Does the accumulation of foreign currency reserves affect risk-taking? An event study approach

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Abstract

Fatum and Yetman (2017) assess whether foreign currency reserves accumulation in the Asia-Pacific region is systematically associated with risk-taking, using an event study approach to examine the responses of various proxies of risk-taking to official announcements of reserves stocks. Across a wide range of specifications and robustness checks, we find little evidence that reserves accumulation has a significant influence on risk-taking.

Keywords: foreign exchange reserves, risk-taking, implied volatility, credit default swaps.

JEL classifications: F31, G15.

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1. Introduction

The massive accumulation of foreign currency reserves across economies in the Asia-Pacific region is now well known, and the cost of holding large stocks of foreign exchange reserves has been extensively discussed.[2] In this paper, we summarise our work (Fatum and Yetman (2017)), which seeks to add to the discussion by assessing whether reserves accumulation in the Asia-Pacific region is systematically associated with changes in private sector risk-taking within the economy where the accumulation is taking place.[3]

To motivate the importance of this research, suppose that a central bank were to accumulate foreign exchange reserves for the purpose of being able to provide emergency foreign currency funding in the event of significant financial stress. If the act of accumulating, or holding, a large stock of reserves had the effect of encouraging greater risk-taking, then this would work against the intended purpose of the accumulation: the very act of holding those reserves would increase the likelihood that they would need to be deployed at some point. The alternative scenario – where reserves accumulation does not have such undesirable side effects – would support the view that reserves stocks can be used to provide meaningful insurance against shocks. In either case, the results would have important implications for central bank policies, to be considered along with all the existing discussion surrounding the trade-offs of holding foreign currency reserves.[4]

To address this research question, Fatum and Yetman (2017) carry out a country-specific daily data event study analysis of whether official announcements of reserves stocks influence risk-taking. We focus on 10 Asia-Pacific economies (Australia, China, Hong Kong SAR, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thailand) over a sample period beginning in the early-mid 2000s (depending on data availability for each economy) until approximately the end of 2016.

Our primary proxy for risk-taking is the implied volatility of out-of-the-money currency options, both calls and puts, at two different horizons (one month and 12 months). We also consider other, less direct, proxies (CDS spreads on sovereign US dollar-denominated bonds and equity price indices).

Events are defined as the announcement relative to some alternative, which would ideally represent market expectations of the announcement. Where expectations are available, we utilise these. But generally they are not available. Therefore we consider both the prior announcement and projected reserves (from a simple projection model) as alternatives to compare reserves announcements against.

Our baseline results, as well those from a large set of robustness analyses, suggest that reserves accumulation does not exert a significant influence on risk-taking. We therefore conclude that, while excessive reserves accumulation might be

[2] See, for example, Filardo and Yetman (2012) and Park and Estrada (2009).

[3] We use the term "risk-taking" to mean the willingness to take on currency risk. We do not attempt to distinguish between whether a change in risk-taking is because of changed expectations about the direction of the exchange rate, the expected volatility of the exchange rate or the associated risk premium.

[4] See ECB (2006) for an excellent overview of the more traditional costs associated with large foreign currency reserves holdings.

costly for reasons already acknowledged in the literature, any additional indirect costs via a risk-taking channel are likely to be small.

The rest of this summary is organised as follows. Section 2 outlines the macroeconomic context of the study and summarises previous studies of particular relevance. Section 3 details the empirical methodology and describes the data. Section 4 presents the results. Section 5 concludes.

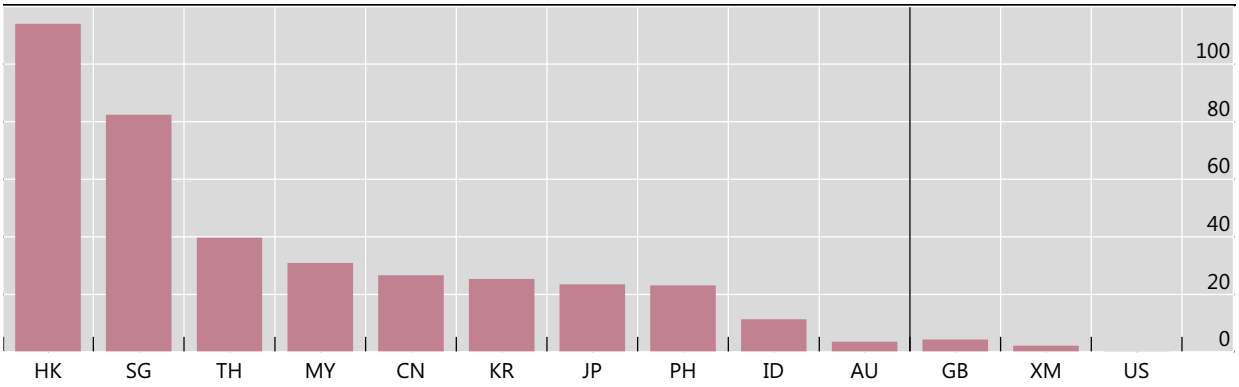
2. Context and previous results

2.1 Macroeconomic context

Underlying this research question about the possible effects of a build-up of foreign exchange reserves on risk-taking is the massive stocks of reserves across economies in the Asia-Pacific region. Graph 1 displays total foreign exchange reserves as a share of GDP for 10 major Asia-Pacific economies that Fatum and Yetman (2017) study and, for comparison, for three major economies from outside the region, as of the end of 2016. What is clear from the graph is that reserves in the region are large, in both absolute and relative terms. They exceed 20% of GDP for eight regional economies, and are more than 80% of GDP for Singapore and Hong Kong.

Foreign exchange reserves

2016 Q4, as a percentage of nominal annualised GDP — Graph 1



AU= Australia; CN = China; GB = United Kingdom; HK = Hong Kong SAR; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = euro area.

Sources: CEIC; Datastream; IMF, *International Financial Statistics*; national data.

Another remarkable feature of the Asian reserves data is the importance of foreign exchange reserves' growth in accounting for changes in the overall size of central bank balance sheets. For many regional economies, foreign exchange reserves growth is responsible for virtually all of the increase in balance sheet size in the region over the past decade, but very little of it for those same economies from other regions displayed above (Graph 2).

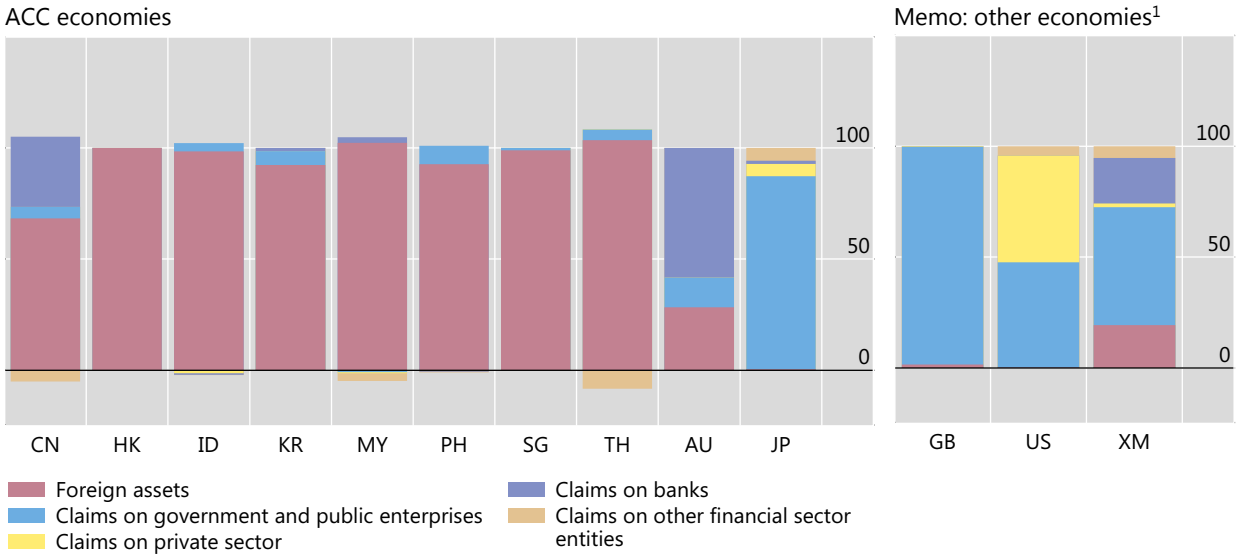
Our research question is whether this accumulation of reserves might have had unintended consequences on private sector risk-taking. High levels of reserves may be perceived to reduce the cost of currency mismatches, for example if market participants view reserves as providing a form of insurance, since the central bank can use them to stabilise exchange rates in the event of sharp depreciation pressures. This

could increase the willingness by market participants to take on unhedged foreign currency liabilities on their balance sheets.

A circumstance where reserves may seem particularly likely to encourage such risk-taking is where the central bank has used reserves to act as a provider-of-foreign-currency-liquidity-of-last-resort in the past, and may therefore be expected to do so again in future. For example, many central banks used either their own reserves or the proceeds of swaps with the US Federal Reserve or other central banks during the 2007–09 crisis to alleviate dislocations in FX markets (Jara et al (2009); Baba and Shim (2014)).[5]

Change in the composition of central bank assets in ACC economies, 2006–16

As a percentage of change in total assets — Graph 2



AU = Australia; CN = China; GB = United Kingdom; HK = Hong Kong SAR; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = euro area.

[1] For United Kingdom, *net* claims on central government instead of claims on government and public enterprises.

Source: IMF, *International Financial Statistics*.

2.2 Existing evidence

Fatum and Yetman (2017) build on existing literature modelling and documenting possible links between reserves accumulation and risk-taking. For example, Chutasripanich and Yetman (2015) use simulations of a simple model to illustrate how intervention intended to limit exchange rate volatility can increase the level of speculative activity of risk-averse speculators, and may hence be counterproductive. Caballero and Krishnamurthy (2000) show that reserves accumulation, and associated sterilisation operations, can have important (and perhaps counterproductive) effects on capital flows and risks. Caballero and Krishnamurthy (2004) argue that foreign

[5] Baba and Shim (2010, 2014) find that, in the case of Korea, auctioning off the proceeds of swaps with the US Federal Reserve was more effective than the use of own reserves in alleviating currency market dislocations, and postulate that this may be because the former did not result in a reduction in the level of reserves, and hence did not reduce market confidence.

exchange intervention policies limit the development of domestic financial markets and so contribute to the underinsurance of foreign currency risks. Burnside et al (2004) illustrate how implicit guarantees to banks' foreign creditors (which reserves can be used to provide) can be a root cause of self-fulfilling twin banking-currency crises. The existence of the guarantees encourages banks to take unhedged foreign currency exposures, and to then renege on these in the event of an exchange rate devaluation.

In terms of empirical evidence, Cook and Yetman (2012) report that higher foreign exchange reserves appear to provide banks with insurance against exchange rate shocks, in that their equity prices become less sensitive to exchange rate movements. Sengupta (2010) finds that reserves accumulation appears to lead to greater currency risk-taking (in terms of a higher level of dollar-denominated debt) in the corporate sector in Latin America based on data for 1,500 firms in six Latin American economies. In contrast, Berkman and Cavallo (2009) report mixed evidence of the direction of causality: while economies with high levels of liability dollarisation tend to have more active exchange rate stabilisation operations, floating exchange rates do not result in de-dollarisation in their sample. Meanwhile Ismailescu and Phillips (2015) find that high levels of foreign exchange reserves are associated with less trading of sovereign CDS in a sample of 41 countries, which could reflect less efforts being taken to insure against currency risks. Relatedly, Amstad and Packer (2015) report a positive relationship between the stock of foreign exchange reserves in Asian economies and credit ratings on foreign currency debt, which may be expected to translate into a lower cost of taking on foreign currency exposures for many borrowers.

The increase in risk-taking could, in principle, lie in the countries who are the recipients of the reserves flows rather than in the source, especially if reserves accumulation influences asset prices. The reserves are held in terms of foreign currency-denominated assets and this could depress interest rates elsewhere, encouraging increased risk-taking. Along this line, Gerlach-Kristen et al (2016) report that, during the 2003–04 period, official Japanese purchases of foreign exchange appear to have lowered long-term interest rates in the United States and, to a lesser extent, in other major advanced economies (including Japan) as well. However, the question of any effects outside of the accumulating economy is beyond the scope of Fatum and Yetman (2017).

3. Empirical methodology

The research question could be addressed in different ways. One possibility would be to include the stock of reserves in an otherwise well specified empirical model, and test to see if the reserves stocks have any significant effect on macroeconomic variables of interest (GDP, inflation, investment etc) at some horizon based on typical macroeconomic frequencies (quarterly or annual). We first examined this possibility, but found that the results were inconclusive. This was not completely surprising, given that reserves stocks are a slow-moving series and any effect is likely to be buried within all the other shocks and propagation processes affecting the economy.

An event study involves taking a complementary approach. It entails asking about a very short-term effect of a very specific event. Because of the high frequency, evidence of an effect is typically sought from financial market variables that might be directly affected. These may be proxies for the effect one is seeking to identify. A

change in the market price that coincides with the event is assumed to be driven primarily by the event, rather than other factors. The narrower the event window within which the effect is measured, the more likely this is to be the case. Given a sufficiently large number of events, event studies can have very high power to test hypotheses about the effects of the events.

In order to perform an event study, it is important to ensure that the timing of the event variable and response variable are correctly aligned, especially when financial market data are being drawn from different markets with varying opening and closing times, and some markets may be affected by daylight-saving time. In some cases, using daily frequency data (as in Fatum and Yetman (2017)) data for either the announcements or the response variables may need to be lagged by one day to ensure that the data are correctly synchronised.

In the context of the effects of reserves on risk-taking, one concern is that any correlation might reflect reverse causality: central banks increasing reserves in response to growing risk-taking activity. An event study is an effective way to address this concern, for three related reasons. First, it looks at the effects around the time of the announcement of reserves, rather than when any associated intervention in foreign exchange markets takes place, so any direct effects of central bank actions on proxies of risk-taking are likely to have occurred outside of the event windows. Second, if there was some common factor that was fuelling a change in our risk-taking measure and the change in reserves, this is unlikely to occur just at the time of the announcement. Third, for most tests it is possible to compare the behaviour of a variable in a pre-event window with a post-event window, which reduces the effect of any conflating factors that affect both windows – which is analogous to the use of fixed effects in panel regression contexts.

One important channel through which foreign exchange reserves may influence risk-taking is by reducing the perceived risks associated with exchange rate exposures. In that case, we would expect the cost of insuring against exchange rate changes to vary systematically with changes in the known level of foreign exchange reserves. Fatum and Yetman (2017) thus use the cost of insuring against exchange rate changes vis-à-vis the US dollar as a measure of risk-taking. We consider four measures of this: the implied volatility of each of calls and puts, at one-month and 12-month horizons. The precise measures used are based on 25-delta options which are out-of-the-money, to the extent that a given change in the exchange rate results in approximately 25% of that change in the value of the options. The implied volatility of currency options have previously been used to consider the effects of central bank foreign exchange intervention, including in Bonser-Neil and Tanner (1996) and Disyatat and Galati (2007).

One feature of the analysis is the examination of the implied volatility of calls and puts separately since, depending on the mechanism at work, one could expect to see a different link between either and risk-taking. Calls may be used to insure against exchange rate appreciation, and puts to insure against exchange rate depreciation. The implied volatility is a measure of the cost of taking out such insurance. On the one hand, if an increase in the level of reserves is perceived to reduce the risk of a large exchange rate depreciation more than appreciation, since the central bank can use those reserves to counter depreciation pressures, we might expect to find a stronger link between reserves and the implied volatility of puts than calls. On the other hand, if an increase in the level of reserves is thought to reflect active intervention to prevent exchange rate appreciation, and this pattern of intervention

is expected to persist into the future, then this may act as a bound on expected appreciation risks and so reduce the cost of insuring against appreciations more than it does the cost of depreciations. In that case, the link between reserves and the implied volatility of calls may be stronger than that of puts.

Fatum and Yetman (2017) consider four different tests of the effects of reserves on risk-taking, following the approach taken in Fatum (2000) and Fatum and Hutchison (2003). The first is the direction criterion test, which assesses if the response variable (the proxy for risk-taking) moves in the direction consistent with the reserves announcement during the post-event window. The null hypothesis for this test is that reserves have no influence on risk-taking. Thus the probability of observing an event consistent with the direction criterion is the same as observing an event that is not consistent with the direction criterion. That is, under the null hypothesis, the probability of either outcome is 0.5. The test essentially counts up the number of events that go the "right" way and compares that with the number that would be expected if the probability for each one was 50%. The probability density function and cumulative density function for this test are based on the binomial distribution.

The second test is the reversal criterion test, which focuses on the subset of events where the announcement goes in the direction opposite to what might have been expected, based on the direction of the response variable in the pre-event window. The number of successes in this test is the number of such events where the direction changes in the post-event window. For example, if risk-taking declines in the pre-event window and the reserves announcement indicates an increase in reserves, we would record a success if risk-taking rises in the post-event window. In this case, the number of successes is compared with the proportion of changes in direction between pre- and post-windows around non-events.

The third test is the smoothing criterion test, which is a less stringent version of the second test. Here, an event is recorded as a success if, in the post-event window, the response variable moves in the direction predicted by the reserves announcement, without it necessarily changing direction. So, if the measure of risk-taking in the pre-event window increased, and then the reserves announcement was positive, did risk-taking increase by less or decline in the post-event window (a success) or increase by more (a failure)? Again, this is compared with the analogue constructed from windows around periods when there are no events.

Finally, a fourth test, the information criterion, assesses whether reserves announcements have any information content at all. If they do, then the absolute size of the change in the measure of risk-taking in the post-event window should be larger than in the pre-event window. But, if they do not, then an increase in the absolute size of the change should be no more likely than a decrease. As with all the other tests, the evidence can be assessed against the binomial distribution.

4. Results

Table 1 contains the baseline results from Fatum and Yetman (2017), based on two-day windows where the event (the announcement of reserves) falls in the first day of the post-event window (except for one-day windows for Thailand, due to the very high frequency of announcements) and the announcement is measured relative to the previous announcement. We conduct the tests outlined in the above section for each economy, one at a time. As is conventional, asterisks indicate statistical significance at the 5% (**) or 1% (***) level.

The key thing to note is the lack of statistically significant results. Indeed, across 160 tests in all, there are a total of only five rejections of the null hypothesis based on 5% critical values, which is below the level of rejections that one would expect by chance in the event that there is no relationship at all, simply due to Type I errors.

Fatum and Yetman (2017) then go on to try many variations on the event study, and report essentially the same results in each case. We vary the window length (one, two or three days), whether the event falls in the first day of the post-event window or between the two windows, examine CDS spreads and equity prices, measure the announcement relative to either market expectations or projected reserves, test the opposite results (that reserves reduce rather than increase risk-taking), focus on the post-crisis period, split the sample based on the direction of change of either the exchange rate or reserves, or the size of the change in reserves, and run event regressions.

The greatest evidence for a positive effect of reserves accumulation on risk-taking comes from sovereign CDS spreads: the overall rejection rate at the 5% level is around 13%. However, CDS spreads are a very indirect measure of currency risk-taking, and may be affected by other factors, such as fiscal solvency. Across all the other robustness checks we examine, we get the same essential results as reported above for the base results.

One particularly intriguing set of results comes from reversing the hypotheses, and testing whether reserves accumulation reduces risk-taking. Here we actually find more evidence in favour of the opposite hypotheses than for the original ones.

Baseline results from Fatum and Yetman (2017): implied volatility, two-day windows Table 1

		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put	
		Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non
Test		**Australia**								**China**							
1	Yes	67		69		67		67		24		26		28		26	
	No	51		48		50		50		35		33		30		32	
	p-val	0.08		0.03 **		0.07		0.07		0.94		0.85		0.65		0.82	
2	Yes	33	1462	32	1374	30	1292	26	1259	14	1467	16	1469	16	1432	13	1459
	No	21	1255	21	1566	21	1425	26	1458	14	1541	14	1539	16	1576	20	1549
	p-val	0.17		0.19		0.07		0.35		0.52		0.38		0.46		0.89	
3	Yes	43	2084	42	2073	43	1979	37	1969	22	2222	24	2237	26	2196	22	2203
	No	11	614	11	623	8	651	15	672	6	693	6	671	6	678	11	666
	p-val	0.41		0.42		0.09		0.77		0.49		0.44		0.34		0.94	
4	Yes	58		56		55		60		26		28		25		31	
	No	62		64		64		60		33		31		33		26	
	p-val	0.68		0.79		0.82		0.54		0.85		0.70		0.88		0.30	
Test		**Hong Kong**								**Indonesia**							
1	Yes	73		73		68		76		78		82		79		81	
	No	62		62		68		60		75		71		73		71	
	p-val	0.20		0.20		0.53		0.10		0.44		0.21		0.34		0.23	
2	Yes	37	1199	37	1202	31	1160	33	1169	27	986	33	1058	31	1012	38	1062
	No	30	1358	34	1355	43	1397	38	1388	29	1227	28	1155	32	1202	34	1152
	p-val	0.11		0.23		0.76		0.49		0.34		0.20		0.33		0.24	
3	Yes	56	1808	52	1801	59	1784	56	1795	43	1538	48	1589	45	1559	59	1567
	No	11	449	19	464	15	470	15	463	13	522	13	467	18	488	13	480
	p-val	0.30		0.92		0.52		0.62		0.43		0.47		0.85		0.17	
4	Yes	76		72		67		75		80		79		82		72	
	No	67		72		80		71		65		66		63		72	
	p-val	0.25		0.53		0.88		0.40		0.12		0.16		0.07		0.53	
Test		**Japan**								**Korea**							
1	Yes	78		79		72		71		76		73		75		75	
	No	70		68		78		78		68		72		69		72	
	p-val	0.28		0.21		0.72		0.74		0.28		0.50		0.34		0.43	
2	Yes	29	1367	32	1332	25	1228	25	1194	27	1177	33	1216	37	1116	42	1142
	No	35	1187	37	1222	35	1326	40	1360	41	1380	43	1341	29	1442	32	1416
	p-val	0.93		0.99		0.87		0.93		0.88		0.80		0.03 **		0.02 **	
3	Yes	46	1940	41	1928	45	1866	41	1856	46	1860	50	1884	51	1809	58	1830
	No	18	594	18	600	15	614	24	624	22	629	26	610	15	635	16	612
	p-val	0.85		0.91		0.59		0.99		0.93		0.98		0.33		0.30	
4	Yes	81		75		73		80		77		82		76		86	
	No	70		77		75		71		72		67		67		59	
	p-val	0.21		0.60		0.60		0.26		0.37		0.13		0.25		0.02 **	

Notes: Day of event included in post-event window. Columns labelled "Non" display the number of non-events used in tests 2 and 3. Only non-overlapping events/non-events are included. Results for Thailand are based on one-day windows due to the small number of non-overlapping two-day events. **/*** denote rejection of null hypothesis of no increase in risk-taking at 95/99% levels of significance.

Baseline results from Fatum and Yetman (2017): implied volatility, two-day windows (cont)

Table 1

		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put		Implied vol 1-month call		Implied vol 1-month put		Implied vol 12-month call		Implied vol 12-month put	
		Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non	Events	Non
Test		**Malaysia**								**Philippines**							
1	Yes	97		105		99		98		53		52		51		51	
	No	113		105		111		113		63		64		62		61	
	p-val	0.88		0.53		0.82		0.87		0.85		0.89		0.87		0.85	
2	Yes	44	643	50	649	38	631	44	650	23	1012	21	1036	20	970	22	1014
	No	54	805	51	799	63	818	58	799	32	1492	31	1468	35	1534	32	1490
	p-val	0.50		0.20		0.90		0.67		0.47		0.61		0.69		0.54	
3	Yes	69	1020	73	1024	64	1024	69	1033	35	1614	33	1617	38	1606	36	1642
	No	29	349	28	345	37	332	33	323	20	501	19	497	17	457	18	417
	p-val	0.85		0.76		1.00		0.98		0.99		0.99		0.95		0.99	
4	Yes	122		127		124		127		69		64		64		67	
	No	115		110		115		112		54		59		57		54	
	p-val	0.35		0.15		0.30		0.18		0.10		0.36		0.29		0.14	
Test		**Singapore**								**Thailand**							
1	Yes	78		76		75		72		313		309		315		314	
	No	62		64		68		68		298		302		286		284	
	p-val	0.10		0.18		0.31		0.40		0.29		0.40		0.13		0.12	
2	Yes	27	1226	30	1229	32	1174	27	1152	152	689	150	681	162	694	160	723
	No	34	1343	33	1340	40	1395	40	1417	151	641	150	649	116	637	120	608
	p-val	0.75		0.56		0.63		0.81		0.74		0.68		0.02 **		0.19	
3	Yes	46	1865	51	1881	53	1843	46	1862	227	1003	221	987	231	973	228	999
	No	15	607	12	591	19	568	21	540	76	223	79	242	47	229	52	200
	p-val	0.57		0.23		0.76		0.97		1.00		1.00		0.20		0.82	
4	Yes	78		78		77		79		306		311		284		288	
	No	70		71		69		66		307		304		325		322	
	p-val	0.28		0.31		0.28		0.16		0.53		0.40		0.96		0.92	

Notes: Day of event included in post-event window. Columns labelled "Non" display the number of non-events used in tests 2 and 3. Only non-overlapping events/non-events are included. Results for Thailand are based on one-day windows due to the small number of non-overlapping two-day events. **/*** denote rejection of null hypothesis of no increase in risk-taking at 95/99% levels of significance.

5. Conclusion

In this paper, we have summarised our work in Fatum and Yetman (2017), where we carried out a country-specific daily data event study analysis of whether official announcements of reserves stocks influence risk-taking in the Asia-Pacific region. Our main risk-taking proxy measure was the implied volatility of currency options. Our results suggest that there is no large effect of reserves accumulation on risk-taking.

There are a number of takeaways for central banks from this work. First, conventional assessments of the costs and benefits of reserves holdings are not missing an important link between reserves and risk-taking that would have the effect of reducing the benefits from holding reserves. Second, if the accumulation of reserves did not materially increase risk-taking, then a reduction in the rate of accumulation – as has been seen in many economies in recent years – may be expected to have relatively benign effects too. Third, but more speculatively, even a substantial decline in reserves in future might be expected to have limited effects on risk-taking as well.

Although the findings are based on negative results, in the sense that there was insufficient evidence to reject the absence of any relationship between reserves

accumulation and risk-taking, they are based on numerous tests across multiple specifications and many robustness checks, as well as several different risk-taking measures.

But any such empirical study has limitations. For example, Fatum and Yetman (2017) focused on windows defined in terms of a one- to three-day span, due to data availability. Perhaps that is too long, and misses an immediate market response that dissipates over the trading day. Or perhaps it is too short, and the effects take longer to register in implied volatilities, in which case an event study may be a less-than-ideal tool to identify an effect.

Another possibility is that there are sectoral effects that are masked by looking at implied volatility, which is a market price. For example, Cook and Yetman (2012) found that bank equities are less affected by exchange rate changes the larger is the stock of foreign currency reserves. Suppose increased reserves increased risk-taking by banks, but that this was either offset by decreased risk-taking elsewhere or masked by a lack of change in other sectors of the economy. Given the crucial role of the banking sector in the economy, such a change in the sectoral composition of overall risk-taking would be of first-order importance for policymakers, even if there were no effect on the market price of risk.

References

Amstad, M and F Packer (2015): "Sovereign ratings of advanced and emerging economies after the crisis", *BIS Quarterly Review*, December, pp 77–91.

Baba, N and I Shim (2010): "Policy responses to dislocations in the FX swap market: the experience of Korea", *BIS Quarterly Review*, June, pp 29–39.

——— (2014): "Dislocations in the won-dollar swap markets during the crisis of 2007–2009", *International Journal of Finance and Economics*, vol 19, no 4, pp 279–302.

Berkman, A and E Cavallo (2009): "Exchange rate policy and liability dollarization: what do the data reveal about causality?", *IMF Working Paper*, no 07/33.

Bonser-Neil, C and G Tanner (1996): "Central bank intervention and the volatility of foreign exchange rates: evidence from the options market", *Journal of International Money and Finance*, vol 15, no 6, pp 853–78.

Burnside, C, M Eichenbaum and S Rebelo (2004): "Government guarantees and self-fulfilling speculative attacks", *Journal of Economic Theory*, vol 119, no 1, pp 31–63.

Caballero, R and A Krishnamurthy (2000): "International liquidity management: sterilization policy in illiquid financial markets", *NBER Working Paper*, no 7740.

——— (2004): "Smoothing sudden stops", *Journal of Economic Theory*, vol 119, no 1, pp 104–27.

Chutasripanich, N and J Yetman (2015): "Foreign exchange intervention: strategies and effectiveness", *BIS Working Papers*, no 499.

Cook, D and J Yetman (2012): "Expanding central bank balance sheets in emerging Asia: a compendium of risks and some evidence", in "Are central bank balance sheets in Asia too large?", *BIS Papers*, no 66, pp 30–75.

Disyatat, P and G Galati (2007): "The effectiveness of foreign exchange intervention in emerging market countries: evidence from the Czech koruna", *Journal of International Money and Finance*, vol 26, no 3, pp 383–402.

ECB (2006): "The accumulation of foreign reserves", *Occasional Paper Series*, no 43.

Fatum, R (2000): "On the effectiveness of sterilized foreign exchange intervention", *European Central Bank Working Paper* no 10.

Fatum, R, and M Hutchison (2003): "Is sterilized foreign exchange intervention effective after all? An event study approach", *Economic Journal*, vol 113, no 487, pp 390–411.

Fatum, R and J Yetman (2017): "Accumulation of foreign currency reserves and risk-taking", *BIS Working Papers*, forthcoming.

Filardo, A and J Yetman (2012): "The expansion of central bank balance sheets in emerging Asia: what are the risks?" *BIS Quarterly Review*, June, pp 47–63.

Gerlach-Kristen, P, R McCauley and K Ueda (2016): "Currency intervention and the global portfolio balance effect: Japanese lessons", *Journal of the Japanese and International Economies*, vol 39, pp 1–16.

Ismailescu, I and B Phillips (2015): "Credit default swaps and the market for sovereign debt", *Journal of Banking and Finance*, vol 52, pp 43–61.

Jara, A, R Moreno and C Tovar (2009): "The global crisis and Latin America: financial impact and policy responses", *BIS Quarterly Review*, June, pp 53–68.

Park, D and G Estrada (2009): "Are developing Asia's foreign exchange reserves excessive? An empirical investigation", *ADB Economics Working Paper*, no 170.

Sengupta, R (2010): "Does reserve accumulation lead to higher currency-risk taking in the corporate sector? Firm-level evidence for Latin America", *Santa Cruz Institute for International Economics Working Paper*, no 11-08.