The Impact of Global Liquidity on the Dynamics of Bank Leverage in Macao

I. F. Chau and W.M. Cheong
Research and Statistics Department, Monetary Authority of Macao

Abstract

Monetary policies in advanced economies have altered the international banking landscape significantly, thus influencing the level of global liquidity. More frequent interactions between global and domestic banks through cross-border borrowing and lending activities are likely to exert pressures on banks' capital management. On the other hand, the banking industry of Macao is highly internationalised, in terms of capital structure, asset distribution and service network. This paper examines how global liquidity could influence the adjustment of bank leverage in the case of Macao. We conduct a standard partial adjustment model to investigate the mean-reverting feature of bank leverage, which is then extended by incorporating global liquidity proxy. According to our estimation, the trade-off theory of leverage is broadly applicable to banks in Macao. In addition, abundant global liquidity induces banks to increase their leverage in general and speeds up the mean reversion mechanism of leverage of local branches of banks incorporated outside Macao. Our findings could help policy-makers to understand the dynamics of bank leverage, which is important as excessive leveraging or rapid deleveraging of banks poses significant risks to financial stability.

1. Introduction

Since the global financial crisis in 2008 and the outbreak of the COVID-19 pandemic, excessive global liquidity triggered by unconventional monetary policies in advanced economies has notably altered the international banking landscape. A direct consequence of ample global liquidity is to raise cross-border borrowing and lending activities, which may have implications for capital management decisions of the banking sector. Despite the potential problems caused by excessive leveraging, given that the key function of banks is to channel fund flows through credit intermediation and maturity transformation, a significant degree of leverage is inevitable for them. In this study, we employ Macao as a case study to consider the determinants and dynamics of bank leverage.

As the banking industry of Macao has become increasingly internationalised in terms of capital and business structures, it offers a suitable empirical setting to study banks' capital management when there is an abundance of global liquidity. The capital structure of Macao's banking sector is highly globalised, composing of institutions originated from different countries or regions, including Mainland China, Hong Kong, Chinese Taiwan, Portugal, the United Kingdom, Singapore and the United States. Furthermore, asset distribution of Macao's banking sector is increasingly internationalised.

As at end-September of 2022, international assets of Macao's banking system constituted 84.7% of total assets while the share of international liabilities in total liabilities stood at 82.4%. In terms of service networks, Macao's banking sector is extending its outlets to neighbouring regions, cementing its position as a platform for financial services between China and Portuguese-speaking countries. Through the lens of optimal capital structure theory, we investigate whether the leverage dynamics of Macao banks would be impacted by external liquidity shocks. Specifically, we examine the leverage dynamics of branches of banks incorporated outside Macao, assuming that they tend to have more frequent intra-group fund flows.

In line with supervisory requirements, Macao banks maintain capital buffers which would continuously anchor financial stability and reduce external vulnerabilities emanating from global economic uncertainties. As at end-September 2022, the capital adequacy ratio (CAR) of banks incorporated in Macao, that is, the proportion of regulatory capital to risk-weighted assets, stood at 15.1%, well above the minimum capital requirement of 8.0% stipulated Notice no. 011/2015-AMCM based on Basel II. The study of global liquidity on banks' level of leverage adjustment provides insights for policy-makers to understand the dynamics of bank leverage, enhancing the monitoring of capital adequacy and resilience of the banking sector.

The trade-off theory of leverage, a celebrated model for understanding leverage adjustment of banks, provides insights for the mean reversion of leverage towards a targeted level. Following previous studies, we conduct a standard partial adjustment model to examine if this self-correcting adjustment mechanism applies to Macao's banking sector, in which overleveraged banks reduce their leverage and adjust towards the target level over time, and vice versa.

Given that changes in global liquidity might have a significant impact on the funding cost of banks and, hence, the leverage adjustment, we extend our study by introducing a global liquidity proxy to the standard partial adjustment equation. This is to identify the effect of global liquidity on banks' level of leverage adjustment and the speed in reverting back to their targets.

The strong presence of global banks in the form of branches or subsidiaries in Macao suggests that the banking sector could be exposed to external liquidity shocks. Hence, applying the same set of models, we conduct independent tests for local branches of banks incorporated outside Macao to examine if leverage of these banks would respond more aggressively towards external liquidity shocks from a host-region perspective, leveraging on their massive intra-group fund flows with global banks.

The rest of the paper is organised as follows. Section 2 reviews theoretical and empirical literature related to capital management and the impact of global liquidity. Section 3 discusses empirical models employed in this study while Section 4 describes the data and research methodologies adopted. The estimated results are presented in Section 5 while the last section analyses the implications and concludes.

2. Literature Review

2.1 Trade-off theory of leverage

The trade-off theory by Kraus and Litzenberger (1973) remains a leading contender to understand the capital structure decisions of firms, which balance the benefits and costs of debt financing in deciding their preferred capital structure. Of which, the most commonly known is the tax-shield benefits of debts against the cost of bankruptcy. The optimal capital structure of firms can be derived by equating the marginal benefit with the marginal cost of debts.

Theoretically, the trade-off argument should apply equally to banks. The main implication is that banks would actively optimise their preferred capital structure, as opposed to just keeping the minimum capital level as required by regulations. Hence, the trade-off theory complements the theories of optimal bank capital structure in explaining banks' capital management decisions. Gropp and Heider (2010) examine the determinants of banks' capital structure using the cross-section and time-series variations in a sample of large and publicly traded banks spanning 16 countries (including the Unites States and European countries) from 1991 until 2004. According to their estimations, standard cross-sectional determinants of firms' capital structures also apply to large, publicly traded banks.

According to Frank and Goyal (2009), the trade-off theory appears in both static and dynamic forms. In the static version, bank leverage is determined by a trade-off between various factors that could affect the leverage. The implication of the static trade-off theory is to investigate the determinants of bank leverage and check whether this conforms to the theoretical predictions of the trade-off theory. On the other hand, the dynamic version of the model adds further structure on how banks attain their preferred optimal capital structure. The partial adjustment model postulates that there is a mean-reverting force which acts as a self-correcting mechanism for bank leverage, with over-leveraged banks having a tendency to lower their leverage, and vice versa.

2.2 Partial adjustment model

The partial adjustment framework assumes that banks are aimed at establishing optimal capital and risk levels, i.e. the "target levels". Since exogenous shocks drive actual levels away from target levels, banks will then adjust capital and risk to meet the target levels. However, full adjustment may be too costly and difficult, therefore banks adjust levels only partially towards the target levels. The partial adjustment framework assumes that the adjustment is proportional to the difference between optimal and actual levels.

Berger *et al.* (2008) examine the capital adjustment process with the annual panel data for publicly traded US bank holding companies (BHCs) from 1992 through 2006. They utilise a variable-rate of partial adjustment model that includes the possibility of a time-varying, firm-specific target capital ratio as well as a time-varying, firm-specific capital adjustment speed. According to their estimations, BHCs adjust towards their targets quite rapidly, with undercapitalised BHCs adjust towards their targets more quickly than well-capitalised BHCs.

Drakos (2012) investigates whether there is any difference in the capitalisation speed-of-adjustment across regulatory capitalisation buckets[1] of Federal Deposit Insurance Corporation (FDIC)-insured commercial banks in the United States, for the period 2002-2009. After estimating the partial adjustment model, the results suggest

[1] US banks are categorised as five buckets, including critically undercapitalised, significantly undercapitalised, undercapitalised, adequately capitalised and well capitalised.

that the speed of adjustment is monotonically increasing for banks belonging to lower capitalisation buckets, after controlling for bank-specific capitalisation determinants. In addition, differential impacts of capitalisation drivers across regulatory buckets are uncovered. Generally, size, risk and asset quality tend to decrease capitalisation, while market discipline tends to increase it.

The paper of Heid *et al.* (2004) assesses how German savings banks adjust capital and risk under capital regulation, with a sample of around 570 local German savings banks over 1993-2000. The coordination of capital and risk adjustments depends on the amount of capital the banks hold in excess of the regulatory minimum (i.e., the capital buffer). Banks with low capital buffers try to rebuild an appropriate capital buffer level by raising capital while simultaneously lowering risk. In contrast, banks with high capital buffers are more able to maintain investment with higher risk and potential returns. According to the estimations, the speeds of capital and risk adjustments are highly significant, yet relatively low. Banks with low capital buffers adjust capital faster than banks with high capital buffers.

Using a panel of Colombian banks' data between 1996 and 2010, García-Suaza *et al.* (2012) study the relationship between short-run adjustments in bank capital buffers and the business cycle. Following a partial adjustment framework with control variables (i.e. return on equity (ROE), non-performing loans and loan size), a negative co-movement of capital buffers and the business cycle is identified. Banks hold different levels of capital depending on their individual characteristics, such as their access to equities markets, the levels of risk they assume, their size and also the present stage of business cycle. Large banks, with better access to capital markets, lower their capital buffers during economic expansions without incurring in major risks while seeking to take advantage of profitable lending opportunities. Small banks find it more costly to re-build their capital stocks due to limited access to equities markets, and thus their optimal capital buffer is less responsive to short-run variations on economic condition.

2.3 Global liquidity

Frequent interactions between global and domestic banks through cross-border borrowing and lending activities are likely to influence banks' capital management decisions. Furthermore, the prevailing abundant global liquidity triggered by unconventional monetary policies at the onset of the global financial crisis and the COVID-19 pandemic may add further complications to the dynamics of bank leverage.

Bruno and Shin (2014) investigate global factors associated with bank capital flows, with a panel data of banks in 46 countries, for the time span of 1996-2011. They formulate a model of the international banking system where global banks interact with local banks. Leverage of the broker-dealer sector is employed as a proxy for global liquidity, which captures the ability of global banks to facilitate cross-border lending, thereby increasing the leverage of the whole banking system. The results highlight the bank leverage cycle as the determinant of the transmission of financial condition across borders through banking sector capital flows. Both the level of bank leverage (which determines the rate at which one dollar's increase in bank capital is turned into lending) and the change in the leverage (which determines the lending based on existing bank capital) should enter as supply push determinants of banking flows.

Rey (2018) suggests that one of the determinants of the global financial cycle is monetary policy in the centre country, which affects leverage of global banks, capital flows and credit growth in the international financial system. The author conducts a vector autoregressive analysis with data of European banks in 1990 to 2012. The analysis also includes variables like US gross domestic products, global credit, European bank leverage, Fed funds rates and global liquidity indices. The results point out that when the Fed funds rate goes down, global liquidity rises while bank leverage and gross credit flows also move up.

Regarding the case of Hong Kong, two papers study the trade-off theory and the effect of global liquidity on bank leverage. Firstly, the paper of Ho *et al.* (2016) examines how abundant global liquidity could influence the adjustment of bank leverage. Using banks in Hong Kong (annual observations between 1998 and 2012) as the sample, they find that the trade-off theory of leverage is generally applicable. Global liquidity effect is significant, and that mean reversion of bank leverage may, under certain circumstances, be more than offset by abundant global liquidity. Furthermore, the empirical results suggest that changes in global liquidity not only affect the level of leverage adjustment but also the adjustment speed of bank leverage. Under more favourable (tighter) global liquidity condition, banks will speed up (slow down) to close the gap between its current and target leverage levels.

Furthermore, Ho *et al.* (2015) conduct separate estimations for domestic banks and foreign subsidiaries in Hong Kong. Under the partial adjustment model, the dynamic trade-off theory equally applies to both groups of banks. When incorporating a global liquidity index into the equation, the results suggest that global liquidity could induce both groups of banks to increase leverage. However, the leverage of foreign subsidiaries responds more sensitively to global liquidity than that of domestic banks.

3. Empirical Models

In this section, we present three empirical models used in our study. In the first model, we follow Berger *et al.* (2008), Gropp and Heider (2010) and Ho *et al.* (2016) to apply a standard partial adjustment model for banks in Macao. This could test whether the partial adjustment model is applicable to them and if bank leverage will display a mean-reverting feature. In the second model, we examine how the mean-reverting feature of leverage may be affected by global liquidity in the context of the partial adjustment model. Finally, the third model further extends the second one by assuming that global liquidity not only influences the mean-reverting mechanism of bank leverage, but also affects the speed of bank leverage in reverting back to their targets.

3.1 Partial adjustment model without global liquidity effect

The following panel regression summarises the standard partial adjustment model applicable to banks employed by Berger *et al.* (2008), Gropp and Heider (2010) and Ho *et al.* (2016):

$$L_{i,t} - L_{i,t-1} = \lambda\left(L^*_{i,t} - L_{i,t-1}\right) + b_i + v_t + \varepsilon_{i,t} \tag{1}$$

The dependent variable leverage (L) is the asset-to-equity ratio of banks at book value. Equation (1) states that banks are expected to close a constant proportion λ of the gap between the actual ($L_{i,t}$) and target leverage ($L^*_{i,t}$) each period. Meanwhile, b_i, v_t and $\varepsilon_{i,t}$ represent bank fixed effect, quarterly fixed effect and error term of the regression, respectively. To yield a testable empirical equation from Equation (1), we need to make assumptions about the formation of banks' target leverage. We follow previous studies to model banks' unobservable target leverage $L^*_{i,t}$ as a function of their *ex ante* balance sheet characteristics:

$$L^*_{i,t} = \beta_0 + \beta_1 ROA_{i,t-1} + \beta_2 COL_{i,t-1} + \beta_3 TA_{i,t-1} + \beta_4 LLR_{i,t-1} \equiv \beta X_{i,t-1} \tag{2}$$

In Equation (2), ROA, COL, TA and LLR are used to proxy banks' profitability, tangibility, size and asset quality respectively. The profitability of banks is measured by return on assets (ROA), a common proxy used in the literature. The trade-off theory suggests that more profitable firms should have a higher leverage as the benefit of a tax-shield is more valuable, supporting a positive sign for β_1. On the contrary, empirical evidences presented by Frank and Goyal (2009) show that firms with higher profits typically have lower leverage. This is consistent with the pecking order theory,[2] which argues that firms prefer internal finance to external funds. With investments and dividends fixed, more profitable firms should become less levered over time. Consequently, we do not have a priori expectation on the sign of β_1.

The variable COL measures the tangibility of bank assets, equivalent to the share of the sum of cash, fixed assets and securities to total assets. Tangible assets can be used as collaterals for funding and prevent bank distress. Therefore, from a trade-off perspective, banks with a higher share of collateralisable assets are able to leverage more and β_2 is expected to be positive.

Bank size is measured by the natural logarithm of total assets (TA). Intuitively, larger banks should have more diversified business plans and more sophisticated risk management systems, which are associated with lower default risks than smaller banks. In addition, as larger banks could have better access to the capital market, they tend to be more flexible in terms of financing options. Therefore, from a trade-off perspective, larger banks are expected to have higher leverage and β_3 is expected to carry a positive sign.

LLR represents the ratio of loan loss reserves to total loans, measuring the asset quality of banks. From a trade-off perspective, banks with deteriorating asset quality in their loan portfolio may avoid maintaining high leverage owing to solvency

[2] The pecking order theory states that managers display the following preference of sources to fund investment opportunities: first, through the company's retained earnings, followed by debt, and choosing equity financing as a last resort. Company managers typically possess more information regarding the company's performance, prospects, risks and future outlook than external users such as creditors (debt holders) and investors (shareholders). Therefore, to compensate for information asymmetry, external users demand a higher return to counter the risk that they are taking. External sources of finances demand a higher rate of return to compensate for higher risks.

concerns. Moreover, regulators may force banks to reduce their leverage by restraining credit growth. To capture this feature in the model, we use LLR to measure banks' capacity to absorb future loan losses. β_4 is expected to be negative.

We incorporate Equation (2) into Equation (1) and generate the following regression model:

$$L_{i,t} = (1-\lambda)L_{i,t-1} + \lambda\beta X_{i,t-1} + b_i + v_t + \varepsilon_{i,t} \quad (3)$$

3.2 Partial adjustment model with global liquidity affecting the level of bank leverage

Assuming that abundant global liquidity could act as a shock exerting undue pressures on bank leverage adjustment, Equation (1) is adjusted as follows:

$$L_{i,t} - L_{i,t-1} = \lambda\left(L^*_{i,t} - L_{i,t-1}\right) + \theta EXP_{i,t-1} \times GL_{t-1} + \gamma EXP_{i,t-1} + b_i + v_t + \varepsilon_{i,t} \quad (4)$$

where λ is the speed of adjustment parameter and Θ is a scalar; b_i, v_t and $\varepsilon_{i,t}$ are the bank fixed effect, the time effect and error term of the regression respectively.

The term GL_{t-1} is added to capture the effect of global liquidity on bank leverage. It is interacted with banks' reliance on external funding, as measured by banks' ratio of total cross-border liabilities to total liabilities ($EXP_{i,t}$), such that quarterly fixed effect can be retained in the regression. This is important because the quarterly fixed effect can help disentangle the effects of global liquidity from common macroeconomic shocks to bank leverage. The interaction term between $EXP_{i,t}$ with GL_{t-1} can further investigate whether the effect of global liquidity on bank leverage adjustment is heterogeneous among banks, which may be determined by banks' reliance on external funding. Specifically, we conjecture that banks with higher dependence on external funding would tend to increase their leverage more than their peers in response to more accommodative global liquidity as they would likely benefit more from lower funding costs.

Replacing $L^*_{i,t}$ by Equation (2), we have the following regression model:

$$L_{i,t} = (1-\lambda)L_{i,t-1} + \lambda\beta X_{i,t-1} + \theta EXP_{i,t-1} \times GL_{t-1} + \gamma EXP_{i,t-1} + b_i + v_t + \varepsilon_{i,t} \quad (5)$$

3.3 Partial adjustment model with global liquidity affecting both the level and dynamics of bank leverage

Our next regression specification augments Equation (4) by examining whether the speed of adjustment varies with global liquidity. Specifically, we follow Drobetz and Wanzenried (2006) by assuming a linear functional form between the speed of adjustment parameter and global liquidity:

$$\lambda = \alpha_0 + \alpha_1 GL_{t-1} \quad (6)$$

By integrating Equations (2), (4) and (6):

$$L_{i,t} = \phi_1 L_{i,t-1} + \phi_2 GL_{i,t-1} \times L_{i,t-1} + \phi_3 X_{i,t-1} + \phi_4 GL_{i,t-1} \times X_{i,t-1} + \theta EXP_{i,t-1} \times GL_{t-1} + \gamma EXP_{i,t-1} + b_i + v_t + \varepsilon_{i,t} \quad (7)$$

where $Ø_1 = 1 - \alpha_0$, $Ø_2 = -\alpha_1$, $Ø_3 = \alpha_0\beta$ and $Ø_4 = \alpha_1\beta$. With the new notations, Equation (6) can be rewritten as:

$$\lambda = 1 - \phi_1 + \phi_2 GL_{t-1} \quad (8)$$

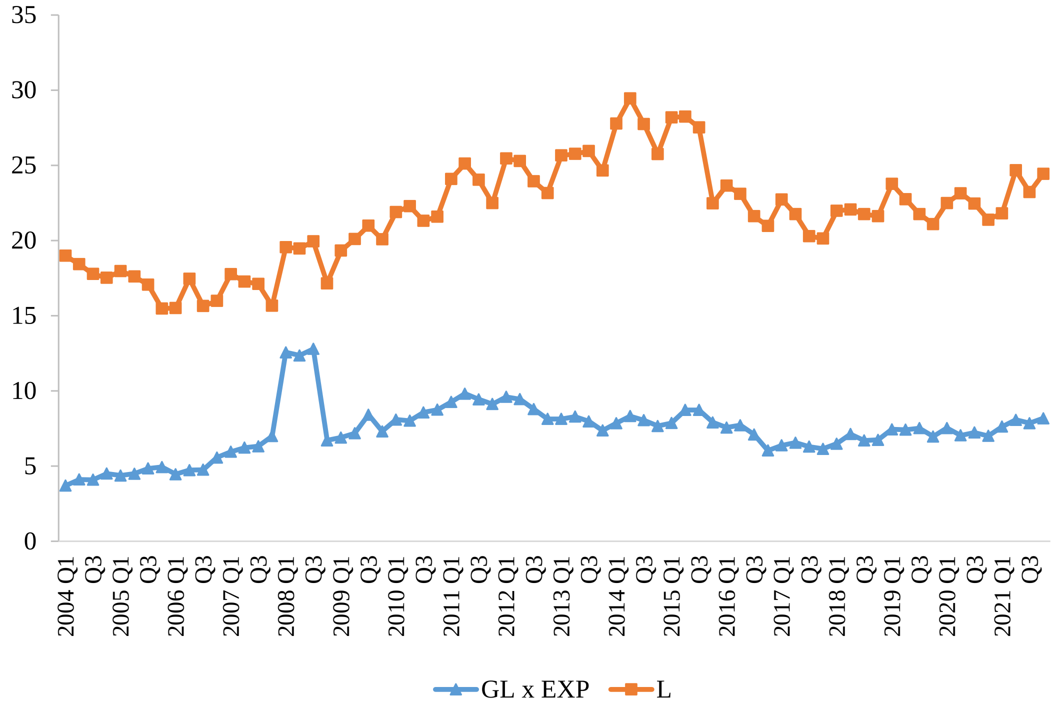
4. Data Analysis and Research Methodologies

In our research, bank-level data are sourced from the Monetary and Financial Statistics (MFS) and Financial Soundness Indicators (FSI) of the Monetary Authority of Macao (AMCM). Disaggregated data from individual banks are used for heterogeneities, which will lead to estimation biases in models that are based on aggregated data. Our sample includes banks with capital requirements (i.e. banks incorporated in Macao), as well as branches of banks incorporated outside Macao reporting capital in their balance sheets, giving a good snapshot of the banking sector in Macao. The panel data of this study consists of 22 banks; among which, 10 of them are branches of banks incorporated outside Macao.

Considering that branches of banks incorporated outside Macao tend to have more frequent intra-group fund flows resulting from the parent and subsidiary relationship, we conduct an independent set of tests for these banks to investigate if their leverage would behave more rigorously in responding to external liquidity shocks from a host-region perspective. The quantity-based measure of global liquidity is represented by the leverage of the US broker-dealer sector from the Flow of Funds account published by the US Federal Reserve. The data comprises quarterly observations between 2004Q1 and 2021Q4.

Chart 1 displays the alteration of the interaction term of banks' external exposure with global liquidity and bank leverage over the sample period. As shown in the chart, the two measures broadly moved in line with each other. Particularly, the rise in leverage was in tandem with abundant liquidity generated at the onset of the global financial crisis during 2007 and 2008. The leverage ratio of Macao banks remained largely benign throughout the rest of the sample period.

Chart 1: Overview of Bank Leverage and Global Liquidity



Sources: The US Federal Reserve and the AMCM.

With regard to the capital structure, the asset size of Macao's banking sector was expanding throughout the sample period, with debt financing serving as the major source of funding. Over 90% of total assets was financed by debts, with the remainder supported by capital. The asset-to-equity ratio is adopted to measure bank leverage in this study. The denominator of the ratio is paid-up capital and bank reserves. Banks in Macao are generally well capitalised and their leverage kept relatively stable in the sample period, with a mean leverage of 22.1 times.

In terms of capital quality, it is noteworthy that around 70% of capital held by Macao banks belonged to Tier 1 capital – the most permanent and loss absorbing instruments. Tier 1 capital consists of equity capital and disclosed reserves that are considered freely available to meet claims against the bank. It is also comprised of paid-up shares, common stock and disclosed reserves created or increased by appropriation of retained earnings or other surpluses.

Table 1: Descriptive Statistics of Macao Banks

	Mean	Median	Maximum	Minimum	Standard deviation
	All sampled banks				
TA (MOP billion)	47.61	10.40	852.11	0.08	101.37
L	22.07	12.96	553.57	1.00	46.00
ROA (%)	0.52	0.94	14.06	-141.39	5.32
COL (%)	16.02	13.28	83.75	0.05	14.93
LLR (%)	1.87	1.27	15.36	0.00	1.91
EXP (%)	36.46	20.86	98.65	0.00	30.64
	Branches of banks incorporated outside Macao				
TA (MOP billion)	61.46	5.57	852.11	0.08	153.28
L	36.59	29.20	553.57	1.00	72.14
ROA (%)	0.59	0.76	6.41	-27.80	2.35
COL (%)	6.92	3.49	61.28	0.05	8.57
LLR (%)	1.74	1.18	14.77	0.00	1.81
EXP (%)	68.17	76.31	98.65	5.32	22.98

Note: TA denotes total assets of banks. L denotes banks' asset-to-equity ratio. ROA refers to return on assets. COL refers to the share of the sum of cash, fixed assets and total securities to total assets. LLR denotes the loan provisions to total loans ratio. EXP denotes the share of banks' total external liabilities from all sectors to total liabilities.

Source: Underlying data from the AMCM.

Table 1 presents the descriptive statistics for all sampled banks and branches of banks incorporated outside Macao separately over all quarters of the observed period (2004Q1 to 2021Q4). In particular, the mean leverage (L) and external liabilities to total liabilities (EXP) of all sampled banks are 22.1 times and 36.5% respectively. On the other hand, these ratios of branches of banks incorporated outside Macao are 36.6 times and 68.2% correspondingly, implying that in general they are more leveraged and have a higher degree of external exposure.

To eliminate biased estimates in the presence of lagged dependent variables and bank fixed effects in the regressions caused by ordinary least squares estimations, the generalised method of moments (GMM) developed by Arellano and Bond (1991) and Blundell and Bond (1998) are adopted in our study to estimate the empirical models.

5. Estimation Results

5.1 Partial adjustment model without global liquidity effect

We use the GMM to estimate the three regression models. Tables 2 and 3 present the estimation results for all sampled banks and branches of banks incorporated outside Macao respectively. In Model 1, we adopt the traditional partial adjustment model without considering global liquidity. The results are shown in column 1 of both tables. Except for tangibility (COL), all other determinants of leverage are statistically significant and consistent as predicted by the trade-off theory. In particular, profitability (ROA) and bank size (TA) are positively related to leverage, with estimated coefficients of 0.272 and 0.044 for all sampled banks and 2.201 and 0.155 for branches of banks incorporated outside Macao. This suggests that banks with higher profit and larger scale are more inclined to maintain higher leverage as underpinned by the tax-shield benefit and their ability to access the capital market.

On the other hand, loan provisions to total loans ratio (LLR) is estimated to be negative, which are -0.422 for all sampled banks and -1.011 for branches of banks incorporated outside Macao, indicating that banks with higher asset quality tend to have less solvency concerns and can therefore sustain higher leverage ratios. Meanwhile, the estimated coefficient on the lagged dependent variable (L_{t-1}) is significant at the 1% level and bounded between zero and one for both sets of samples. It is estimated that a bank, on average, would close approximately 84% of the gap, or 85% for a branch of bank incorporated outside Macao, between its target and actual leverage levels within a quarter. In conclusion, Model 1 suggests that the trade-off theory of leverage is broadly applicable to banks in Macao.

5.2 Partial adjustment model with global liquidity affecting the level of bank leverage

Given bank leverage generally exhibits mean-reverting feature, we expand our hypothesis by considering global liquidity in the model. In Model 2, we use the leverage of the US broker-dealer sector as a proxy for global liquidity, the estimated coefficients for the interaction term between global liquidity and external exposure (EXP_{t-1} x GL_{t-1}) are 0.003 for all sampled banks and 0.017 for branches of banks incorporated outside Macao respectively; both are significant at a 5% level.

The positive coefficients suggest that abundant global liquidity, as indicated by a higher leverage of the broker-dealer sector, induces banks to increase their leverage further when other variables are held constant. The effect is found to be larger when banks are more reliant on cross-border borrowing. Consistent with our baseline result, leverage of branches of banks incorporated outside Macao responds more sensitively to global liquidity. The speed of adjustment (λ) is estimated to be 0.85 in this model, both for all sampled banks and branches of banks incorporated outside Macao banks.

5.3 Partial adjustment model with global liquidity affecting both the level and dynamics of bank leverage

As we find out that global liquidity plays a crucial role in the mean-reverting mechanism of bank leverage, we therefore take a further step to investigate whether abundant liquidity is conducive to bank leverage growth and simultaneously accelerate its growth trajectory. Model 3 is conducted based on Equation (7), assuming a linear function between global liquidity and the pace of adjustment.

When compared with the results in Model 2 for all sampled banks, the key findings continue to hold, where the trade-off theory of leverage is still applicable and banks are prone to increase their leverage during times when global liquidity is ample. The estimated coefficients of L_{t-1} and EXP_{t-1} x GL_{t-1} are 0.170 and 0.001 at conventional significance levels (Table 2; column 3). As the coefficient of L_{t-1} x GL_{t-1} is not significant, there is no strong evidence showing that global liquidity has an impact on bank leverage dynamic.

Therefore, we repeat the exercise for branches of banks incorporated outside Macao with the assumption that they tend to have more frequent intra-group fund flows. The hypothesis where banks with higher external exposure would be more affected by global liquidity is supported under this augmented partial adjustment model, as implied by the significant coefficient of 0.018 for the interaction term (EXP_{t-1} x GL_{t-1}). In addition, we find that the speed of adjustment parameter depends on global liquidity in this model, where the estimated coefficient of L_{t-1} x GL_{t-1} is 0.056 and the speed of adjustment (λ) for branches of banks incorporated outside Macao is estimated to be 0.87 in this model. According to the above estimated results, the empirical finding supports our conjecture that global liquidity would influence bank leverage in general, as well as the adjustment speed of leverage for branches of banks incorporated outside Macao.

Table 2: Estimation Results for Sampled Banks

	Dependent variable = L_t					
	(1)		(2)		(3)	
L_{t-1}	0.157	***	0.156	***	0.170	**
	(0.002)		(0.003)		(0.075)	
ROA_{t-1}	0.272	*	0.278	*	0.040	**
	(0.333)		(0.355)		(0.492)	
TA_{t-1}	0.044	*	0.037	*	0.037	*
	(0.054)		(0.051)		(0.052)	
COL_{t-1}	-0.048		-0.039		-0.321	
	(0.050)		(0.050)		(0.339)	
LLR_{t-1}	-0.422	**	-0.374	*	-1.393	**
	(0.411)		(0.418)		(1.317)	
EXP_{t-1}			0.144	*	0.170	**
			(0.077)		(0.108)	
EXP_{t-1} x GL_{t-1}			0.003	**	0.001	*
			(0.001)		(0.003)	
L_{t-1} x GL_{t-1}					0.051	
					(0.035)	
ROA_{t-1} x GL_{t-1}					0.014	
					(0.028)	
TA_{t-1} x GL_{t-1}					0.000	
					(0.000)	
COL_{t-1} x GL_{t-1}					0.006	
					(0.009)	
LLR_{t-1} x GL_{t-1}					0.054	*
					(0.050)	
Observations	1,289		1,289		1,289	
No. of banks	22		22		22	
Quarterly fixed effect	Y		Y		Y	
Bank fixed effect	Y		Y		Y	
λ (Speed of adjustment)	0.84		0.85		0.83	

*Notes: 1. *, ** and *** represent significant levels at 10%, 5% and 1% respectively.*
2. Standard errors are reported in parentheses.
Sources: Underlying data from the AMCM and the US Federal Reserve.

Table 3: Estimation Results for Branches of Banks Incorporated outside Macao

	Dependent variable = L_t		
	(1)	(2)	(3)
L_{t-1}	0.153 ***	0.150 ***	0.128 **
	(0.005)	(0.005)	(0.006)
ROA_{t-1}	2.201 **	1.939 **	5.462 **
	(1.985)	(1.975)	(2.660)
TA_{t-1}	0.155 **	0.130 *	0.154 *
	(0.139)	(0.138)	(0.165)
COL_{t-1}	0.225	0.109	0.630
	(0.353)	(0.284)	(1.074)
LLR_{t-1}	-1.011 **	-0.945 **	-2.666 *
	(0.706)	(0.735)	(3.519)
EXP_{t-1}		0.810 ***	0.721 ***
		(0.227)	(0.228)
EXP_{t-1} x GL_{t-1}		0.017 **	0.018 *
		(0.009)	(0.008)
L_{t-1} x GL_{t-1}			0.056 *
			(0.033)
ROA_{t-1} x GL_{t-1}			0.137 **
			(0.070)
TA_{t-1} x GL_{t-1}			0.001
			(0.001)
COL_{t-1} x GL_{t-1}			-0.019
			(0.027)
LLR_{t-1} x GL_{t-1}			-0.158 *
			(0.095)
Observations	538	538	538
No. of banks	10	10	10
Quarterly fixed effect	Y	Y	Y
Bank fixed effect	Y	Y	Y
λ (Speed of adjustment)	0.85	0.85	0.87

*Notes: 1. *, ** and *** represent significant levels at 10%, 5% and 1% respectively.*
2. Standard errors are reported in parentheses.
Sources: Underlying data from the AMCM and the US Federal Reserve.

6. Implications and Conclusion

This paper studies the mean reverting mechanism of bank leverage and how it may be influenced by global liquidity. The main conclusion is that the trade-off theory of leverage is broadly applicable to banks in Macao, implying a self-correcting adjustment mechanism in which banks that are underleveraged have a tendency to increase their leverage and adjust towards their target levels from time to time, and vice versa.

We find that this mean-reversion inherent in the leverage of banks in Macao could be counteracted by the effect of global liquidity, as banks are inclined to increase their leverage by taking advantage of more favourable liquidity condition. In particular, in line with our expectations that branches of banks incorporated outside Macao tend to be exposed to a higher degree of external shocks, liquidity has a more tangible impact on them in general and would significantly influence their speed of adjustment, which in turn, affects their leverage dynamics. Specifically, tighter global liquidity could impede underleveraged banks from reverting back to their target leverage levels swiftly.

Against the backdrop that ample global liquidity following the global financial crisis and the COVID-19 pandemic has notably changed the international banking landscape, overleveraging renders the financial sector fragile against adverse shocks. Since the onset of 2022, as inflationary pressures heightened, advanced countries have tightened monetary policies, which in turn has altered the dynamic of global liquidity.

Empirical results of our paper offer important policy implications. From a financial stability perspective, it is crucial for the authorities to understand how global liquidity affects the capital management of banks. Given that excessive leveraging or rapid deleveraging of banks could pose risks and vulnerabilities to the financial sector, a better understanding of the impact of global liquidity on bank leverage can help policymakers to formulate effective countercyclical measures to lean against external liquidity shocks and contain risks arising from sharp changes in bank leverage. In general, this paper provides useful insights for strengthening the resilience of the banking system in Macao.

Finally, it is worth pointing out the limitation of this study. Notice no. 011/2015-AMCM based on Basel II stipulates that locally incorporated banks must maintain a minimum CAR of 8.0%. On the other hand, branches of banks incorporated outside Macao are not subject to this statutory capital adequacy requirement. Given the primary responsibility for supervising capital adequacy rests with the home supervisor, some of the banks do not maintain capital in their position. Therefore, only banks reporting capital in their balance sheets are covered in our study, which limits the inferential power and general applicability of our findings. For this reason, further research is needed to address such shortcomings by replicating the concept and performing studies with a larger sample size.

References

Arellano M., S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," Review of Economic Studies, Vol. 58, Issue 2, 277-297.

Bank for International Settlements (2013), "Global Liquidity: Selected Indicators. Update of a Note Prepared for the April 2013 G20 Meetings in Washington DC," 7 October.

Berger, A., R. DeYoung, M. Flannery, D. Lee and O. Oztekin (2008), "How do Large Banking Organizations Manage Their Capital Ratios?" Journal of Financial Services Research, Vol. 34, 123–149.

Blundell R. and S. Bond (1998), "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models," Journal of Econometrics, Vol. 87, 115-143.

Bruno, V. and H. S. Shin (2014), "Cross-border Banking and Global Liquidity," BIS Working Papers, No. 458.

Cetorelli, N. and L. Goldberg (2012), "Liquidity Management of U.S. Global Banks: Internal Capital Markets in the Great Recession," Journal of International Economics, Vol. 88, 299–311.

Diamond, D. and R. Rajan (2000), "A Theory of Bank Capital," Journal of Finance, Vol. 55, Issue 6, 2431-2465.

Drakos, K. (2012), "US Banks' Capitalisation Speed-of-adjustment: a Microeconometric Approach," Journal of Financial Economic Policy, Vol. 4, No. 3, 270-286.

Drobetz, W. and G. Wanzenried (2006), "What Determines the Speed of Adjustment to the Target Capital Structure?" Applied Financial Economics, Vol. 16, Issue 13, 941–958.

Fischer, E., R. Heinkel and J. Zechner (1989), "Dynamic Capital Structure Choice: Theory and Tests," Journal of Finance, Vol. 44, Issue 1, 19-40.

Flannery, M. and K. Rangan (2006), "Partial Adjustment toward Target Capital Structure," Journal of Financial Economics, Vol. 79, 469-506.

Frank, M. and V. Goyal (2009), "Trade-off and Pecking Order Theories of Debt," Financial Management, No. 38, Issue 1, 1–37.

García-Suaza, A. F., J. E. Gomez-Gonzalez, A. M. Pabon, F. Tenjo-Galarza (2012), "The Cyclical Behavior of Bank Capital Buffers in an Emerging Economy: Size does Matter," Economic Modelling, No. 29, 1612-1617.

Gropp, R. and F. Heider (2010), "The Determinants of Bank Capital Structure," Review of Finance, Vol. 14, 587–622.

Heid, F., D. Porath and S. Stolz (2004), "Does Capital Regulation Matter for Bank Behaviour? Evidence for German Saving Banks," Deutsche Bundesbank Discussion Paper Series 2: Banking and Financial Supervision, No. 3.

Ho, K., C. H. Hui, K. F. Li and J. Wong (2015), "Capital Management and Leverage of Foreign Bank Subsidiaries in a Host Country: A Case in Hong Kong," Hong Kong Institute for Monetary Research Working Paper, No. 3.

Ho, K., C. H. Hui, K.F. Li and J. Wong (2016), "How Changes in Global Liquidity Affect Dynamics of Banks' Leverage: A Case in Hong Kong," Pacific Economic Review, Vol. 24, 493–507.

Kraus, A. and R. Litzenberger (1973), "A State Preference Model of Optimal Financial Leverage," Journal of Finance, No. 28, 911-922.

Kwan, S., E. Wong and C.H. Hui (2014), "The International Transmission of Shocks: Foreign Bank Branches in Hong Kong during Crisis," Federal Reserve Bank of San Francisco Working Papers, Vol. 2014-25.

Memmel, C. and P. Raupach (2010), "How do Banks Adjust their Capital Ratios?" Journal of Financial Intermediation, Vol. 19, 509-528.

Modigliani, F. and M. Miller (1958), "The Cost of Capital, Corporation Finance and the Theory of Investment," American Economic Review, Vol. 48, Issue 3, 261–297.

Rey, H. (2018), "Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence," NBER Working Paper Series, Working Paper 21162.

Strebulaev, I. (2007), "Do Tests of Capital Structure Theory Mean What They Say?" Journal of Finance, Vol. 62, Issue 4, 1747-1787.