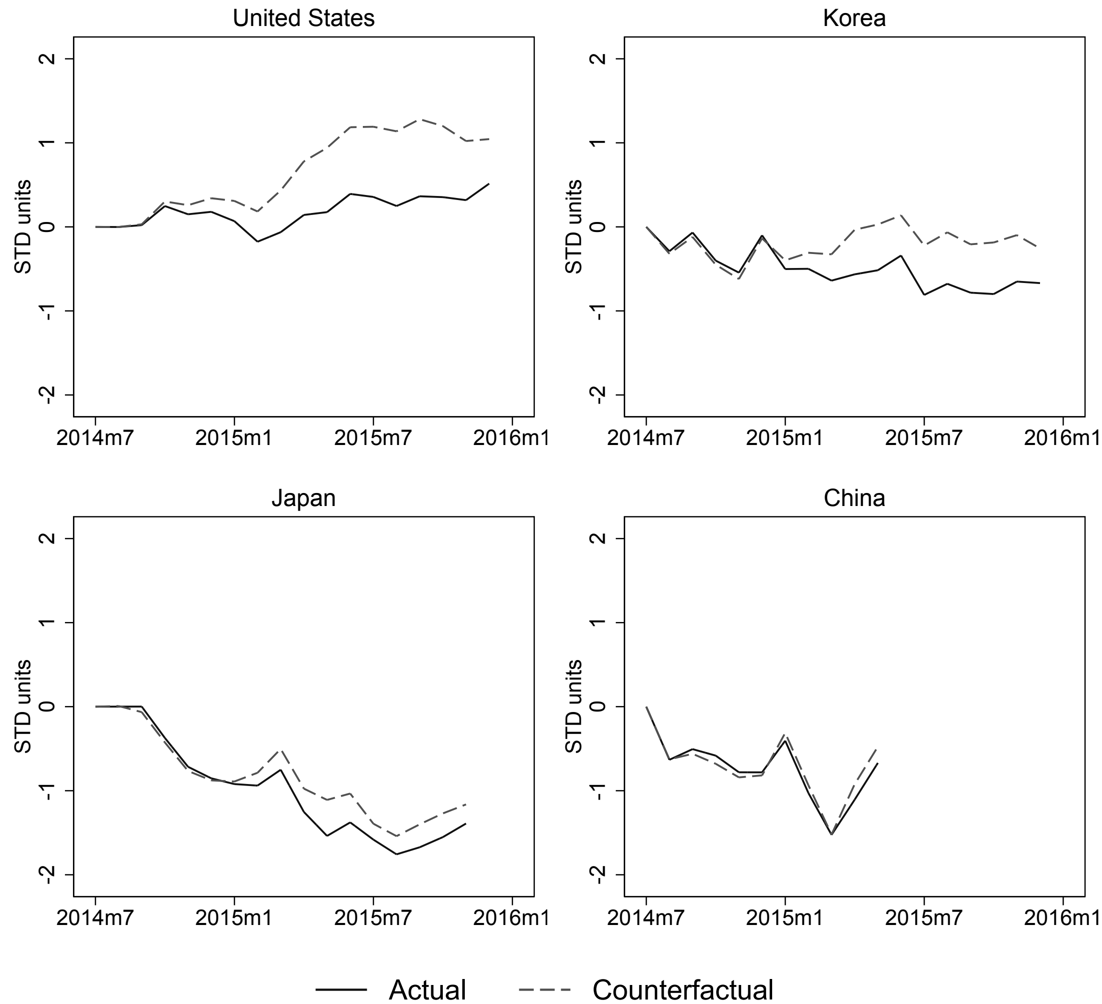

FIGURE 7. The actual path of local conditions index (the solid line) versus the counterfactual path (the dashed line), the latter of which is calculated from the estimated FAVAR model but imposing the assumption that the broad dollar index in July 2014 through the end of the sample remained unchanged at its June 2014 level.

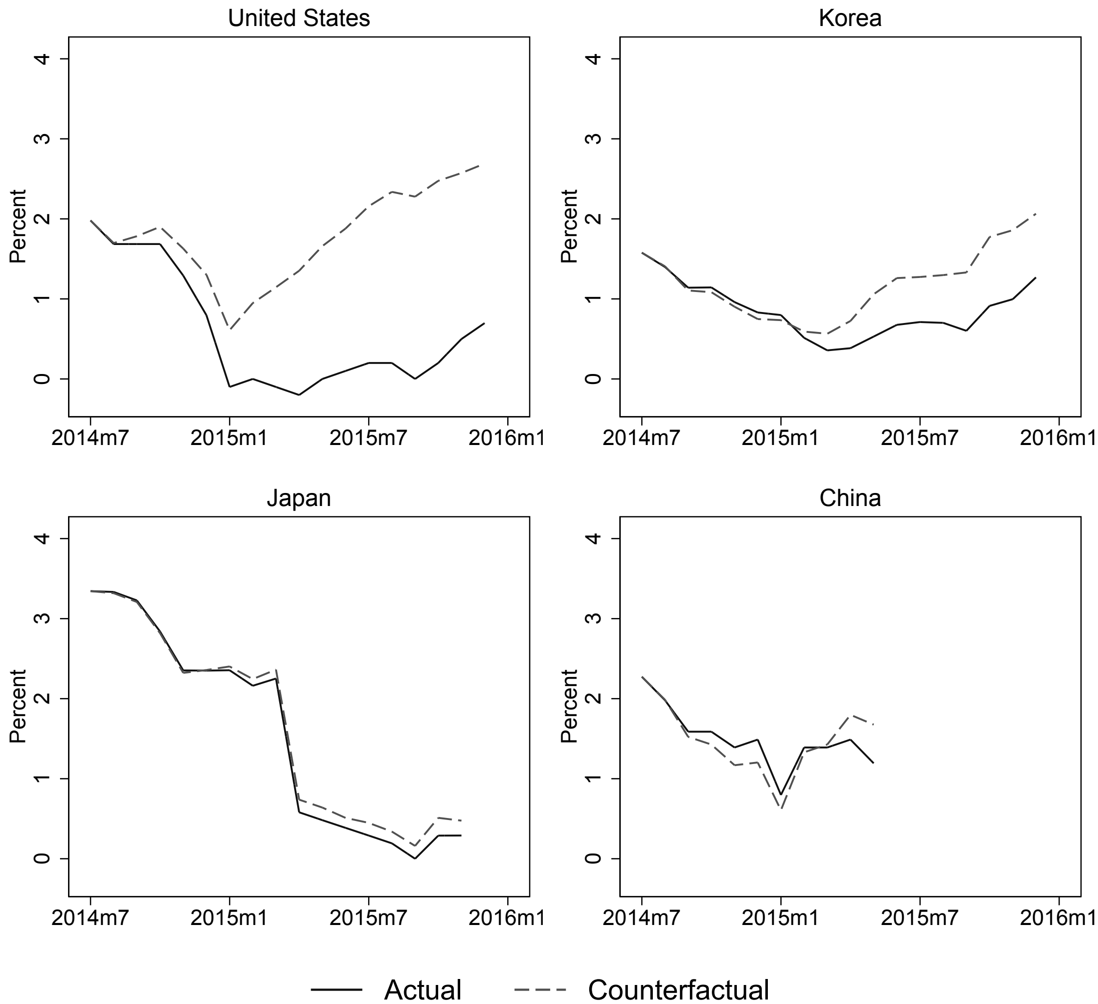

Figure 8. The actual path of inflation (the solid line) versus the counterfactual path (the dashed line), the latter of which is calculated from the estimated FAVAR model but imposing the assumption that the broad dollar index in July 2014 through the end of the sample remained unchanged at its June 2014 level.

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