

# The Macroeconomic Relevance of Mobile Money to Inflation Dynamics

**Mphatso Elias Ackim**, Nicola Viegi, Vincent Dadam,  
Omogolo Mighty Maripe, Marietta Mpingasa

**Inflation: Drivers, effects, and trade-offs Conference**

*Future Africa Campus, University of Pretoria*

May 8th 2025

# Overview

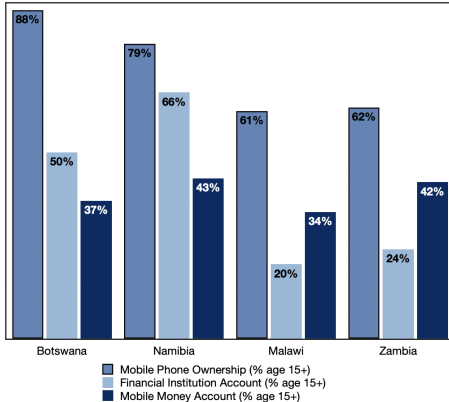
- 1 Summary
- 2 Motivation
- 3 Objectives
- 4 Related Literature
- 5 First Exercise Methodology
- 6 First Exercise Data
- 7 First Exercise Results
- 8 Second Exercise Methodology
- 9 Second Exercise Data
- 10 Second Exercise Diagnostics
- 11 Second Exercise Results
- 12 Conclusion
- 13 References

## **Registered mobile money accounts have exceeded conventional bank accounts in most developing economies (*Sahay et al., 2020*).**

- The structural shift may entail revisiting monetary policy conduct and analysis (*Aron et al., 2015*).
- We examine the implications of money growth before (2003 - 2011) and after (2012 - 2020) mobile money emergence.
- The inclusion of mobile money improved inflation and real output growth forecasts.
- After the emergence of mobile money, money growth shocks accounted for a larger proportion of inflation forecast errors.
- Following the emergence of mobile money, inflation, and real output growth became more resilient to real and monetary policy shocks.

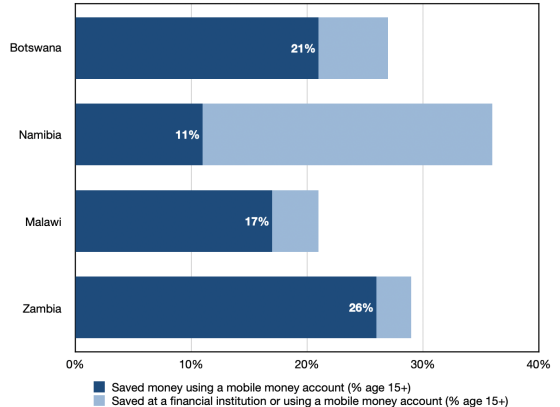
# Motivation

Figure 1: Mobile Phone and Mobile Money Usage (2021/2022)



Data Source: The World Bank's Global Index Database

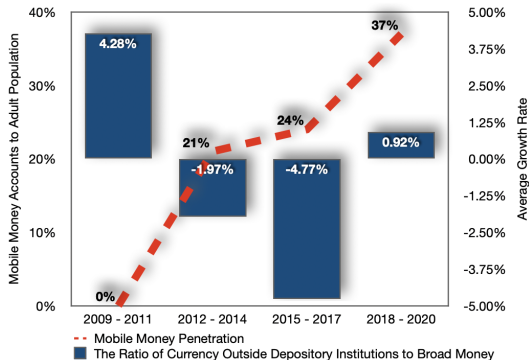
Figure 2: Saving Pattern (2021/2022)



Data source: The World Bank's Global Index Database

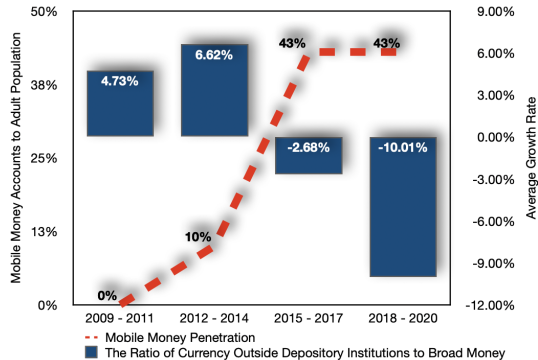
# Motivation

Figure 3: Currency Outside Depository Institutions (Botswana)



Data Source: The Global Findex Database and Bank of Botswana

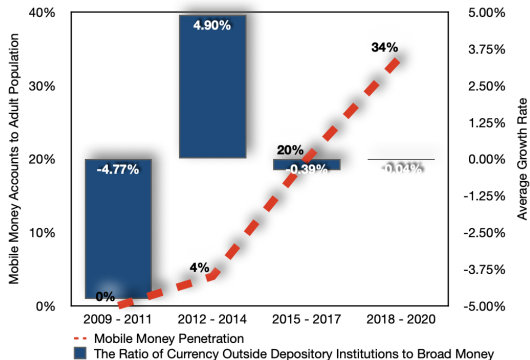
Figure 4: Currency Outside Depository Institutions (Namibia)



Data Source: The Global Findex Database and Bank of Namibia

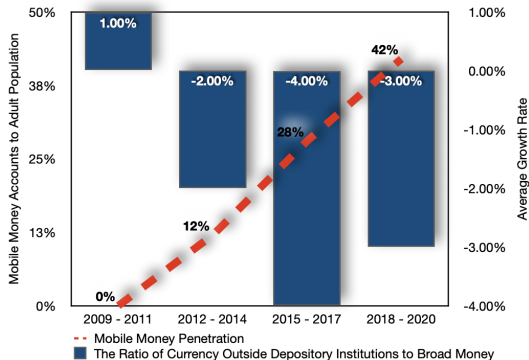
# Motivation

Figure 5: Currency Outside Depository Institutions (Malawi)



Data Source: The Global Findex Database and Bank of Malawi

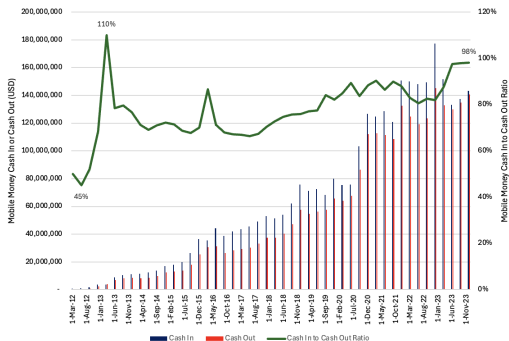
Figure 6: Currency Outside Depository Institutions (Zambia)



Data Source: The Global Findex Database and Bank of Zambia

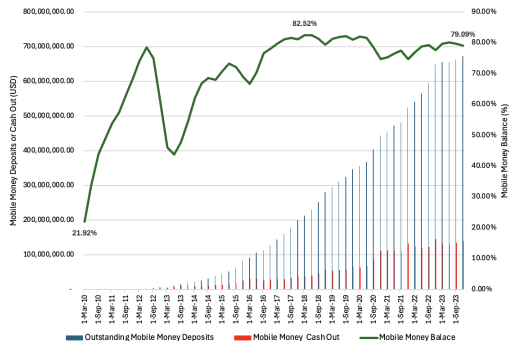
# Motivation

Figure 1: Retention of Mobile Money Deposits in Southern Africa (2012 - 2023)



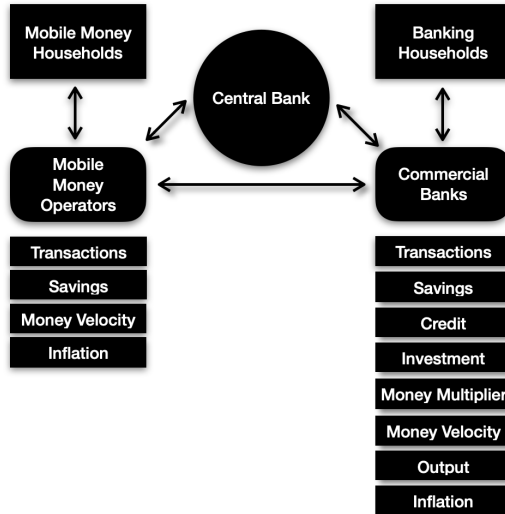
Data Source: Global Mobile Money Dataset 2024 Version 1.0 by GSMA

Figure 2: Mobile Money Balances in Southern Africa (2010 - 2023)

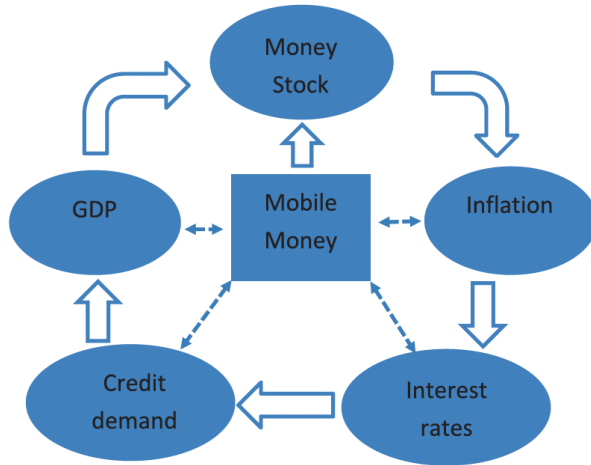


Data Source: Global Mobile Money Dataset 2024 Version 1.0 by GSMA

# Motivation



# Motivation



Source: Mawejje and Lakuma (2017)

- **To investigate the macroeconomic relevance of mobile money, we specify three objectives:**
  - 1 Examine the importance of money growth to forecasting inflation and real output growth before and after mobile money emergence.
  - 2 Analyze the contribution of money growth shocks to inflation and real output growth forecast errors before and after mobile money emergence.
  - 3 Examine the response of inflation and real output growth to real and monetary policy shocks before and after the emergence of mobile money.

# Related Literature and Contribution

- **Micro level analysis of mobile money**

- ① Amoah et al. (2015) and Aggarwal et al. (2020).
- ② Batista and Vicente (2020).
- ③ Aron (2018) analysis of existing literature.

- **Macro level analysis of mobile money:**

- ① Wiafe et al. (2022) for Ghana
- ② Lapuken (2015) for Malawi.
- ③ Aron (2015) for Uganda.

- **Contribution of the Study**

- ① Heterogeneity considerations
- ② Bayesian approach to address data limitations
- ③ Robust identification and forecasting techniques.

## The Structural Vector Auto-Regressive (VAR) Model

$$\begin{bmatrix} \gamma_{yy} & \gamma_{y\pi} & \gamma_{yr} & \gamma_{yc/m} & \gamma_{ymm} \\ \gamma_{\pi y} & \gamma_{\pi\pi} & \gamma_{\pi r} & \gamma_{\pi c/m} & \gamma_{\pi mm} \\ \gamma_{ry} & \gamma_{r\pi} & \gamma_{rr} & \gamma_{rc/m} & \gamma_{rmm} \\ \gamma_{c/my} & \gamma_{c/m\pi} & \gamma_{c/mr} & \gamma_{c/mc/m} & \gamma_{c/mmm} \\ \gamma_{mmy} & \gamma_{mm\pi} & \gamma_{mmr} & \gamma_{mmc/m} & \gamma_{mmmm} \end{bmatrix} \begin{bmatrix} y_t \\ \pi_t \\ r_t \\ c/m_t \\ mm_t \end{bmatrix} = \sum_{\rho=1}^n \begin{bmatrix} \phi_{yy}^{(\rho)} & \phi_{y\pi}^{(\rho)} & \phi_{yr}^{(\rho)} & \phi_{yc/m}^{(\rho)} & \phi_{ymm}^{(\rho)} \\ \phi_{\pi y}^{(\rho)} & \phi_{\pi\pi}^{(\rho)} & \phi_{\pi r}^{(\rho)} & \phi_{\pi c/m}^{(\rho)} & \phi_{\pi mm}^{(\rho)} \\ \phi_{ry}^{(\rho)} & \phi_{r\pi}^{(\rho)} & \phi_{rr}^{(\rho)} & \phi_{rc/m}^{(\rho)} & \phi_{rmm}^{(\rho)} \\ \phi_{c/my}^{(\rho)} & \phi_{c/m\pi}^{(\rho)} & \phi_{c/mr}^{(\rho)} & \phi_{c/mc/m}^{(\rho)} & \phi_{c/mmm}^{(\rho)} \\ \phi_{mmy}^{(\rho)} & \phi_{mm\pi}^{(\rho)} & \phi_{mmr}^{(\rho)} & \phi_{mmc/m}^{(\rho)} & \phi_{mmmm}^{(\rho)} \end{bmatrix} \begin{bmatrix} y_{t-\rho} \\ \pi_{t-\rho} \\ r_{t-\rho} \\ c/m_{t-\rho} \\ mm_{t-\rho} \end{bmatrix} + \begin{bmatrix} \epsilon_{yt} \\ \epsilon_{\pi t} \\ \epsilon_{rt} \\ \epsilon_{c/mt} \\ \epsilon_{mmt} \end{bmatrix} \quad (1)$$

### 1 Estimation Technique

- Bayesian Estimation with Bambura Prior

### 2 Identification Strategy

- Sign Restrictions

### 3 Structural Shocks Analysis

- Impulse Response Function (IRF)
- Forecast Error Variance Decomposition (FEVD)

## Identification Scheme

**Table 1: Identification Restrictions of the Structural Shocks**

| Shock               | Real GDP | Consumer Prices | Policy Rate | Cash to M2 Ratio | Mobile Money |
|---------------------|----------|-----------------|-------------|------------------|--------------|
| Aggregate Demand    | $\geq 0$ | $\geq 0$        | $\geq 0$    |                  |              |
| Aggregate Supply    | $\leq 0$ | $\geq 0$        | $\geq 0$    |                  |              |
| Monetary Policy     | $\leq 0$ |                 | $\geq 0$    | $\geq 0$         |              |
| Cash Preference     |          |                 | $\geq 0$    | $\geq 0$         | $\leq 0$     |
| Financial Inclusion |          |                 |             | $\leq 0$         | $\geq 0$     |

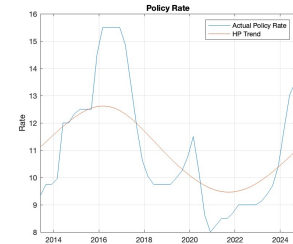
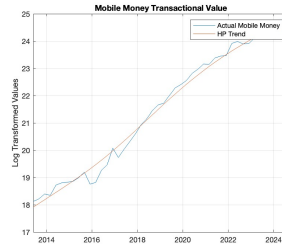
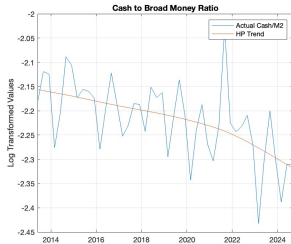
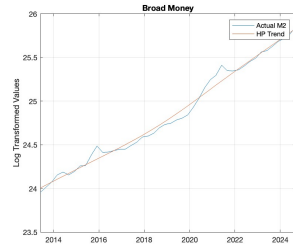
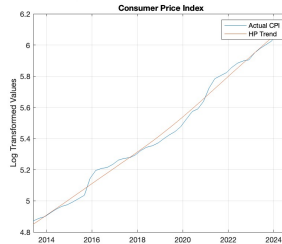
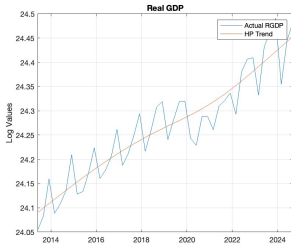
**Note:** Sign restrictions only hold on impact and the next period.

- **Bayesian Model Specifications and Applications**

- 1 12,000 iterations and 6,000 burn-ins for the Gibbs Sampler
- 2 Credibility Intervals at 68%
- 3 20-periods horizon

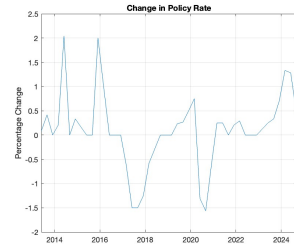
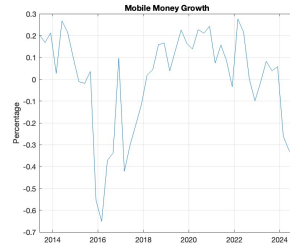
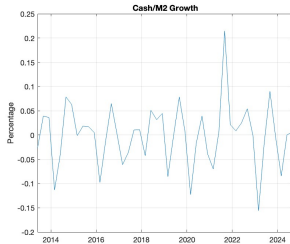
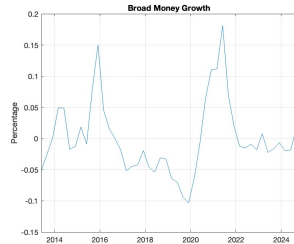
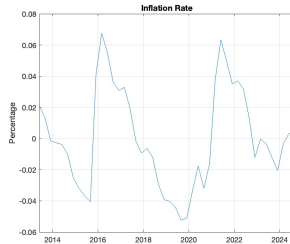
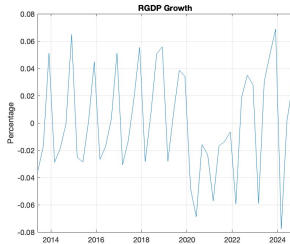
# First Exercise Data for Zambia

Figure 13: Trends Vs Actual Data (Zambia)



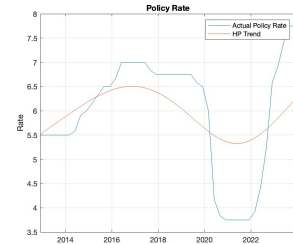
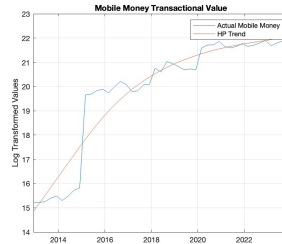
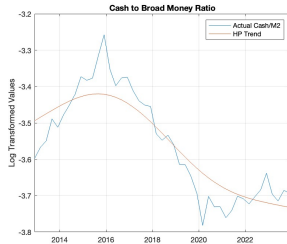
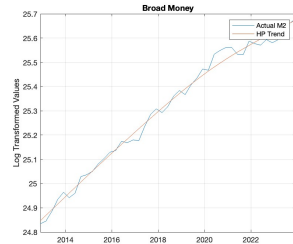
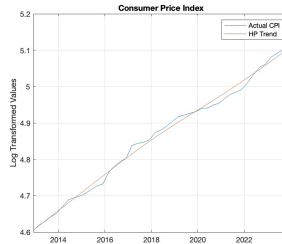
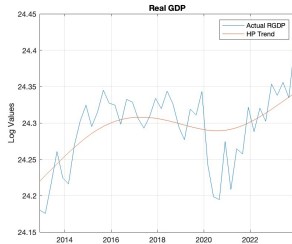
# First Exercise Data for Zambia

Figure 13: Cyclical Components of Data (Zambia)



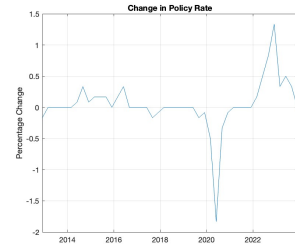
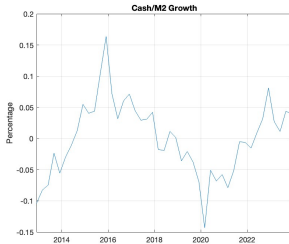
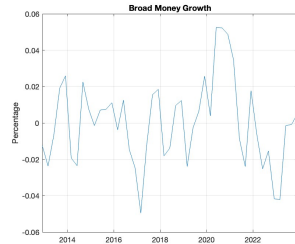
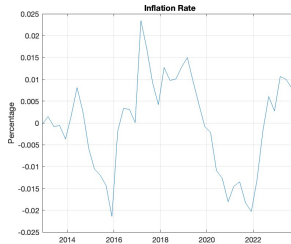
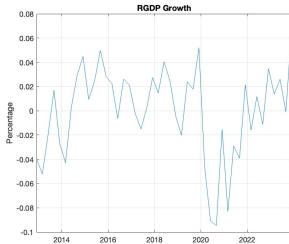
# First Exercise Data for Namibia

Figure 13: Trends Vs Actual Data (Namibia)



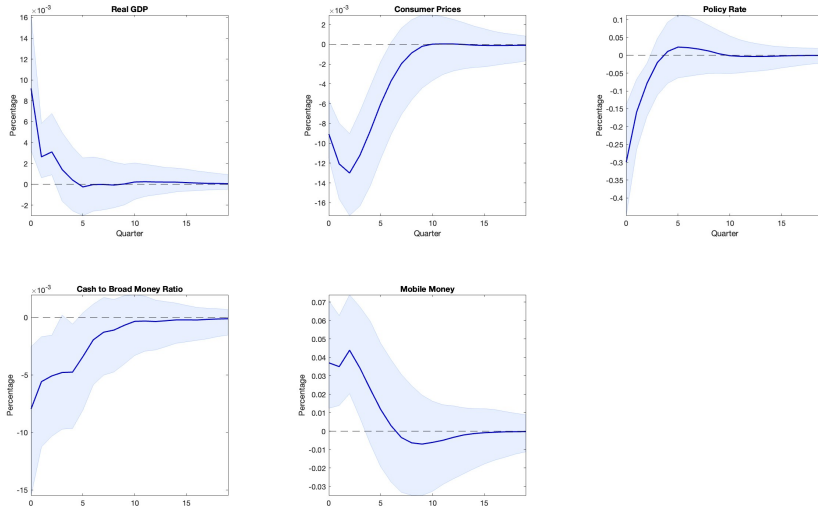
# First Exercise Data for Namibia

Figure 13: Cyclical Components of Data (Namibia)



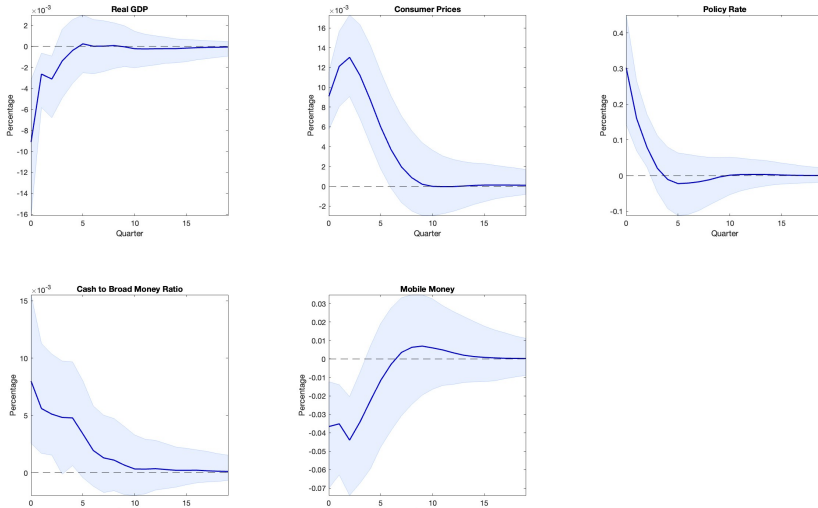
# First Exercise IRF Results for Zambia

Figure 1: The Response to Financial Inclusion Shock (Zambia)



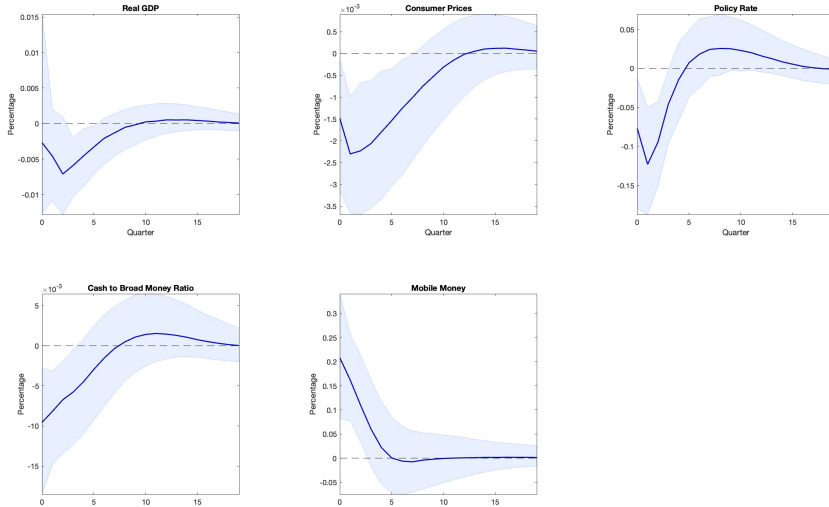
# First Exercise IRF Results for Zambia

Figure 2: The Response to Cash Preference Shock (Zambia)



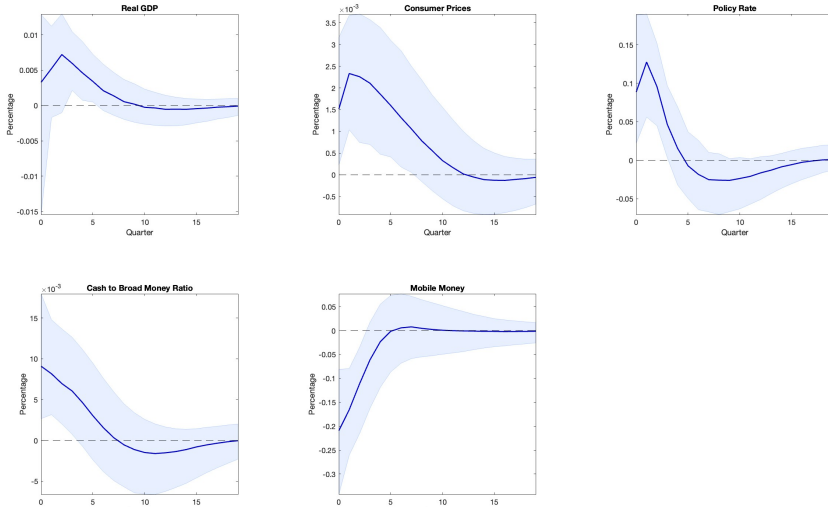
# First Exercise IRF Results for Namibia

Figure 1: The Response to Financial Inclusion Shock (Namibia)



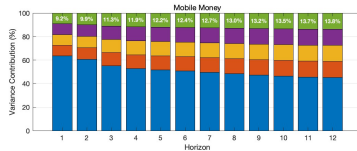
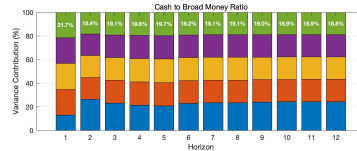
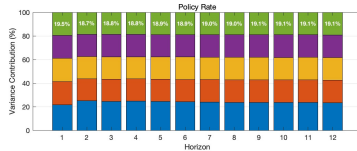
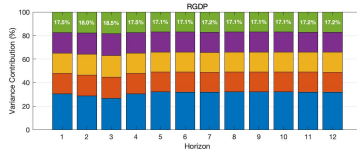
# First Exercise IRF Results for Namibia

Figure 2: The Response to Cash Preference Shock (Namibia)



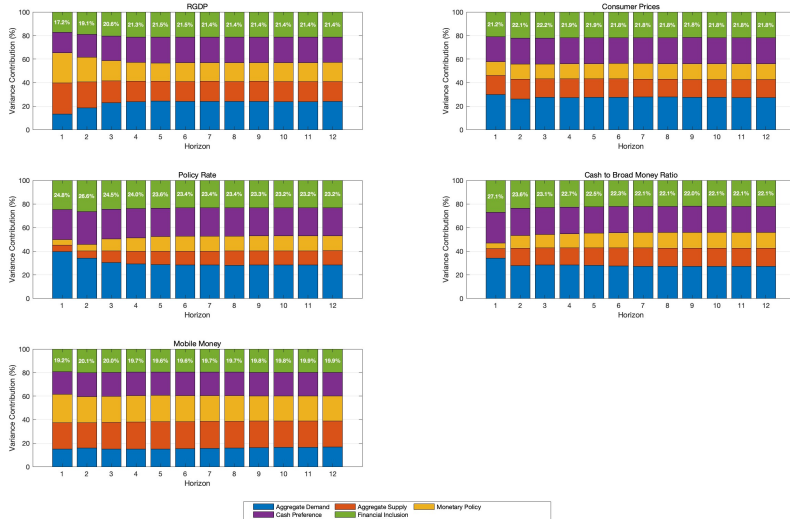
# First Exercise FEVD Results for Zambia

Forecast Error Variance Decomposition (Zambia)



# First Exercise FEVD Results for Namibia

Forecast Error Variance Decomposition (Namibia)



## The Structural Vector Auto-Regressive (VAR) Model

$$\begin{bmatrix} \gamma_{rr} & \gamma_{rm} & \gamma_{ry} & \gamma_{r\pi} \\ \gamma_{mr} & \gamma_{mm} & \gamma_{my} & \gamma_{m\pi} \\ \gamma_{yr} & \gamma_{ym} & \gamma_{yy} & \gamma_{y\pi} \\ \gamma_{\pi r} & \gamma_{\pi m} & \gamma_{\pi y} & \gamma_{\pi\pi} \end{bmatrix} \begin{bmatrix} r_t \\ m_t \\ y_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} c_r \\ c_m \\ c_y \\ c_\pi \end{bmatrix} + \begin{bmatrix} \phi_{rr}^{(1)} & \phi_{rm}^{(1)} & \phi_{ry}^{(1)} & \phi_{r\pi}^{(1)} \\ \phi_{mr}^{(1)} & \phi_{mm}^{(1)} & \phi_{my}^{(1)} & \phi_{m\pi}^{(1)} \\ \phi_{yr}^{(1)} & \phi_{ym}^{(1)} & \phi_{yy}^{(1)} & \phi_{y\pi}^{(1)} \\ \phi_{\pi r}^{(1)} & \phi_{\pi m}^{(1)} & \phi_{\pi y}^{(1)} & \phi_{\pi\pi}^{(1)} \end{bmatrix} \begin{bmatrix} r_{t-1} \\ m_{t-1} \\ y_{t-1} \\ \pi_{t-1} \end{bmatrix} + \begin{bmatrix} \phi_{rr}^{(2)} & \phi_{rm}^{(2)} & \phi_{ry}^{(2)} & \phi_{r\pi}^{(2)} \\ \phi_{mr}^{(2)} & \phi_{mm}^{(2)} & \phi_{my}^{(2)} & \phi_{m\pi}^{(2)} \\ \phi_{yr}^{(2)} & \phi_{ym}^{(2)} & \phi_{yy}^{(2)} & \phi_{y\pi}^{(2)} \\ \phi_{\pi r}^{(2)} & \phi_{\pi m}^{(2)} & \phi_{\pi y}^{(2)} & \phi_{\pi\pi}^{(2)} \end{bmatrix} \begin{bmatrix} r_{t-2} \\ m_{t-2} \\ y_{t-2} \\ \pi_{t-2} \end{bmatrix} + \begin{bmatrix} \epsilon_{rt} \\ \epsilon_{mt} \\ \epsilon_{yt} \\ \epsilon_{\pi t} \end{bmatrix} \quad (2)$$

### 1 Estimation Technique

- Bayesian Estimation with Normal Diffuse Prior

### 2 Identification Strategy

- Sign Restrictions

### 3 Forecast Evaluation

- Log Predictive Scores (LPS) and Continuous Ranked Probability Score (CRPS)

### 4 Structural Shocks Analysis

- Forecast Error Variance Decomposition (FEVD)
- Impulse Response Function (IRF)

## Identification Scheme

**Table 2: Identification Restrictions of the Structural Shocks**

| Shock            | Policy Rate | Money Growth | Output Growth | Inflation Rate |
|------------------|-------------|--------------|---------------|----------------|
| Monetary Policy  | $\geq 0$    | $\leq 0$     | $\leq 0$      | $\leq 0$       |
| Money Growth     |             |              | $\geq 0$      | $\geq 0$       |
| Aggregate Demand |             | $\geq 0$     | $\geq 0$      | $\geq 0$       |
| Aggregate Supply |             | $\geq 0$     | $\leq 0$      | $\geq 0$       |

**Note:** Sign restrictions hold only on impact and the next period.

- **Bayesian Model Specifications and Applications**

- 1 6000 iterations and 3000 burn-ins for the Gibbs Sampler
- 2 Credibility Intervals at 95%
- 3 One step ahead forecast evaluation

# Second Exercise Data of Botswana and Namibia

Figure 9: Time Series Plots (Botswana)

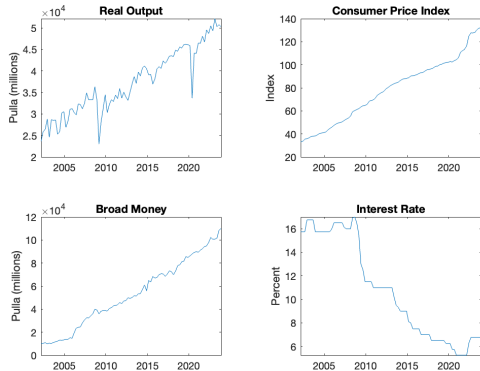
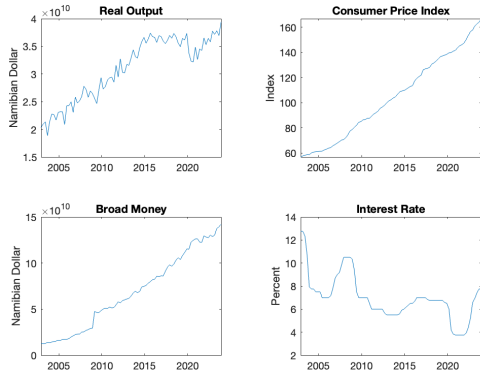


Figure 10: Time Series Plots (Namibia)



# Second Exercise Data for Malawi and Zambia

Figure 11: Time Series Plots (Malawi)

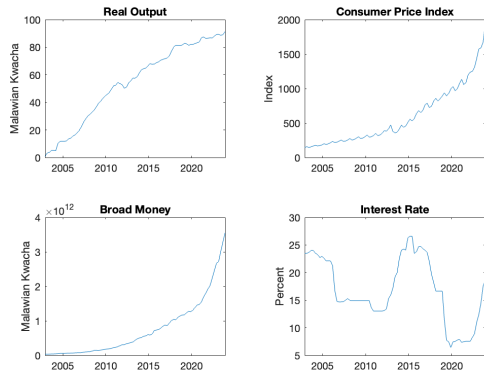
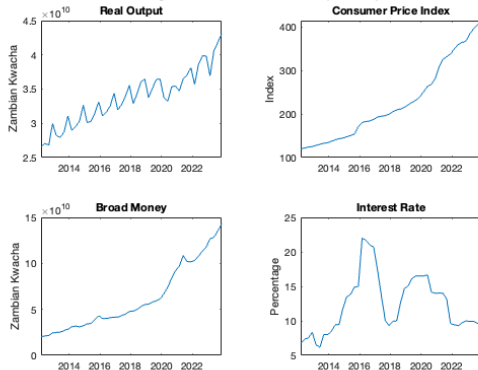


Figure 12: Time Series Plots (Zambia)



# Second Exercise Diagnostics

## Bayesian VAR Model Stability Condition

**Table 2: Roots of the Characteristic Polynomial (Modulus)**

| Country  | Model               | Lag     | $r_t$ | $m_t$ | $y_t$ | $\pi_t$ |
|----------|---------------------|---------|-------|-------|-------|---------|
| Botswana | Before Mobile Money | Lag (1) | 0.967 | 0.631 | 0.033 | 0.007   |
|          |                     | Lag (2) | 0.647 | 0.600 | 0.033 | 0.001   |
|          | After Mobile Money  | Lag (1) | 0.941 | 0.642 | 0.033 | 0.021   |
|          |                     | Lag (2) | 0.642 | 0.620 | 0.023 | 0.017   |
| Namibia  | Before Mobile Money | Lag (1) | 0.788 | 0.648 | 0.060 | 0.010   |
|          |                     | Lag (2) | 0.674 | 0.622 | 0.012 | 0.007   |
|          | After Mobile Money  | Lag (1) | 0.948 | 0.625 | 0.024 | 0.005   |
|          |                     | Lag (2) | 0.693 | 0.607 | 0.021 | 0.005   |
|          | Broad Money         | Lag (1) | 0.933 | 0.646 | 0.025 | 0.015   |
|          |                     | Lag (2) | 0.688 | 0.614 | 0.015 | 0.000   |
|          | Mobile Money        | Lag (1) | 0.940 | 0.656 | 0.023 | 0.003   |
|          |                     | Lag (2) | 0.667 | 0.638 | 0.006 | 0.003   |

# Second Exercise Diagnostics

## Bayesian VAR Model Stability Condition

**Table 3: Roots of the Characteristic Polynomial (Modulus)**

| Country | Model               | Lag     | $r_t$ | $m_t$ | $y_t$ | $\pi_t$ |
|---------|---------------------|---------|-------|-------|-------|---------|
| Malawi  | Before Mobile Money | Lag (1) | 0.933 | 0.659 | 0.046 | 0.016   |
|         |                     | Lag (2) | 0.695 | 0.568 | 0.016 | 0.002   |
|         | After Mobile Money  | Lag (1) | 0.962 | 0.636 | 0.067 | 0.011   |
|         |                     | Lag (2) | 0.653 | 0.621 | 0.020 | 0.000   |
|         | Broad Money         | Lag (1) | 0.973 | 0.654 | 0.050 | 0.008   |
|         |                     | Lag (2) | 0.669 | 0.629 | 0.020 | 0.005   |
|         | Mobile Money        | Lag (1) | 0.970 | 0.648 | 0.047 | 0.003   |
|         |                     | Lag (2) | 0.668 | 0.648 | 0.006 | 0.003   |
| Zambia  | Broad Money         | Lag (1) | 0.846 | 0.668 | 0.033 | 0.015   |
|         |                     | Lag (2) | 0.703 | 0.630 | 0.015 | 0.009   |
|         | Mobile Money        | Lag (1) | 0.817 | 0.646 | 0.032 | 0.015   |
|         |                     | Lag (2) | 0.683 | 0.646 | 0.032 | 0.012   |

# Second Exercise Results and Interpretation

## Out-of-Sample Forecast Evaluation

### Two Period Inflation Forecast Comparison

**Table 4: Inflation Forecast Evaluation**

| Country  | Training Dataset    | CRPS   | LPS     |
|----------|---------------------|--------|---------|
| Botswana | After Mobile Money  | 0.225* | −1.329* |
|          | Before Mobile Money | 0.525  | −1.850  |
| Namibia  | After Mobile Money  | 0.356* | −1.368* |
|          | Before Mobile Money | 0.384  | −6.986  |
| Malawi   | After Mobile Money  | 13.522 | −5.009  |
|          | Before Mobile Money | 2.503* | −3.371* |

**Note:** \* signifies a relatively superior forecast of the two periods.

# Second Exercise Results and Interpretation

## Out-of-Sample Forecast Evaluation

### Two Period Real Output Growth Forecast Comparison

**Table 5: Two Period Comparison of Real Output Growth Forecast**

| Country  | Training Dataset    | CRPS   | LPS     |
|----------|---------------------|--------|---------|
| Botswana | After Mobile Money  | 3.905* | −3.741* |
|          | Before Mobile Money | 5.073  | −4.018  |
| Namibia  | After Mobile Money  | 1.608* | −3.081* |
|          | Before Mobile Money | 5.139  | −3.540  |
| Malawi   | After Mobile Money  | 0.393* | −1.510* |
|          | Before Mobile Money | 0.555  | −1.857  |

**Note:** \* signifies a relatively superior forecast of the two periods.

# Second Exercise Results and Interpretation

## Out-of-Sample Forecast Evaluation

### Monetary Activity Measure and Inflation Forecasting

**Table 6: Inflation Forecasts Evaluation**

| Country | Measure      | CRPS    | LPS     |
|---------|--------------|---------|---------|
| Namibia | Mobile Money | 0.368*  | −1.367* |
|         | Broad Money  | 0.387   | −1.439  |
| Malawi  | Mobile Money | 13.546* | −5.011* |
|         | Broad Money  | 14.543  | −5.072  |
| Zambia  | Mobile Money | 0.743*  | −2.111* |
|         | Broad Money  | 0.768   | −2.177  |

**Note:** \* signifies a relatively superior forecast of the two measures.

# Second Exercise Results and Interpretation

## Out-of-Sample Forecast Evaluation

### Monetary Activity Measure and Real Output Growth Forecasting

**Table 7: Real Output Growth Forecast Evaluation**

| Country | Measure      | CRPS   | LPS     |
|---------|--------------|--------|---------|
| Namibia | Mobile Money | 1.775  | −3.140  |
|         | Broad Money  | 1.567* | −3.081* |
| Malawi  | Mobile Money | 0.378  | −1.480  |
|         | Broad Money  | 0.362* | −1.450* |
| Zambia  | Mobile Money | 2.524  | −3.316  |
|         | Broad Money  | 2.422* | −3.282* |

**Note:** \* signifies a relatively superior forecast of the two measures.

# Second Exercise Results and Interpretation

## Forecast Error Variance Decomposition (FEVD)

Figure 7: Botswana's FEVD Before Mobile Money

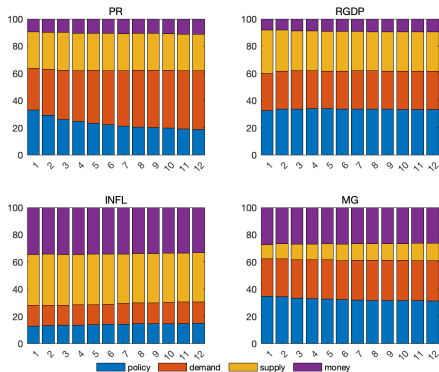
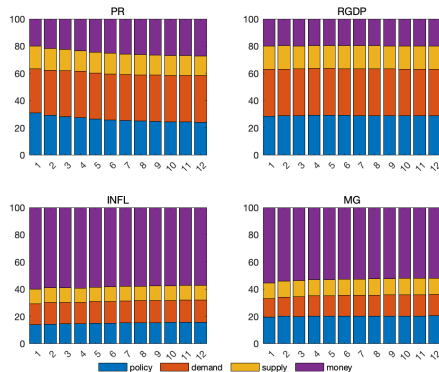


Figure 8: Botswana's FEVD After Mobile Money



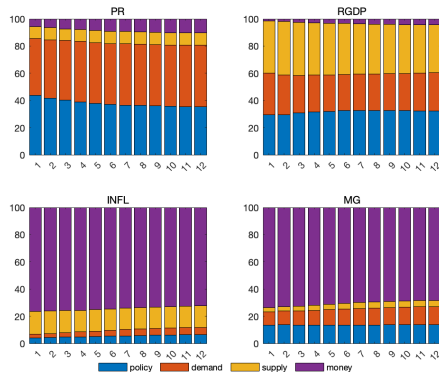
# Second Exercise Results and Interpretation

## Forecast Error Variance Decomposition (FEVD)

Figure 9: Namibia's FEVD Before Mobile Money



Figure 10: Namibia's FEVD After Mobile Money



# Second Exercise Results and Interpretation

## Forecast Error Variance Decomposition (FEVD)

Figure 11: Malawi's FEVD Before Mobile Money

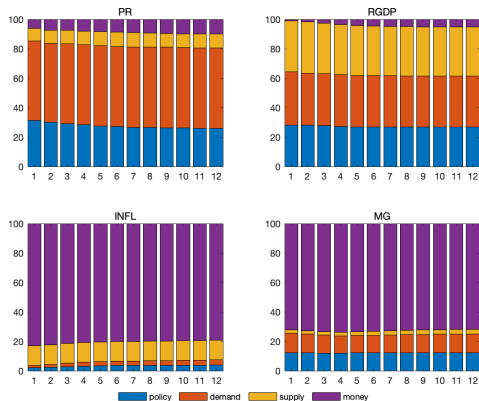
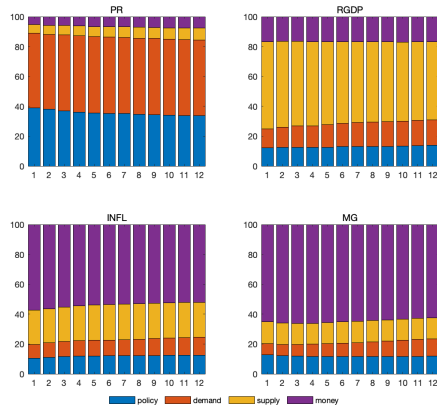


Figure 12: Malawi's FEVD After Mobile Money



# Second Exercise Results and Interpretation

## Forecast Error Variance Decomposition (FEVD)

Figure 13: Malawi's FEVD With Broad Money

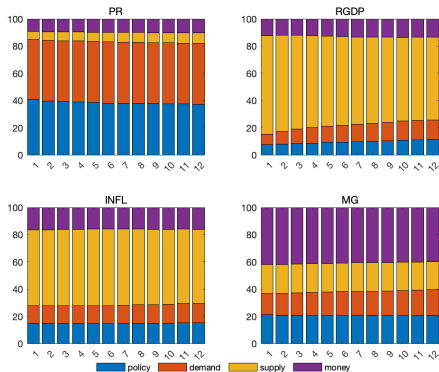
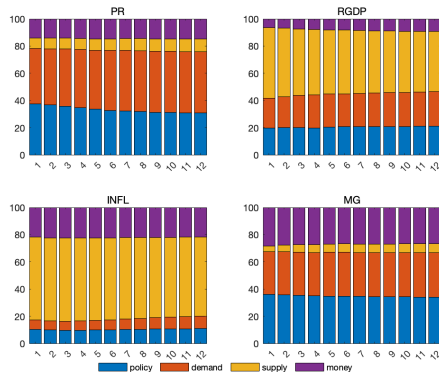


Figure 14: Malawi's FEVD with Mobile Money



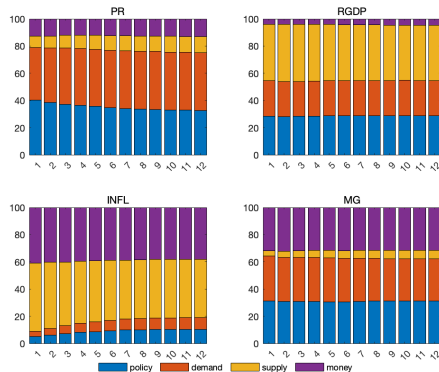
# Second Exercise Results and Interpretation

## Forecast Error Variance Decomposition (FEVD)

Figure 15: Zambia's FEVD with Broad Money



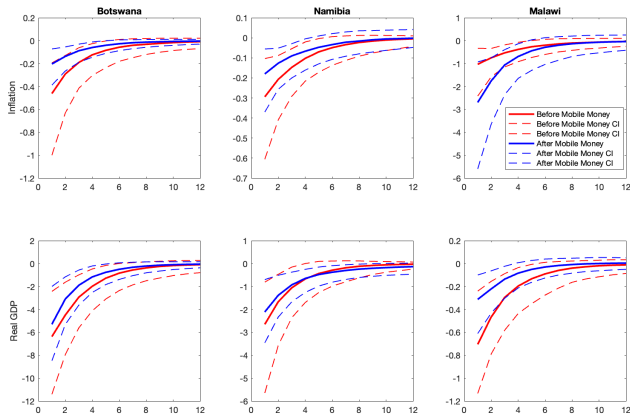
Figure 16: Zambia's FEVD with Mobile Money



# Second Exercise Results and Interpretation

## Impulse Response Functions (IRFs)

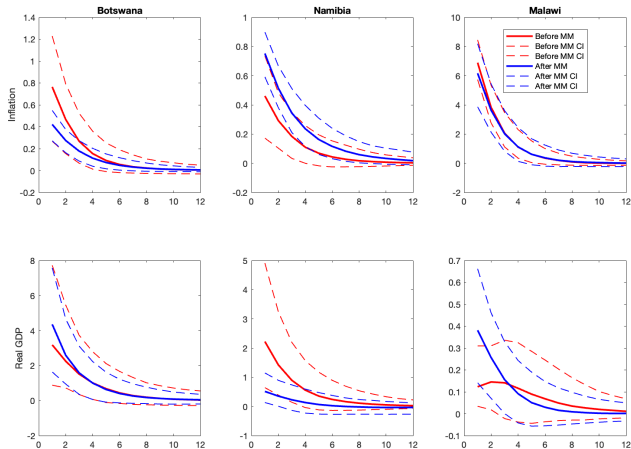
Figure 21: Response of Inflation and Real GDP to Policy Rate Shock



# Second Exercise Results and Interpretation

## Impulse Response Functions (IRFs)

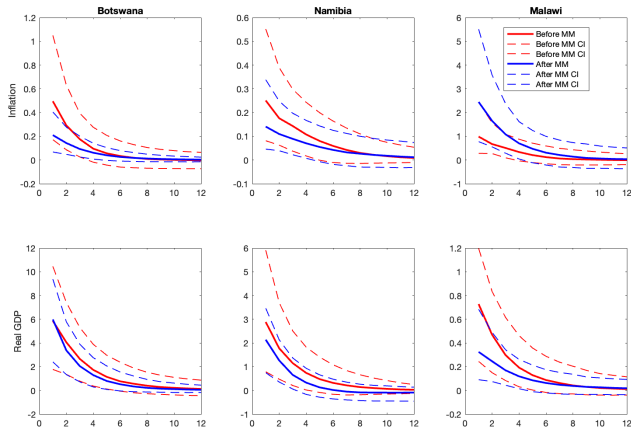
Figure 22: Response of Inflation and Real GDP to Money Growth Shock



# Second Exercise Results and Interpretation

## Impulse Response Functions (IRFs)

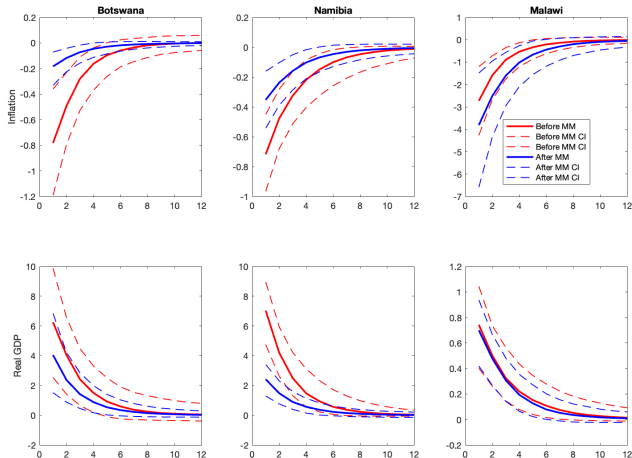
Figure 23: Response of Inflation and Real GDP to Aggregate Demand Shock



# Second Exercise Results and Interpretation

## Impulse Response Functions (IRFs)

**Figure 24: Response of Inflation and Real GDP to Aggregate Supply Shock**



- **Mobile money appears to be relevant for the macroeconomy.**
- **Monetary policy frameworks should adapt to the changing macroeconomic landscape shaped by digital financial transformation.**
- **An extension of the paper explores time-varying parameter models to account for non-linearity.**

# Abridged References



Liu, G. Gupta, R., & Schaling, E. (2009).

A new-keynesian dsge model for forecasting the south african economy

*Journal of Forecasting*. 28(5), 387–404.



Li, B., Liu, Q., & Pei, P. (2021).

Investigating the role of money in the identification of monetary policy behavior: A Bayesian DSGE perspective.

*Macroeconomic Dynamics*. 25(6), 1495–1537.



Wiafe, E., Quaidoo, C., & Sekyi, S. (2022).

Monetary policy effectiveness in the advent of mobile money activity: Empirical evidence from ghana.

*Cogent Economics & Finance*. 10.



Ngalawa, H. (2018).

Informal financial transactions and monetary policy in low-income countries: Interpolated informal credit and interest rates in Malawi

*South African Journal of Economic and Management Sciences*. 21(1), 1–14.

# Thank You

Questions? Comments?