Silent Sterilization: Quantifying the Shadow Fiscal Buffer Behind Macao's HKD-Linked Pataca Peg

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1 Research Question & Contribution

Research Question

How much of Macao's exchange-rate stability under the MOP–HKD–USD "peg-on-a-peg" is effectively maintained by fiscal buffer operations (asset sales, swaps, liquidity management by the government), rather than by formal monetary policy from the Monetary Authority of Macao (AMCM)? Can we measure and estimate the stabilizing role of these fiscal reserves—the "silent sterilization"—in offsetting capital flow pressures in an economy characterized by deep currency substitution?

Contribution

This paper provides the first quantitative estimate of **active fiscal substitution for monetary policy** in a currency board context. It builds directly on de Macedo et al. (2004), which established that Macao's fiscal reserves enhance the peg's *credibility*. This paper tests a new hypothesis: that these reserves are also used as an *active, short-term policy tool* for direct intervention.

The paper's contributions are:

1. Constructing a novel **Fiscal–Monetary Sterilization Index (FMSI)** to measure the liquid, usable portion of the government's massive fiscal reserves.
2. Providing a **Stylized Theoretical Model** of this "shadow" balance sheet operation, which is necessitated by the widespread currency substitution (HKD for MOP) identified by Scott (1997).
3. Using **SVAR-IV and Event Study** methods to prove that shocks to this $FMSI$, not official AMCM reserves, are the primary mechanism for absorbing capital flow shocks (such as the 2013-2016 anti-corruption campaign identified by Yin et al. (2018)).
4. Introducing a **political economy dimension** (Fong, 2021), arguing that Macao's executive-dominant and opaque budget process provides the *political discretion* necessary for this "silent" mechanism to operate.

2 Stylized Theoretical Model (The Dual Balance Sheet Mechanism)

Our model is based on the unique institutional reality of Macao: a "peg-on-a-peg" (MOP–HKD–USD) and widespread *currency substitution* (Scott, 1997), where the HKD is a *de facto* parallel currency. This means a "run" on the MOP is not the only risk; a general *liquidity crisis* (a demand for HKD cash) is also a major threat.

Actors & Key Assets:

- **AMCM (Monetary Authority):** Holds Official FX Reserves (R_{amcm}), which are legally required to back the Pataca Monetary Base (MB_{mop}). Its mandate is peg stability (Chan, 2007).
- **Fiscal Authority (Government):** Holds the Fiscal Reserve (F), a separate, massive pool of assets (equities, bonds, deposits in HKD, USD, RMB) derived from gaming surpluses (Pao, 2009; Cai, 2019). Its *official* mandate is long-term investment, *not* peg stability (IMF, 2019, 2024).
- **Private Sector:** Holds MB_{mop} (Pataca) but also vast quantities of HKD deposits and cash.

2.1 Scenario A: Standard Currency Board (Official Intervention)

1. **Shock:** A capital outflow shock ($u > 0$) occurs (e.g., from an anti-corruption campaign, Yin et al., 2018). The public wants to sell MOP to buy u worth of HKD.
2. **Intervention:** Banks sell the MOP to the AMCM to get the required HKD.
3. **Balance Sheet Impact:**
   - **AMCM:** Assets (R_{amcm}) $\downarrow u$, Liabilities (MB_{mop}) $\downarrow u$.
4. **Result (Non-Sterilized):** The peg is saved, but the domestic Pataca Monetary Base contracts one-for-one. This is the *classic, painful adjustment* that tightens domestic credit.

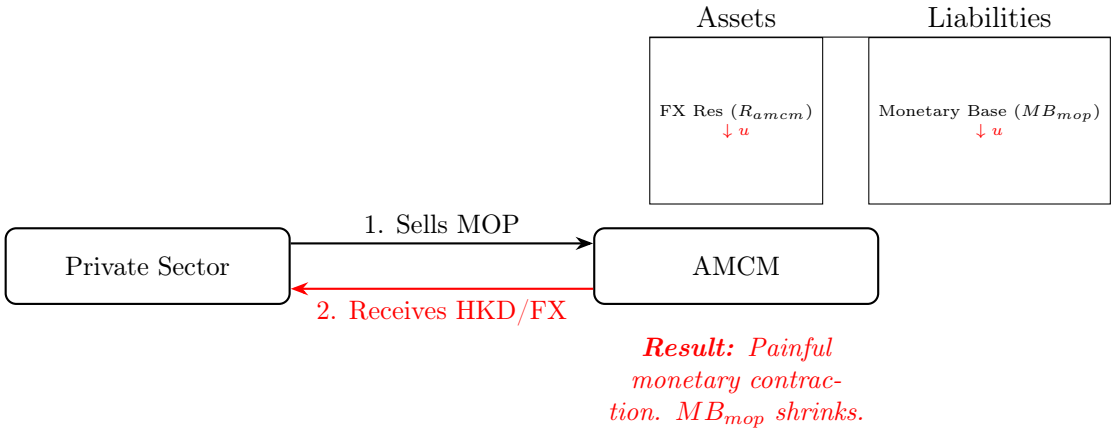

Figure 1: Scenario A: Standard Currency Board Adjustment

2.2 Scenario B: "Silent Sterilization" (Fiscal Buffer Intervention)

1. **Shock:** The same capital outflow shock ($u > 0$) occurs.
2. **Intervention (The Fiscal Action):** The Fiscal Authority acts as the "shadow" central bank. To prevent the *painful* contraction in Scenario A, it intervenes *first*. It sells u worth of its *own* liquid foreign assets (F_{fx}) and *buys* the excess MOP from the private sector/banks.
3. **Balance Sheet Impact:**
   - **Fiscal Authority:** Assets (F_{fx}) $\downarrow u$, Assets (F_{mop}) $\uparrow u$.
   - **AMCM:** Assets (R_{amcm}) $\rightarrow 0$ (no change), Liabilities (MB_{mop}) $\rightarrow 0$ (no change).
4. **Result (Sterilized):** The peg is saved. The private sector's demand for HKD is met by the Fiscal Authority, *not* the AMCM. The official Monetary Base is *completely insulated.* The fiscal buffer has simultaneously conducted an FX intervention *and* sterilized it, a function the AMCM cannot perform.

Testable Hypothesis: This model provides a sharp, testable hypothesis: In response to an exogenous capital outflow shock, a "standard" currency board would show $\Delta R_{amcm} < 0$ and $\Delta MB_{mop} < 0$. If "silent sterilization" is occurring, we will instead observe $\Delta F_{fx} < 0$, while $\Delta R_{amcm} \approx 0$ and $\Delta MB_{mop} \approx 0$.

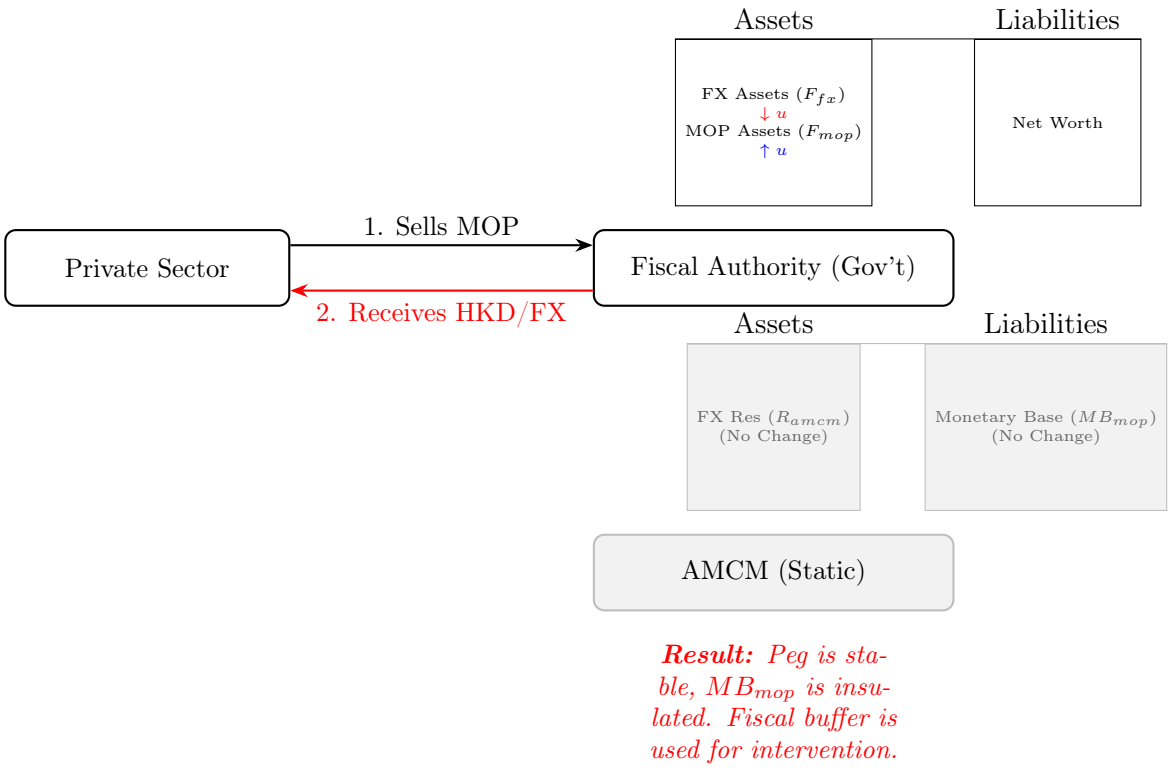

Figure 2: Scenario B: Silent Sterilization Mechanism

3 Literature Review & Institutional Context

This paper is grounded in five interconnected bodies of literature that perfectly frame the Macao case.

3.1 The Unique Institutional Setup: A "Peg-on-a-Peg"

Macao's monetary system is unique. Scott (1997) provides the foundational description, noting that the Pataca (MOP) is pegged to the Hong Kong Dollar (HKD), which is itself pegged to the US Dollar (USD). More importantly, Scott identifies widespread **currency substitution**, where the HKD is the dominant currency for savings and large transactions, and the MOP acts as a "bad money" for daily use (Gresham's Law). This institutional setup means that Macao's true monetary liabilities are far larger than the MOP monetary base, creating an inherent vulnerability that necessitates a large backstop.

3.2 The "Smoking Gun": Macao's *De Jure* Dual Reserve System

Our thesis is built on an *explicit institutional separation* of Macao's public assets, documented by official sources.

- **FX Reserves (AMCM):** Chan (2007), an AMCM paper, explicitly defines the "Official International Reserves" as assets whose *sole purpose* is to ensure the "stability and convertibility of the legal tender" under the currency board.
- **Fiscal Reserve (Government):** Pao (2009), another AMCM paper, details the *history* of the "Fiscal Reserve," which is legally separate and built from fiscal surpluses. Chan (2007) calls these "surplus reserves" (funds *exceeding* the monetary base backing) and argues they can be managed with a "more return-oriented investment strategy."

- **The Official Doctrine:** The IMF's Article IV reports (IMF, 2019, 2024) codify this separation, stating verbatim: "Macao SAR also holds significant fiscal reserves... These can be an additional buffer but are primarily intended for fiscal needs [or investment] rather than supporting the exchange rate regime." **Our proposal is designed to test this exact claim.**

3.3 The Source of Shocks: A Volatile, Gaming-Concentrated Economy

The *need* for a stabilization buffer arises from Macao's extreme economic concentration. Mieiro et al. (2012) characterize the post-2002 gaming boom as a classic "Dutch Disease" event, where massive foreign currency *inflows* from tourism created the surpluses for the Fiscal Reserve while causing de-industrialization. Yin et al. (2018) perfectly illustrates the violent downside, showing that the 2013-2016 anti-corruption campaign in Mainland China (an exogenous shock) caused a *massive* 17.5% average *reduction* in Macao's real GDP growth. This volatility in gaming revenues (McCartney, 2020) is the direct source of the massive fiscal surpluses that created the stabilization tool in the first place.

3.4 The Academic Antecedent: Fiscal Reserves as *Credibility*

de Macedo et al. (2004) is the key antecedent. Applying Exchange Market Pressure (EMP) models (Girton & Roper, 1977) to Macao, they were the first to find that Macao's "substantial fiscal reserves" were a primary anchor for the peg's long-term *credibility*. Our paper builds directly on this by testing if these reserves are also used as an *active, short-term intervention tool* during a crisis, a question de Macedo et al. (2004) did not test. The validity of using VAR and Impulse Response Functions (IRFs) in this context is supported by Song & Witt (2006), who applied this methodology to forecast Macao's tourism.

3.5 The Political Enabler: Opaque Governance

Fong (2021) provides the crucial political context that explains *how* this "silent" sterilization is feasible. Fong's comparative analysis finds that Macao's budget process is characterized by extremely weak legislative oversight, low transparency, and executive dominance, in sharp contrast to Hong Kong. This opaque, executive-led system provides the *operational discretion* for the government to deploy the Fiscal Reserve for unstated monetary stabilization purposes without facing the legislative or media scrutiny that would occur in a more transparent system.

4 Data Acquisition & FMSI Construction

This section details the practical data collection plan and the methodological construction of the paper's core explanatory variable, the Fiscal-Monetary Sterilization Index (FMSI). A comprehensive list of all variables, sources, and codes for the entire project is consolidated in the "Data Acquisition Plan" in **Section 5.B**.

4.1 Key Data Sources

This project relies exclusively on publicly available data from Macao's official bodies:

1. **Monetary Authority of Macao (AMCM):** *Monthly Statistical Bulletin* (for high-frequency data on MB_{mop}, R_{amcm}, i_{macao}, bank deposits) and *Annual Reports* (for lower-frequency, detailed breakdowns of the Fiscal Reserve's composition).

2. **Macao Statistics and Census Service (DSEC):** *Database* (for quarterly BOP/capital flows, GDP, and inflation).

3. **Macao Financial Services Bureau (DSF):** *Budget Reports* (for annual data on fiscal performance and total reserve assets).

4. **External Sources:** Hong Kong Monetary Authority (HKMA) for i_{hk} and a financial data provider (e.g., Bloomberg, Refinitiv) for VIX.

4.2 Key Challenge: Data Frequency & Interpolation

The primary methodological challenge is data frequency. Detailed asset breakdowns of the Fiscal Reserve (e.g., % in equities, bonds, deposits; currency breakdown) are essential for our index but are typically reported at a low frequency (annually or semi-annually), as noted in reports like Cai (2019). In contrast, headline aggregates ("Total Fiscal Reserve," "Monetary Base") are available at a higher frequency (monthly or quarterly) (IMF, 2024).

To create a high-frequency (quarterly or monthly) time series of the underlying asset components, we will employ a standard and methodologically accepted procedure:

1. Collect the **annual/semi-annual** detailed "benchmark" breakdown of the Fiscal Reserve's composition.

2. Collect all available **higher-frequency (monthly/quarterly)** "indicator" series (e.g., `GOV_FISCAL_RES_TOTAL`, `GOV_DEPOSITS_AMCM`).

3. Use the **Chow-Lin or Denton proportional interpolation method** to disaggregate the low-frequency benchmark data. This method uses the high-frequency indicators to "distribute" the annual totals, creating a high-frequency estimate of the underlying asset classes that is consistent with the annual reports.

4.3 Constructing the Fiscal–Monetary Sterilization Index (FMSI)

The core premise of this paper is that not all assets in the Fiscal Reserve are available for "silent sterilization." The official mandate of the fund is long-term investment, not liquidity (Pao, 2009; Chan, 2007). As Cai (2019) documents, the fund is an actively managed portfolio containing assets like equities, which are not 100% liquid.

Therefore, to measure the *true, immediate stabilization capacity* of the buffer, we must construct a weighted index, the **Liquidity-Adjusted Fiscal Buffer (LAFB)**, by discounting each asset class for two distinct risks: **(1) asset liquidity risk** and **(2) currency usability risk**.

4.3.1 Create Asset Matrix

From the interpolated data, we create a time series ($V_{i,t}$) of all fiscal assets.

4.3.2 Assign Liquidity Weight ($\lambda_{i,t}$)

This weight (0 to 1) reflects an asset's "fire-sale" value. It answers: "In a crisis, how much of this asset's pre-crisis value can be immediately converted to cash?" These are baseline calibrated weights, which will be tested for robustness.

- **Cash & Deposits:** $\lambda = 1.0$
  - *Motivation:* By definition, these assets are 100% liquid.
- **Short-Term Bonds (<1y, G7/HK):** $\lambda = 0.95$
  - *Motivation:* Highly liquid, but a minor 5% discount accounts for bid-ask spreads in a crisis.

- **Equities (Marketable):** $\lambda = 0.4$
  - *Motivation:* This is a critical calibration. In a systemic crisis, we assume a $\tilde{6}0\%$ "fire-sale" discount from pre-crisis highs. This reflects the high volatility of the equity portfolio noted by Cai (2019).
- **Illiquid/Alternatives:** $\lambda = 0.1$
  - *Motivation:* Assets like private equity or real estate are not usable for immediate sterilization. A 90% discount reflects that they are effectively locked up.

4.3.3 Assign Currency Usability Weight ($\phi_{i,t}$)

This weight (0 to 1) reflects the friction of converting the asset's currency into the *intervention currency*.

- **HKD Assets:** $\phi = 1.0$
  - *Motivation & Citation:* This is the *intervention currency*. Scott (1997) provides the definitive motivation: the MOP is pegged to the HKD, and the HKD is the dominant medium of exchange and savings in Macao.
- **USD Assets:** $\phi = 0.98$
  - *Motivation & Citation:* The HKD is, in turn, pegged to the USD (Scott, 1997; de Macedo et al., 2004). USD is a near-perfect substitute. The minor 2% discount accounts for transaction costs and the minor risk of the HKD fluctuating within its USD band.
- **Other Currencies (CNY, EUR, etc.):** $\phi = 0.7$
  - *Motivation & Citation:* The Fiscal Reserve holds non-peg currencies like the Renminbi (Chan, 2007; Cai, 2019). These are *not* usable for intervention. They must first be sold for USD or HKD, introducing significant exchange rate risk and conversion friction.
- **MOP Assets:** $\phi = 0.2$
  - *Motivation:* MOP-denominated assets are useless for *FX intervention* (Scenario B). We assign a low, non-zero value to reflect their limited, non-FX utility (e.g., domestic liquidity management).

4.3.4 Compute Liquidity-Adjusted Fiscal Buffer (LAFB)

The LAFB is the sum of all weighted assets, representing the total *usable* fiscal firepower available to the government at time t.

$$LAFB_t = \sum_i (V_{i,t} \times \lambda_{i,t} \times \phi_{i,t}) \tag{1}$$

4.3.5 Normalize to FMSI (Main Index & Robustness Check)

Finally, we normalize the $LAFB$ to create our key explanatory variable.

- **Baseline Index:** $FMSI_{MB,t}$

$$FMSI_{MB,t} = \frac{LAFB_t}{MB_{mop,t}} \tag{2}$$

– *Motivation:* This is our main index. It measures the fiscal buffer's sterilization capacity relative to the *de jure* Pataca Monetary Base (MB_{mop}) it must protect.

- **Robustness Index: $FMSI_{CS,t}$ (Currency Substitution-Adjusted)**

$$FMSI_{CS,t} = \frac{LAFB_t}{MB_{mop,t} + HKD_{Deposits,t}} \tag{3}$$

– *Motivation & Citation:* This second index is motivated by the deep **currency substitution** (CS) documented by Scott (1997), who showed that HKD holdings form a massive part of Macao's *de facto* money supply. This $FMSI - CS$ index is a more rigorous measure of the buffer's capacity relative to the *true* public demand for liquid assets, not just the Pataca base.

5 Empirical Methodology & Data Plan

We use a three-pronged approach to test our hypothesis. First, we define the pressure variable. Second, we conduct a direct balance sheet accounting analysis. Third, we use a formal SVAR-IV model.

5.1 Primary Dependent Variable: Exchange Market Pressure (EMP) Index

Given the "zero deviation" problem, we must use a pressure index, following de Macedo et al. (2004).

$$EPI_t = w_e(\Delta e_t) + w_i(\Delta i_{Macao-HK,t}) - w_r \left(\frac{\Delta R_{amcm,t}}{MB_{mop,t-1}} \right) \tag{4}$$

Where:

- Δe_t: Change in MOP/HKD exchange rate (will be near-zero).
- Δi_t: Change in Macao-HK interest rate differential.
- $\Delta R_{amcm,t}$: Change in **AMCM's official FX reserves**. This is the crucial part: we test if pressure is absorbed by *this* variable or by our $FMSI$.
- **Weights (w):** Inverse rolling standard deviation of each component.

5.2 Test 1: Balance Sheet Accounting & Event Study

This is the most direct test of our stylized model (Scenario B vs. A). It involves two steps:

5.2.1 Data Acquisition Plan (for Co-Author)

5.2.2 Descriptive & Event Study Analysis

- **Step 1 (Descriptive Plot):** We will generate a "Ratio Plot" from 2000-2024.
  - *Line 1 (Official Cover):* $R_{amcm,t}/MB_{mop,t}$. (We expect this to be stable, just over 100%).
  - *Line 2 (Shadow Cover):* $FMSI_{MB,t}$. (We expect this to grow from <100% to >1000%, showing the massive growth of the "silent" buffer).
- **Step 2 (Correlation Test):** We will run simple correlations: corr(ΔR_{amcm}, BOP_CAPITAL_FLOW) vs. corr(Δ`GOV_FISCAL_RES_TOTAL`, BOP_CAPITAL_FLOW). Our hypothesis predicts the first will be near-zero and the second will be negative and significant.

Table 1: Data Acquisition and Variable Plan

Purpose	Variable	Description	Data Source
AMCM B/S	AMCM_FX_RES	Official FX Reserves	AMCM
AMCM B/S	MB_MOP	Pataca Monetary Base	AMCM
Fiscal Auth. B/S	GOV_FISCAL_RES_TOTAL	Total Fiscal Reserve	AMCM
Fiscal Auth. B/S	GOV_FISCAL_COMP	Detailed Asset Composition	AMCM, DSF
Fiscal Auth. B/S	GOV_DEPOSITS_AMCM	Gov't Deposits held at AMCM	AMCM
FMSI (constru.)	FMSI_MB	LAFB/MB_MOP	*Self-constructed*
FMSI (robust)	FMSI_CS	LAFB/(MB_MOP+HKD_DEPO)	*Self-constructed*
Currency Sub.	HKD_DEPOSITS	HKD Deposits held by public	AMCM
Pressure	MOP_HKD_SPOT	MOP/HKD Exchange Rate	AMCM
Pressure	AMCM_RATE	AMCM Base Rate/Interbank	AMCM
Pressure	HKMA_RATE	HKMA Base Rate/HIBOR	HKMA
Shock (Quantity)	BOP_CAPITAL_FLOW	Net Capital & Financial Account	DSEC
Shock (Proxy)	GAMING_REVENUE	Gross Gaming Revenue (GGR)	DSEC
Shock (Instru.)	GLOBAL_EQUITY	MSCI World Index (or S&P 500)	Data Provider
Shock (Instru.)	VIX	CBOE Volatility Index	Data Provider
Control	CHINA_PMI	China Caixin/Official PMI	Data Provider
Control	MACAO_GDP	Macao Nominal GDP	DSEC

- **Step 3 (Event Study):** We will isolate the 2013-2016 Anti-Corruption Shock (identified in Yin et al., 2018).
  - *Method:* We will plot ΔGOV_FISCAL_RES_TOTAL against ΔR_{amcm} during this period.
  - *Testable Hypothesis:* Our model predicts that during 2014-2016, a period of massive capital *outflow* pressure, we will see R_{amcm} (Official Reserves) remain stable, while GOV_FISCAL_RES_TOTAL (Fiscal Reserves) shows a clear *decline or sharp flattening* (a drawdown or "use" of the buffer) that moves counter to the GAMING_REVENUE (the source of its *inflows*). This divergence is the "smoking gun" for Scenario B.

5.3 Test 2: Structural VAR (SVAR-IV)

This is the formal econometric test.

1. **Variables:** The vector Y_t will include:
   - GlobalRisk (VIX)
   - China_Shock (PMI)
   - NetCapitalFlows$_t$
   - EPI_t
   - $\Delta \log(MB_{mop,t})$
   - $FMSI_{MB,t}$
2. **Identification (SVAR-IV):** We must solve endogeneity (e.g., the government might build its $FMSI$ *because* it expects pressure).

- **Instrument (Z):** We use an instrument based on the "Dutch Disease" (Mieiro et al., 2012) and asset composition (Cai, 2019).

$$\begin{aligned} Z_t = &(\text{Global Equity Shock}_t \times \text{Share}_{\text{Equity},t-1}) \\ &+ (\text{Gaming Revenue Shock}_t \times \text{Tax Rate}) \end{aligned}$$

- This instrument is relevant (it exogenously changes the $FMSI$ value) and exogenous (global equity shocks and shocks to mainland tourist demand are not caused by Macao's *monetary* policy).

3. **Output:** Impulse Response Functions (IRFs) and Forecast Error Variance Decomposition (FEVD).

4. **Key Test:** The FEVD must show that $FMSI$ shocks explain a significant portion of the variance in EPI_t.

6 Expected Results & Policy Implications

1. **H1:** The $FMSI_t$ will be large and time-varying, demonstrating "shadow" sterilization capacity often exceeding 1000% of $MB_{mop,t}$.

2. **H2:** IRFs will show that positive shocks to $FMSI_t$ (or exogenous valuation shocks via the IV) lead to a statistically significant *reduction* in the Exchange Market Pressure Index (EPI_t).

3. **H3 (Event Study):** The 2013-2016 shock will show a significant drawdown in $FMSI$ while R_{amcm} and $MB_{mop,t}$ remain stable, proving the fiscal buffer was actively used for stabilization.

4. **Policy Implication:** Macao's stability is a "shadow" mechanism enabled by (a) a unique peg with currency substitution (Scott, 1997), (b) volatile gaming revenue creating a massive buffer (Mieiro et al., 2012), and (c) an opaque political system (Fong, 2021) allowing its discretionary use. This redefines currency board analysis, suggesting a massive, state-controlled asset buffer can *substitute* for monetary autonomy, creating a unique solution to the "impossible trinity."

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