Uncovered Interest Parity Deviation, Monetary Shocks and Its Dynamic.

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Abstract

Uncovered Interest Parity(UIP for abbreviation), as a cornerstone for many open macro theories, has been found of extensive evidence against it in the past decades. UIP equation asserts such a natural result that economists made enormous attempts to explain the anomalies. UIP is a equilibrium condition, which the real world seldom reach. Different types of shocks are taking place all the time, knocking the UIP off its equilibrium state.

This paper looks into monetary shocks particularly. We first explained in theory why monetary shock can potentially cause UIP to deviate from its equilibrium, and deduceed the deviation direction accordingly. Then we confirmed that monetary shock is a significant factor in explaining the magnitude of UIP deviation within the dataset consists of 4 country pairs, using both OLS and panel data methods, and obtained expected direction of causal effect.

Based on this, we further infered the length of monetary shocks' impact on UIP deviation. And recovered the dynamic effect of monetary shocks using a VAR model. We found consistent evidence in all of the 4 country pairs, that the monetary shocks will be fully digested by market in one or two months.

1 introduction

The Uncovered Interest Parity equation, which is widely used as a cornerstone for many open macro economics theories, can be expressed by the following equation.

$$UIP: \ E[s_{t+k}|I_t] - s_t = i_t - i_t^* \tag{1}$$

Where s denotes the log term of the foreign currency's dollar price and k is the maturity of the interest rate we've chosen, the left of the equation is the expected percentage of change in exchange rate, and the left hand side is the difference in domestic and foreign interest rate.

The point of this equation is "there is no expected return for carry trade". Consider a example, suppose you are living in a country with low interest rate, you may want to sell domestic T bill, exchange the income for foreign currency, and then purchase the T bill of a high interest rate foreign country and hold till maturity. The UIP equation tells you that your effort for making money out of the interest spread will be useless. Because the appreciation of your country's currency will wash away all your arbitrage returns, if you try to exchange the foreign currency back to domestic currency when the foreign T bill you bought expires.

The equation then becomes a equilibrium condition. Indeed, if the equation is not holding, then there will be arbitrage return. Then traders will use as much leverage as they can get to implement carry trade. This behavior will affect variables on both sides of UIP equation, until it return to its equilibrium. In this sense, UIP is a very natural equilibrium result.

But being natural dose not mean it's true. Equilibrium is seldom attained in real world. The observation of UIP from data rejected the UIP extensively. This is called "UIP puzzle". For an overview upon UIP's behaviour in the past two centuries, see Lothian and Wu(2011).

1.1 Deriving The Puzzles: UIP Puzzle and Forward Bias

To gain an impression of our puzzles, we need to accept ”rational expectation” introduced by Muth (1961):

$$s_{t+k} = E[s_{t+k}|I_t] + v_t \tag{2}$$

Here v_t is a perturbation term independent of anything one can think up. The equation says that the expectation should be unbiased of the realized value in the future. Some studies link the deviation of UIP to the failure of ”rational expectation”. For example, Lewis (1989) and Gourinchas and Tornell (2004). In this paper, we accept the assumption of rational expectation.

Putting together 10 and 2 we have the following equation:

$$s_{t+k} - s_t = i_t - i_t^* + v_t \tag{3}$$

Note that in equation 3, the market expectation is replaced by a observable s_{t+k}, so now every thing is observable. Many studies ran the following regression:

$$s_{t+k} - s_t = \beta_0 + \beta_1(i_t - i_t^*) + v_t \tag{4}$$

Where $\beta_0 = 0$ and $\beta_1 = 1$ in theory. The orthogonality of v_t guarantees the exogeneity. Surprisingly, a large scale of literatures running the regression of 4 found out β_1 to be significantly negative, which is far from what UIP theory implies. This estimated negative coefficient, is the called UIP puzzle. Sarno (2005) provides a thorough discussion of the anomalies.

A useful observation from equation 3 is that we can estimate the deviation from UIP equilibrium. Already knowing equation 3 doesn't always hold, we can define the deviation p_t as:

$$deviation_t = (E[s_{t+k}|I_t] - s_t) - (i_t - i_t^*) \tag{5}$$

Then we can let the estimated deviation p_t be:

$$p_t = (s_{t+k} - s_t) - (i_t - i_t^*) \tag{6}$$

Plug in equation 2, we get a relationship between the estimated UIP deviation p_t(which is observable from data) and the actual UIP deviation $deviation_t$(which is not observable from data):

$$p_t = deviation_t + v_t \tag{7}$$

As $E(v_t|I_t) = 0$ and $Var(v_t|I_t) < \infty$, we confirm that observable p_t is unbiased and consistent estimator of the deviation from UIP equilibrium.

”Forward bias” refers to the gap between $f_t^{(k)}$(The k-periods forward contract’s price) and $E[s_{t+k}|I_t]$(The market expectation of the price k periods later, based on current information set I_t). It’s always tempting to assert them as equal. But in our case, unfortunately, they are not equal. To illustrate this, we introduce Covered Interest rate Parity(CIP):

$$f_t^{(k)} - s_t = i_t - i_t^* \tag{8}$$

The intuition behind CIP is that there’s no exchange rate risk by using a forward contract, so a hedged investment in foreign country should never provide more return than domestic investment. Otherwise, there will be arbitrage opportunity, and arbitrage behavior will push the price of forward contract back to the CIP equilibrium. Figure 1 shows the deviation from CIP equation. As the vertical axis is measured in basic point, the deviation before the 2008 crisis is rather small, so it’s safe to assume CIP holds before 2008. After the crisis CIP changed dramatically, for a study of this change, see the working paper Viewsmith(2018). In this paper, we limit our discussion to the period prior to 2008 when CIP holds well.

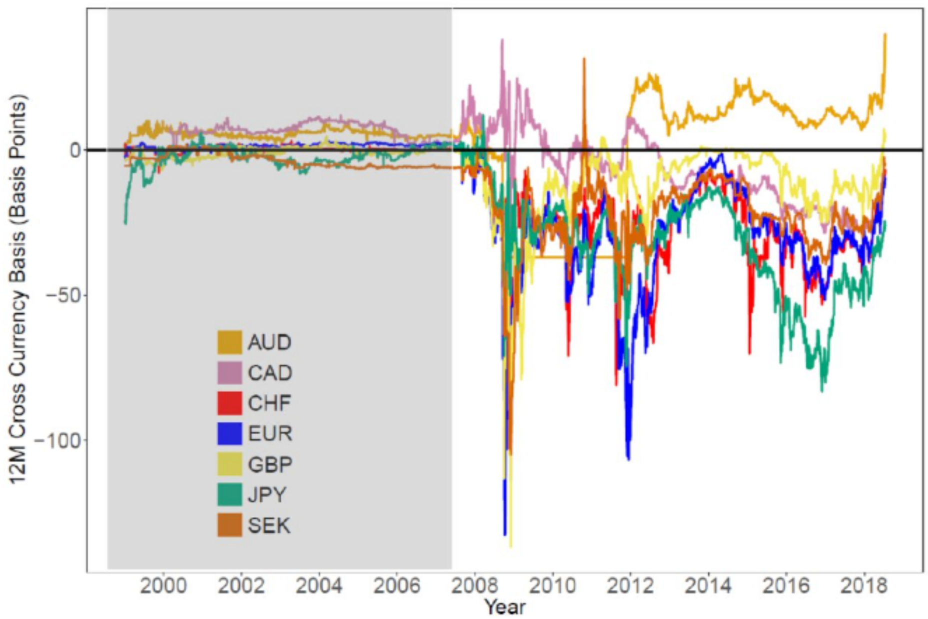


Figure 1: CIP deviation: Foreign Currencies vs. USD

To see forward bias does exist, we subtract equation 7 from equation 8, then we get the forward bias equation:

$$E[s_{t+k}|I_t] = f_t^{(k)} + p_t \tag{9}$$

As p_t, the deviation from UIP, is not zero most of the time, the forward contract's price at time t is strictly not equal to the market expectation of corresponding foreign currency price in the future. This violates our common sense.

Clearly, by solving either Foward Bias Puzzle or UIP Puzzle, we can solve another. Because CIP equation 8 guarantees that p_t is the deviation value of UIP equation, and meanwhile, the value of forward bias. To address these two puzzles, a model or some causation stories for p_t is needed. To see a model for p_t, see Pippenger(2018).

1.2 Paper Introduction

As mentioned above, the core issue in explaining the UIP deviation is to model the deviation measure p_t, or find key factors that explaining p_t. In this paper, we are dedicated to finding the explaining power of monetary shocks in the deviation measure p_t.

In section 2, we go over the literature about UIP deviation. In section 3, we put the theoretical reason why monetary shocks can potentially cause UIP equation to deviate. And then we use both OLS and panel data methods to identify the monetary shocks impact successfully. In addition, we also spend some paragraphs to discuss why this is a causal effect. In section 4, we look into the length of the monetary shocks' impact. Using VAR model, we find that monetary shocks' effect are fully priced in by market in one or two months.

2 Literature Review

Enormous studies are made to explain the puzzle stated in the previous section. Once, two most prominent explanations are risk premium and rational expectation failure. For a discussion of these studies see Sarno (2005). As the magnitude of UIP deviation is so large that risk premium cannot explain it singly. Also, the irrational expectation can explain anomalies caused by bubbles and speculation, but it struggles when explaining a consistent deviation of UIP in regular periods. There's also a relatively newer collection of literatures studying the relationship between UIP puzzle and monetary policy.

In particular, for the measure of monetary shocks, a traditional tool is taylor's rule. In a recent paper Madeira and Palma(2018), they used a DESG model version of Taylor's rule to peel out the monetary shocks. Another measure of monetary shocks is Romer and Romer(2004). In their renowned paper, they developed a monetary shocks measure in 1969-1996. They identified the dates of FOMC meeting and kept track of the fundamentals and federal funds rate around the meeting. Then they constructed a regression model to characterize how the market anticipate the federal funds rate. By looking at the difference around the meeting they peeled out a monetary shock that is more exogenous than traditional measures and can generate more significant results.

Bouakze and Normandin(2010) looked into the monetary shocks dynamic effect on the UIP deviation between the G7 countries. They used a VAR model to peel out a time series of monetary shocks. Then, they used this shock sequence as a controlled variable and found out that the shock can cause the UIP to deviate in a short horizon, and the deviation will gradually return to zero in the long horizon. Whats more, they adopted a variance-decomposition method and found out that the effect of monetary shocks can explain roughly 50% out-of-UIP fluctuation in the exchange rate.

For the link between monetary shocks and UIP puzzle. Pippenger(2018) takes into account the fact that UIP puzzle disappear in the managed exchange rate regime and set up a model for monetary policy and UIP variables. It shows that the sterilized intervention in the foreign exchange market of central banks can cause UIP deviation in theory. A mixture of monetary shocks' inflationary effects and liquidity effects can also lead to UIP puzzle. His work is based on rational expectation and provides a explicit formula for the forward bias p_t. The complicity of his model also makes it appealing to explain other related puzzles.

Engels et al.(2018) revealed another aspects about monetary policy and UIP puzzle. Their work focused on the forecasting of exchange rate. They found out that Taylor rule fundamentals appears to be very significant when adding to UIP regression. Their model not only takes into account monetary shocks, but also liquidity shocks, to generate UIP puzzle. And their model can also explain the add-on forecasting power of Taylor rule fundamental on exchange rate, if the country is inflation targeting.

In this paper we look into one of the factor proposed by Pippenger(2018), which is the monetary shocks' effect on UIP deviation. And we successfully confirmed that monetary shock is an important factor in explaining the deviation level of UIP equation. By doing this, we do a favor to the theoretical model built by Pippenger(2018).

3 Monetary Shocks

In theory, monetary shocks can knock the UIP equation off its balance. Indeed, write the UIP equation here again:

$$UIP: \; E[s_{t+k}|I_t] - s_t = i_t - i_t^* \tag{10}$$

Suppose UIP equation is initially in its equilibrium, and hold the other country's condition as constant. All of a sudden, a contractionary monetary shock appears. The shock will have two stream of effect. The first one is liquidity effect. In our case, a contractionary monetary policy tighten domestic credit and raise domestic interest rate. So the right hand side of equation 10 will increase. Simultaneously, the market realizes this shock will cause unanticipated deflation and the inflation rate will decrease at a certain time in future, due to the inflation effect. And by Purchasing Power Parity(PPP), the dollar price of foreign currency will fall. So the market will adjust its expectation about future exchange rate downwards.

Hence, a contractionary monetary shock push the right hand side of UIP equation up and pull the left hand side down, generating a deviation from its equilibrium. What's more, as the estimation of deviation p_t is defined as left hand side minus right hand side, so a contractionary monetary shock will cause p_t to go in negative direction.

In this section we test this intuition using the data between US and other 4 countries, using both static method like OLS and panel data, and dynamic method like VAR. It will be shown that consistent result in data strongly support our intuition, and monetary shock is a significant factor in explaining UIP puzzle without controversy. To see these, we first need to find a measure for monetary shocks, and be able to tell its direction.

3.1 Peeling Out Monetary Shocks

In this paper we will adopt the Taylor rule regression in Madeira and Palma(2018). The regression is:

$$iff_t = \alpha + \rho iff_{t-1} + (1-\rho)(\mu x_t + \lambda \pi_t) + monetaryShock_t \tag{11}$$

Here iff_t is the federal funds rate at period t, x_t is the output gap measure, π_t is the inflation measure and $monetaryShock_t$ is the residual term. For the measure of inflation, we use month to month percent change of CPI index. For the estimation of output gap, we use the following regression proposed by Bernanke and Gertler(1999):

$$y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + u_t \tag{12}$$

$$x_t = u_t \tag{13}$$

Where y_t is industry output(monthly). The fitted forecast line and x_t series are in figure 2

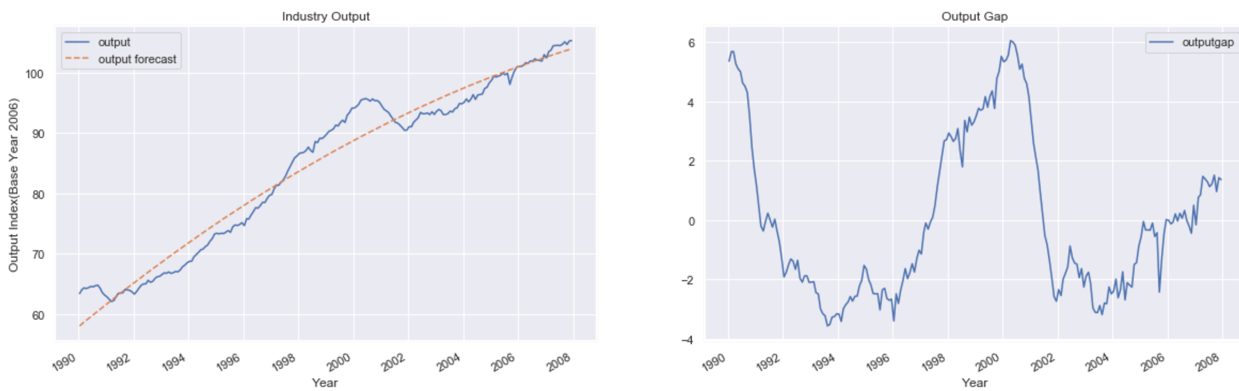


Figure 2: Industry Output

Then we can run the Taylor rule regression in equation 11, the regression result is:

	coef	std err	z	P>|z|	[0.025	0.975]
outputgap	0.0037	0.006	0.613	0.540	-0.008	0.015
cpi	1.2946	5.689	0.228	0.820	-9.856	12.446
iffratelag	0.9810	0.008	122.995	0.000	0.965	0.997
Constant	0.0604	0.038	1.596	0.110	-0.014	0.135

Eventually, the monetary shocks measure looks like figure 3.

A notation, here as the positive value of monetary shocks stands for unanticipated increase in federal funds rate, so the positive value of shocks corresponds to contractionary monetary shocks

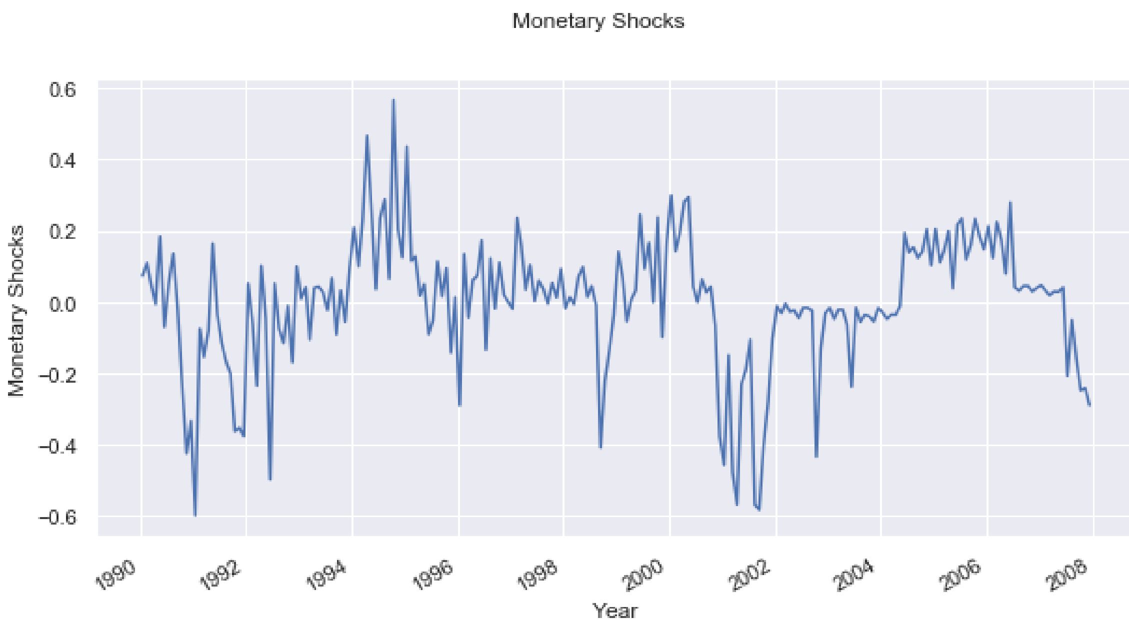


Figure 3: Monetary Shocks

and vice versa. Now we've peeled out the monetary shocks, we will see the empirical fact about UIP deviation and monetary shocks.

3.2 UIP Deviation and Monetary Shocks

As equation 7 mentioned, the observable variable p_t is an unbiased and consistent estimator of UIP deviation magnitude, under the framework of rational expectation. Using the data between 1990 and 2008, we calculated this estimated value p_t and it is in figure 4.

It can be seen, firstly, the UIP deviation is almost all time positive. This is a direct indication of UIP puzzle. Secondly, the UIP deviation contains heavy auto correlation. So we can add the lag term of UIP deviation into independent variables to take care of the auto correlation. Indeed, note that the UIP deviation is measured as the difference between exchange rate first order forward difference and interest rate differential, both characters are generally changing continuously in time. Only in the case where there is huge external shock will they jump, but regularly, central banks adjust interest rate in a continuous manner and exchange rate also adjust continuously.

In this study, we treat monetary shocks as **exogenous**. A discussion of wether this assumption

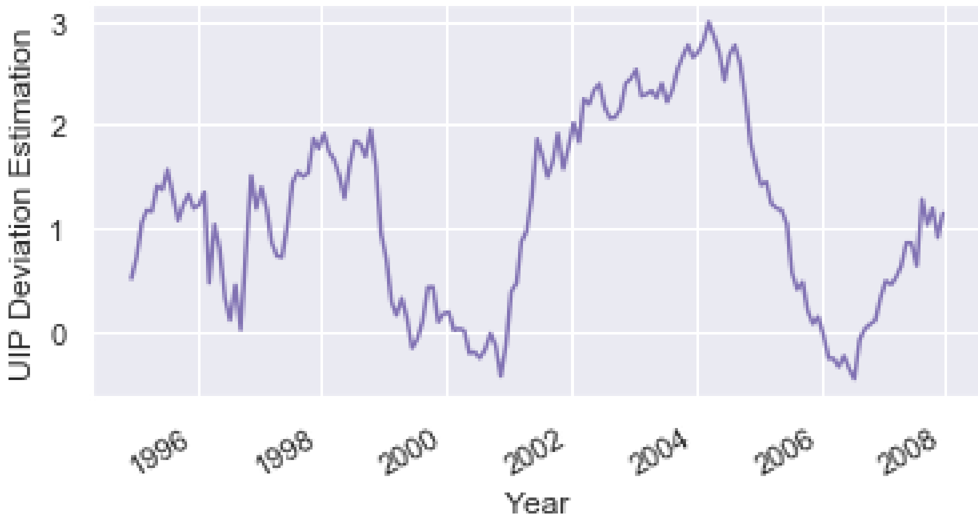


Figure 4: UIP deviation estimation

is proper comes in later section. Bearing this in mind, an OLS regression as follows shows clearly the negative impact of contractionary monetary shocks on the UIP deviation.

$$p_t = \beta_0 + \beta_1 p_{t-1} + \beta_2 monetaryShock_t + u_t \tag{14}$$

A comment on this regression is the lag term of UIP deviation is added due to the observed large auto correlation according to figure 4. To run this regression, we used the data of Britain, Australia, Japan and European Union, each paired with the US. We are using monthly data and the time period is 1994 to prior 2008. This choice of time window is intended for avoiding the Pound-Mark problem and to take advantage of the well-behaved CIP before crisis. The regression result is in table 1.

From the regression table, we can see, firstly, the monetary shocks' impact on p_t (variable UIPdev in the regression table), is fairly negative significant. The result is consistent across all of the four countries. This reconcile with our intuition about the negative impact direction at the start of this section very well. Secondly, the R^2 of these regressions are actually very close to 1 while maintaining the significance of variables, and F statistic is also fairly large. This agrees with the "forecasting power of monetary policy on exchange rate" mentioned by Engels et al.(2018)

Table 1: Regression Result of Equation 14

VARIABLES	(1)UK UIPdev	(2)JP UIPdev	(3)AU UIPdev	(4)EU UIPdev
UIPdev_lag	0.947***	0.978***	0.987***	0.964***
	(0.0179)	(0.0109)	(0.0134)	(0.0127)
monetaryShock	-0.341***	-0.733***	-0.383***	-0.531***
	(0.106)	(0.121)	(0.109)	(0.112)
Constant	0.0666**	-0.0860*	0.0200	-0.0277
	(0.0307)	(0.0446)	(0.0304)	(0.0193)
Observations	156	165	155	167
R-squared	0.929	0.973	0.972	0.974

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

and "monetary shocks can accounts for up to 50% of UIP deviation" posted by Bouakze and Normandin(2010).

However, there remains several concerns. The first one is a lack of lagged monetary shocks terms. As monetary shocks affects the economy in a lasting manner, lagged terms of monetary shocks should be added to the regression to look into their time-varying effect. Secondly, here we've only included the shocks on the US side and didn't add any characters on British side. It should be better to control for British fundamentals in the regression.

To make this up, we modify regression 14 by adding monetary shock lagged terms and foreign country fundamentals, the regression equation becomes:

$$p_t = \beta_0 + \beta_1 p_{t-1} + \sum_{i=0}^{6} \delta_i monetaryShock_{t-i} + \mu \pi_t^* + \nu unemp_t^* + u_t \tag{15}$$

Using the same data between the four countries and the US, the regression result of equation 15 is in table 2

After doing this modification, the regression result in monetary shocks remains roughly the

Table 2: Regression Result of Equation 15

VARIABLES	(1)UK UIPdev	(2)JP UIPdev	(3)AU UIPdev	(4)EU UIPdev
UIPdev_lag	0.942***	0.967***	0.966***	0.947***
	(0.0213)	(0.0151)	(0.0142)	(0.0222)
monetaryShock	-0.186	-0.494***	0.00558	-0.147
	(0.145)	(0.152)	(0.140)	(0.192)
monetaryShock_lag1	-0.612***	-0.517***	-0.237	-0.342*
	(0.174)	(0.172)	(0.186)	(0.191)
monetaryShock_lag2	0.456**	0.0795	-0.226	0.112
	(0.227)	(0.215)	(0.142)	(0.186)
monetaryShock_lag3	-0.0691	0.152	0.0200	-0.0677
	(0.228)	(0.193)	(0.177)	(0.180)
monetaryShock_lag4	0.0195	0.0144	-0.0877	-0.0471
	(0.222)	(0.160)	(0.185)	(0.178)
monetaryShock_lag5	-0.0594	-0.0782	-0.163	-0.179
	(0.208)	(0.140)	(0.186)	(0.160)
monetaryShock_lag6	-0.0815	0.0988	-0.0402	-0.0250
	(0.154)	(0.145)	(0.144)	(0.152)
unemp*	-0.0100	0.0471	-0.0385**	-0.103**
	(0.0223)	(0.0379)	(0.0192)	(0.0476)
inflation*	0.0185	9.539	0.0170	-0.165*
	(0.0275)	(8.412)	(0.0149)	(0.0878)
Constant	0.0942	-0.330	0.258*	1.245**
	(0.131)	(0.210)	(0.144)	(0.547)
Observations	150	159	149	96
R-squared	0.939	0.977	0.976	0.983

Robust standard errors in parentheses
*** p¡0.01, ** p¡0.05, * p¡0.1

same. What's more, it's clear that the effect of monetary shocks are only significant in the starting periods of the shocks' occurrence, after which they should be fully digested by market. This makes good sense because note this is what happens in financial markets, entities are keeping anticipating what happens around them. In real economy, the effect of a monetary shocks can be long lasting and carry on for several years. But in financial market, as entities gradually perceive what is happening, the things in future will immediately release its effect in assets prices. The lag terms included regression for Australia is not generating significant monetary shocks coefficients, but that is due to multicolinearity of shocks terms. After reducing the lagged terms periods from 6 to 4, Australia is also having a negative significant coefficient.

Another point to notice is the behavior of the coefficients. In this regression, the monetary shocks without lagged appears to be insignificant and the last month's shock takes its place. This can possibly happen due to two potential reasons. The first one is the timing of the data collection date. Although in the data, the monetary shock and the UIP deviation is labeled as the same month, it's still possible that the monetary shock actually happens later than the date when the UIP deviation data is collected. And in this case, the effect of the monetary shock will be shifted by exactly one month. And that can account for what's happening here. The second one is due to the reaction of market. Because when a monetary shock is initially released, the market are not sure wether it is a transitory or a permanent shock. So it can takes some time for the market to "hesitate" and finally price in the shocks, generating a delay from when the shocks take place and when its effect is put.

Another issue here is that after releasing its significant negative effect, monetary shock tends to turn around and generate a positive but not that significant effect in the latter month. This is beyond my perception. Two potential reasons are proposed here. The first possible explain for this is the reverse adjustment of market. Because most of monetary shocks are transitory, the market should return to equilibrium after a perturbation. And in our case, as long as market anticipate the shock as transitory, it will tend to make backward adjustment. The second reason is the famous "exchange rate overshooting" phenomenon. Overshooting is a short-term dynamic that refers to exchange rate appreciating more than the monetary neutral level when the contractionary monetary shocks happen, and then adjust backwards, vice versa for expansionary monetary shocks. That seems to be a good excuse for what's happening here. For detailed study about "exchange rate overshooting", see Dornbusch(1976).

Finally, these case by case anomalies are really accustomed to countries, and we will see in the next section that once we pool all countries and run a Panel Data estimation, they will

all disappear.

3.3 Fixed Effect Model

As we noted, the regression result of the four countries behaves roughly the same. So it can be more persuasive to pool them and run a panel data regression with fixed effect. The Fixed effect models are:

$$p_{it} = \alpha_i + \beta_1 p_{i,t-1} + \delta monetaryShock_{it} + \mu unemp^*_{it} + \nu \pi^*_{it} + u_{it} \tag{16}$$

$$p_{it} = \alpha_i + \beta_1 p_{t-1} + \sum_{j=0}^{6} \delta_j monetaryShock_{i,t-j} + \mu \pi^*_{it} + \nu unemp^*_{it} + u_{it} \tag{17}$$

The first one is the panel data model for four countries without lagged monetary shocks and the second one is with lag terms. Then we pool the four countries' data and run the regressions. The result is in table 3.

As we can see, using the fixed effect model. The monetary shock is negative significant within the first one or two month of its occurrence. And all other anomalies mentioned in the previous subsection are polished away. Based on this result, we can confirm our conclusion at the beginning of the section. The monetary shocks are really significant in generating the UIP deviation, and a contractionary shock will generate a negative direction deviation of the UIP equation.

After doing this identification successfully, we are also interested in the time dynamic of the UIP deviation reaction to monetary shocks. A traditional way to study this dynamic is using Vector Auto Regression model, which we will discuss in next section.

3.4 Why This is Causal Effect? The Exogeneity of Monetary Shocks.

Here we spend a few lines to discuss wether treating our measure of monetary shocks is reasonable.

A very first point we made is once the monetary shocks series is exogenous, then we are at 100 percent confidence level that we've identified a causal effect. Then, we should look into how we constructed the monetary shocks series. We peeled this series out by using a residual series of

Table 3: Panel Data Regression of Equation 16 & 17

VARIABLES	(1) UIPdev	(2) UIPdev
UIPdev_lag	0.971***	0.966***
	(0.00691)	(0.00742)
monetaryShock	-0.482***	-0.241***
	(0.0600)	(0.0755)
monetaryShock_lag1		-0.434***
		(0.0943)
monetaryShock_lag2		0.107
		(0.108)
monetaryShock_lag3		0.0251
		(0.102)
monetaryShock_lag4		-0.0106
		(0.0944)
monetaryShock_lag5		-0.106
		(0.0903)
monetaryShock_lag6		0.00509
		(0.0763)
$unemp^*$	-0.00725	-0.0159
	(0.0112)	(0.0120)
$inflation^*$	0.0204	0.0201
	(0.0128)	(0.0129)
D_{JP}	-0.131***	-0.160***
	(0.0478)	(0.0501)
D_{AU}	-0.0133	0.00480
	(0.0342)	(0.0342)
D_{EU}	-0.00682	0.0160
	(0.0477)	(0.0496)
Constant	0.0480	0.0978
	(0.0666)	(0.0713)
Observations	572	554
R-squared	0.992	0.992

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

a interest rate forecasting model. In our framework, the measured monetary shocks series is the unanticipated part of interest rate adjustment, if the market is truly using our model to forecast the future interest rate. In this sense, our question boils down to wether the market is using our model.

Is this true? Probably not. Because the behaviour of the market can be complex and simply not as simple as a lag term included Taylor rule. But a critical reason why we are using Taylor rule is it can successfully characterize the most severe monetary shocks of counties called inflation-targeter. As the monetary shocks are subtle during most of times and occur in large scale in specific chunks of time periods, Taylor rule can do a good job capturing this kind of monetary shocks, and as long as these "big shocks" are dominant in the causal effect identification, using this model can lead to a nearly correct result.

Our time series of monetary shocks is telling its being reasonable. Indeed, look at figure 3, we can see that most of the time, the shock is perfectly near 0. And there are chunks of time where it deviates from 0 intensively. For example, in the beginning of 2000s FED lowered the interest rate very much. And that is clearly shown by our monetary shocks series. So in our situation, we argue that our measure of monetary shocks can be used as exogenous. So the coefficients we got are also good identification of causal relationships.

4 Impulse Response Function of Monetary Shocks

To reveal more characteristic about the monetary shocks' effect, we adopt a Vector Auto Regression(VAR) model. In our study, we choose the auto regression stages to be 6. In fact this number's choice is robust and it makes nearly no difference for results to choose larger or smaller number of stages.

The VAR model can be written as:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_6 Y_{t-6} + u_t \tag{18}$$

Here, $Y_t = (1, p_t, monetaryShock_t, unemp_t^*, \pi_t^*)^T$ is the vector of covariates. A_i is constant matrix with size 5 by 5. u_t is the disturbance term whose with $u_t \sim Normal(0, \sum_u)$.

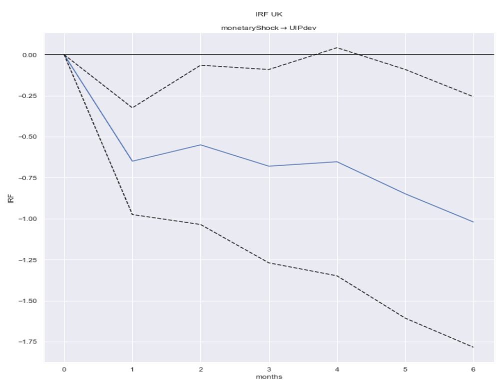
After estimating this model, a closely related functional is the Impulse Response Function, they are calculated by representing the VAR model by all the shock terms along the way, using a

MA(∞) model:

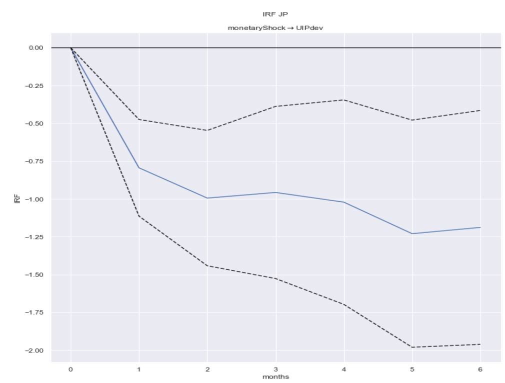
$$Y_t = \mu + \sum_{i=0}^{\infty} \Phi_i u_{t-i} \tag{19}$$

The regression result table is shown at the end of the section. For here, we only show the visualized result, which is the impulse response plots for the four countries. The IRF plots are in figure 5.

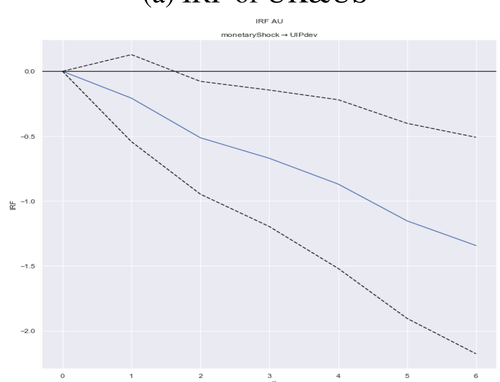
Seeing the result in figure 5, we know that monetary shocks have a negative impact on the



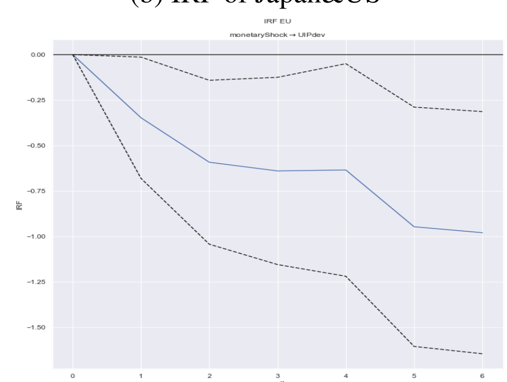
(a) IRF of UK&US



(b) IRF of Japan&US



(c) IRF of Australia&US

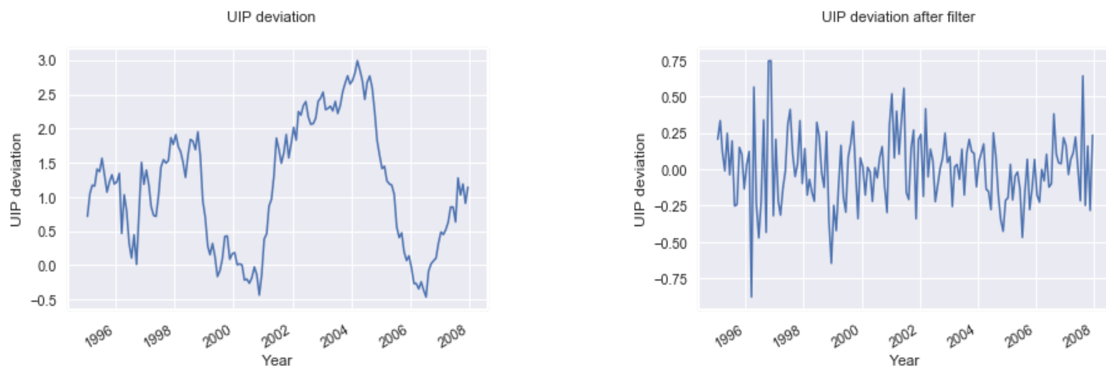


(d) IRF of EU&US

Figure 5: IRF Plots

UIP deviation. But we once claimed the monetary shocks should not have a long lasting impact due to the nature of financial market. This is the really due to the very large auto correlation in the UIP deviation. As the foreign exchange market is fairly large and normally it cannot swing very largely in a short period. So there is surely a lot of inertia in the exchange rate, so in UIP deviation measure. To overcome this large inertia, we need a method to filter out the auto correlation. A method easy to implement is to take the first order backward difference of the UIP deviation. We did this, and the time series of UIP deviation before and after filtered is in figure 6.

Again, consider the following VAR model, instead of using UIP deviation, we are now using



(a) UIP deviation before filter

(b) UIP deviation after filter

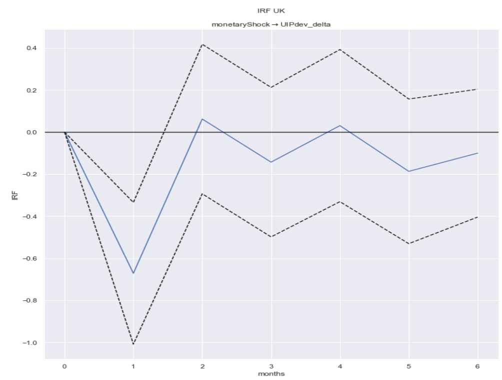
Figure 6: UIP deviation before and after filter

its difference.

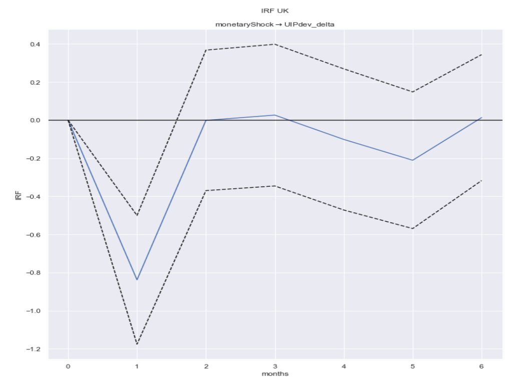
$$\tilde{Y}_t = A_1\tilde{Y}_{t-1} + A_2\tilde{Y}_{t-2} + ... + A_6\tilde{Y}_{t-6} + u_t \tag{20}$$

Here the $\tilde{Y}_t = (1, p_t - p_{t-1}, monetaryShock_t, unemp_t^*, \pi_t^*)^T$. The new IRF plots are in figure 7.

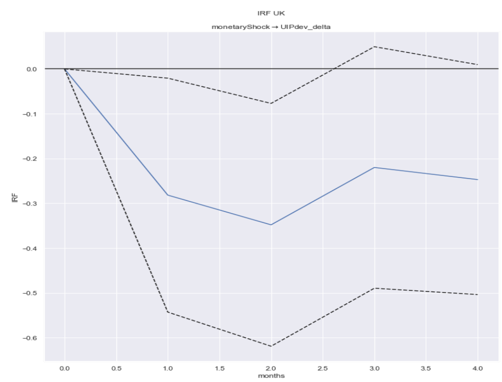
As we can see from the IRF plots after filtering out the auto correlation in the UIP deviation series, we see a negative significant impact of monetary shocks at the very first or second month, then the impact will return to zero. This reconcile with our intuition.



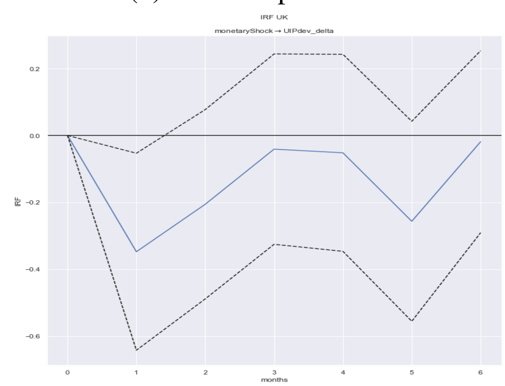
(a) IRF of UK&US



(b) IRF of Japan&US



(c) IRF of Australia&US



(d) IRF of EU&US

Figure 7: IRF Plots

Up till here, we've successfully identified that the impact of monetary shocks on UIP deviation happens in the first one or two months. Hence the dynamic causal effect is really a short term effect.

4.1 VAR Models Regression Results

Table 4: Regression Result of VAR Model 1

VARIABLES	(1) UIPdev	(6) UIPdev	(11) UIPdev	(21) UIPdev
L.UIPdev	1.005***	0.736***	0.842***	0.922***
	(0.0846)	(0.0831)	(0.0813)	(0.107)
L2.UIPdev	-0.0456	0.185*	0.0794	-0.170
	(0.120)	(0.104)	(0.106)	(0.143)
L3.UIPdev	0.108	0.136	0.283***	0.460***
	(0.122)	(0.107)	(0.109)	(0.150)
L4.UIPdev	-0.247**	-0.00155	-0.201*	-0.148
	(0.118)	(0.107)	(0.111)	(0.153)
L5.UIPdev	0.0876	-0.0470	-0.0176	-0.146
	(0.115)	(0.109)	(0.110)	(0.161)
L6.UIPdev	0.0254	-0.0453	-0.0143	0.0322
	(0.0807)	(0.0888)	(0.0823)	(0.109)
L.monetaryShock	-0.640***	-0.795***	-0.216	-0.347**
	(0.149)	(0.146)	(0.150)	(0.138)
L2.monetaryShock	0.401**	-0.155	-0.240	-0.0946
	(0.170)	(0.159)	(0.161)	(0.152)
L3.monetaryShock	-0.0367	0.200	0.115	0.00209
	(0.177)	(0.163)	(0.165)	(0.151)
L4.monetaryShock	0.129	0.133	-0.169	0.181
	(0.179)	(0.161)	(0.168)	(0.155)
L5.monetaryShock	-0.174	-0.0755	-0.271	-0.306*
	(0.178)	(0.158)	(0.168)	(0.161)
L6.monetaryShock	-0.0881	0.0198	0.151	0.0676
	(0.156)	(0.140)	(0.159)	(0.151)
Constant	0.193	-0.312*	0.281**	1.193*
	(0.132)	(0.184)	(0.135)	(0.716)
Observations	150	159	149	90

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: Regression Result of VAR Model 2

VARIABLES	UK UIPdev_delta	JP UIPdev_delta	AU UIPdev_delta	EU UIPdev_delta
L.UIPdev_delta	0.0602	-0.237***	-0.129	-0.0357
	(0.0848)	(0.0836)	(0.0790)	(0.102)
L2.UIPdev_delta	0.0184	-0.0393	-0.0354	-0.157
	(0.0883)	(0.0895)	(0.0807)	(0.103)
L3.UIPdev_delta	0.120	0.104	0.264***	0.286***
	(0.0883)	(0.0936)	(0.0821)	(0.103)
L4.UIPdev_delta	-0.134	0.107	0.0125	0.103
	(0.0871)	(0.0972)	(0.0799)	(0.106)
L5.UIPdev_delta	-0.0324	0.0590	-0.00696	-0.00630
	(0.0830)	(0.0949)	(0.0814)	(0.108)
L6.UIPdev_delta	0.0105	-0.0155	-0.231***	-0.214*
	(0.0831)	(0.0885)	(0.0813)	(0.111)
L.monetaryShock	-0.663***	-0.812***	-0.297**	-0.422***
	(0.155)	(0.151)	(0.147)	(0.144)
L2.monetaryShock	0.427**	-0.144	-0.314**	-0.0562
	(0.176)	(0.162)	(0.159)	(0.150)
L3.monetaryShock	-0.0157	0.221	0.119	0.0128
	(0.183)	(0.166)	(0.163)	(0.150)
L4.monetaryShock	0.143	0.167	-0.149	0.169
	(0.184)	(0.164)	(0.166)	(0.154)
L5.monetaryShock	-0.138	-0.0505	-0.227	-0.209
	(0.182)	(0.162)	(0.166)	(0.160)
L6.monetaryShock	-0.0124	0.0268	0.137	0.0672
	(0.158)	(0.153)	(0.157)	(0.148)
Constant	0.0145	-0.0393	0.225*	0.949
	(0.120)	(0.142)	(0.127)	(0.680)
Observations	150	159	149	90

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

5 Summary

In this paper, we went over the past studies about monetary shocks and UIP deviation. We clearly stated the reason why monetary shocks can cause UIP to deviates. And used 2 models and

2 identification methods to confirm the causal effect of monetary shocks. We argued our monetary shocks measure can be used as exogenous here. And looked into the dynamic effect of monetary shocks. We found out that the effect is really just in short term, which fits our intuition about financial market.

The highlight of our work is that we directly look into the relationship of a potential factor and the deviation level. This can be a very efficient methods to study the UIP deviation problem. Following our way, if enough works are done in future and find more and more factors explaining the deviation. We are making our way towards a better forecast of exchange rate, and a better perception about international carry trade returns. This direct approach is promising.

There are still lots of potential extension for this work. The first one is to find better monetary shocks measure, such as Romer and Romer(2004). A high quality monetary shocks measure can directly make the result get better. The second one is to look into the timing of the monetary shocks, this require not only data in monthly frequency, but also in daily frequency. We can find the exact day and hour when the shocks take place. And do high frequency identification of the causal effect. That can reveal more interest details about this relationship. The third one is to parallelize this method to general arbitrage situation. As UIP deviation is nothing but a arbitrage equilibrium, we can analogously use the same method to study the situation in other market that is suitable for implementing arbitrage, such as Commodity and Oil.

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