# Predictable Financial Crises

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宏观经济稳定性研究的一个核心问题是金融危机的可预测性。

一种重要的观点认为，危机在很大程度上是不可预测的。

另一种观点认为，金融危机是伴随资产价格暴涨的快速信贷扩张在很大程度上可预测的副产品

# 六个发现

1、可以使用简单线性预测回归中的过去信贷增长预测危机

2、伴随着资产价格飙升的大规模信贷扩张时，可预测程度上升

3、企业和家庭信贷市场过热是两个独立现象，独立地预测了未来危机的到来

4、信贷市场过热具有全球成分，并在各国之间相互关联

5、R-zone事件预测了GDP的收缩

6、在促使政策制定者采取先发制人的行动之前，应该允许金融危机的概率攀升到多高？

主要解决的问题

I. Predicting Financial Crises

II. Understanding Crisis Predictability

III. Credit-Market Overheating and Future Economic Growth

IV . Crisis Prediction and Financial Stability Policy

A. Data

Table I

| | *N* | Mean | *SD* | Quantiles | | | |
|---|---|---|---|---|---|---|---|
| *Financial Crisis Indicators*: | | | | | | | |
| Baron, Verner, and Xiong (2021) (%) | 1281 | 3.98 | 19.56 | | | | |
| Jordá, Schularick, and Taylor (2017) (%) | 909 | 2.64 | 16.04 | | | | |
| Reinhart and Rogoff (2011) (%) | 1109 | 3.61 | 18.65 | | | | |
| *Crashes, Failures, and Panics*: | | | | | | | |
| Bank Equity Crash (%) | 1280 | 8.52 | 27.92 | | | | |
| Bank Failures (%) | 1281 | 3.51 | 18.42 | | | | |
| Panics (%) | 1281 | 3.04 | 17.19 | | | | |
| *GDP*: | | | | | | | |
| $\Delta_1$ log real GDP (%) | 1281 | 3.28 | 3.21 | | | | |
| *Debt Growth*: | | | | Q20 | Q40 | Q60 | Q80 |
| $\Delta_3$ Business Debt/GDP (%) | 1258 | 3.86 | 20.74 | −2.76 | 1.03 | 3.99 | 9.03 |
| $\Delta_3$ Household Debt/GDP (%) | 1107 | 3.58 | 5.74 | −0.26 | 1.63 | 3.95 | 7.62 |
| $\Delta_3$ log real Debt (%) | 1281 | 17.90 | 16.85 | 5.22 | 13.05 | 20.43 | 29.27 |
| *Price Growth*: | | | | Q33.3 | | Q66.7 | |
| $\Delta_3$ log real Equity Index (%) | 1258 | 8.65 | 48.80 | −8.53 | | 26.57 | |
| $\Delta_3$ log real House Price Index (%) | 1107 | 6.47 | 17.89 | −0.35 | | 12.68 | |

BVX使用手工收集的银行股票回报历史数据来改进现有的危机年表

B. Predicting Financial Crises with Past Credit Growth

$$Crisis_{i,t+1\text{ to }t+h} = \alpha_i^{(h)} + \beta^{(h)} \cdot \Delta_3 X_{it} + \varepsilon_{i,t+1\text{ to }t+h}, \tag{1}$$

$(\Delta_3(Debt^{Priv}/GDP)_{it})$ 私人信贷总额与GDP之比的三年变化

$(\Delta_3(Debt^{Bus}/GDP)_{it})$ 企业债务与GDP之比的三年变化

$(\Delta_3(Debt^{HH}/GDP)_{it})$ 家庭债务与GDP之比的三年变化

$(\Delta_3\log(Debt^{Priv}/CPI)_{it})$ 私人信贷总额比CPI的三年对数变化

Each of these variables is normalized by its sample standard deviation

B. Predicting Financial Crises with Past Credit Growth

$$Crisis_{i,t+1\text{ to }t+h} = \alpha_i^{(h)} + \beta^{(h)} \cdot \Delta_3 X_{it} + \varepsilon_{i,t+1\text{ to }t+h}, \quad (1)$$

Table II

| | Dependent Variable | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crisis within One Year | | | | Crisis within Two Years | | | | Crisis within Three Years | | | |
| | (1.1) | (1.2) | (1.3) | (1.4) | (2.1) | (2.2) | (2.3) | (2.4) | (3.1) | (3.2) | (3.3) | (3.4) |
| $\Delta_3(Debt^{Priv}/GDP)$ | 2.6* | | | | 4.0*** | | | | 5.3** | | | |
| | [1.7] | | | | [2.9] | | | | [2.6] | | | |
| $\Delta_3(Debt^{Bus}/GDP)$ | | 2.0 | | | | 2.8** | | | | 3.4* | | |
| | | [1.5] | | | | [2.6] | | | | [2.1] | | |
| $\Delta_3(Debt^{HH}/GDP)$ | | | 2.8** | | | | 6.1*** | | | | 9.2*** | |
| | | | [2.2] | | | | [2.9] | | | | [3.4] | |
| $\Delta_3\log(Debt^{Priv}/CPI)$ | | | | 1.3 | | | | 2.3 | | | | 3.5 |
| | | | | [1.2] | | | | [1.6] | | | | [1.7] |
| $R^2$ *(within)%* | 1.5 | 0.9 | 1.7 | 0.4 | 1.9 | 0.9 | 4.4 | 0.6 | 2.5 | 1.0 | 7.3 | 1.0 |
| $N$ | 1281 | 1258 | 1107 | 1281 | 1281 | 1258 | 1107 | 1281 | 1281 | 1258 | 1107 | 1281 |

信贷增长预测金融危机，但可预测性的程度很低，这使得
危机在很大程度上是不可预测的这一观点更加可信。

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## C. Predicting Financial Crises with Past Credit Growth and Asset Price Growth

| | $N$ | Mean | $SD$ | Quantiles | | | |
|---|---|---|---|---|---|---|---|
| *Financial Crisis Indicators*: | | | | | | | |
| Baron, Verner, and Xiong (2021) (%) | 1281 | 3.98 | 19.56 | | | | |
| Jordá, Schularick, and Taylor (2017) (%) | 909 | 2.64 | 16.04 | | | | |
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| Bank Equity Crash (%) | 1280 | 8.52 | 27.92 | | | | |
| Bank Failures (%) | 1281 | 3.51 | 18.42 | | | | |
| Panics (%) | 1281 | 3.04 | 17.19 | | | | |
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| *Debt Growth*: | | | | Q20 | Q40 | Q60 | Q80 |
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| $\Delta_3$ log real Debt (%) | 1281 | 17.90 | 16.85 | 5.22 | 13.05 | 20.43 | 29.27 |
| *Price Growth*: | | | | Q33.3 | | Q66.7 | |
| $\Delta_3$ log real Equity Index (%) | 1258 | 8.65 | 48.80 | −8.53 | | 26.57 | |
| $\Delta_3$ log real House Price Index (%) | 1107 | 6.47 | 17.89 | −0.35 | | 12.68 | |

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C. Predicting Financial Crises with Past Credit Growth and Asset Price Growth

Table III

Panel A: Distribution of Observations (%) by Growth in Business Debt and Equity Prices

| | Debt Quintile | | | | |
|---|---|---|---|---|---|
| Price Tercile | 1 | 2 | 3 | 4 | 5 |
| 1 | 5.6 | 6.5 | 5.8 | 6.8 | 8.7 |
| 2 | 6.8 | 7.6 | 7.0 | 6.7 | 5.3 |
| 3 | 7.6 | 6.0 | 7.2 | 6.6 | 6.0 |

$$p_{T,Q}^{(h)} = E[Crisis_{i,t+1 \text{ to } t+h} \mid \text{Tercile}(\Delta_3 \log(Price_{it})) = T,\ \text{Quintile}(\Delta_3 (Debt/GDP)_{it}) = Q]$$

The unconditional probability that a crisis begins within one year is 4.1%.

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Panel B: Crisis Probabilities (%) by Growth in Business Debt and Equity Prices

One-Year Horizon

| | *Crisis Frequency* Debt Quintile | | | | | *Diff. from Median* Debt Quintile | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 1.4 | 2.4 | 0.0 | 3.5 | 6.4 | −3.1 | −2.1 | −4.5** | −1.0 | 1.9 |
| 2 | 2.4 | 3.2 | 4.5 | 3.6 | 11.9 | −2.2 | −1.4 | 0.0 | −1.0 | 7.4 |
| 3 | 2.1 | 1.3 | 2.2 | 3.6 | 13.3 | −2.5 | −3.2 | −2.3 | −0.9 | 8.8 |

Two-Year Horizon

| | *Crisis Frequency* Debt Quintile | | | | | *Diff. from Median* Debt Quintile | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 1.4 | 4.9 | 2.7 | 4.7 | 14.7 | −5.4 | −1.9 | −4.1 | −2.1 | 7.9 |
| 2 | 2.4 | 4.2 | 6.8 | 7.1 | 16.4 | −4.5 | −2.6 | 0.0 | 0.3 | 9.6 |
| 3 | 8.3 | 5.3 | 8.9 | 8.4 | 26.7 | 1.5 | −1.5 | 2.1 | 1.6 | 19.8* |

Three-Year Horizon

| | *Crisis Frequency* Debt Quintile | | | | | *Diff. from Median* Debt Quintile | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 4.2 | 4.9 | 4.1 | 7.1 | 19.3 | −3.7 | −3.1 | −3.8 | −0.9 | 11.3 |
| 2 | 3.5 | 5.3 | 8.0 | 9.5 | 19.4 | −4.4 | −2.7 | 0.0 | 1.6 | 11.4* |
| 3 | 11.5 | 9.3 | 11.1 | 19.3 | 45.3 | 3.5 | 1.4 | 3.2 | 11.3 | 37.4*** |

Four-Year Horizon

| | *Crisis Frequency* Debt Quintile | | | | | *Diff. from Median* Debt Quintile | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 5.6 | 13.4 | 4.1 | 8.2 | 20.2 | −4.6 | 3.2 | −6.1 | −2.0 | 10.0 |
| 2 | 4.7 | 6.3 | 10.2 | 17.9 | 23.9 | −5.5 | −3.9 | 0.0 | 7.6 | 13.7* |
| 3 | 12.5 | 12.0 | 13.3 | 26.5 | 48.0 | 2.3 | 1.8 | 3.1 | 16.3 | 37.8*** |

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To explore crisis prediction in greater detail, we define the three indicator variables

$$High\text{-}Debt\text{-}Growth_{it} = 1\{\Delta_3 \big(Debt/GDP\big)_{it} > 80^{\text{th}} \text{ percentile}\}, \tag{2a}$$

$$High\text{-}Price\text{-}Growth_{it} = 1\{\Delta_3 \log(Price_{it}) > 66.7^{\text{th}} \text{ percentile}\}, \tag{2b}$$

$$R\text{-}zone_{it} = High\text{-}Debt\text{-}Growth_{it} \cdot High\text{-}Price\text{-}Growth_{it}, \tag{2c}$$

$$
Crisis_{i,t+1 \text{ to } t+h} = \alpha_i^{(h)} + \beta^{(h)} \cdot \textit{High-Debt-Growth}_{it} + \delta^{(h)} \cdot \textit{High-Price-Growth}_{it} + \gamma^{(h)} \cdot \textit{R-zone}_{it} + \varepsilon_{i,t+1 \text{ to } t+h}, \quad (3)
$$

| Panel A: Business Sector | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crisis within One Year | | | | Crisis within Two Years | | | | Crisis within Three Years | | | | Crisis within Four Years | | | |
| | (1.1) | (1.2) | (1.3) | (1.4) | (2.1) | (2.2) | (2.3) | (2.4) | (3.1) | (3.2) | (3.3) | (3.4) | (4.1) | (4.2) | (4.3) | (4.4) |
| *High Debt Growth*$^{Bus.}$ ($\beta^h$) | 6.9** | | 5.3** | | 11.6*** | | 9.5** | | 16.8*** | | 11.5** | | 15.6** | | 10.3* | |
| | [2.3] | | [2.1] | | [3.0] | | [2.5] | | [3.3] | | [2.7] | | [2.7] | | [2.2] | |
| *High Price Growth*$^{Bus.}$ ($\delta^h$) | | 0.4 | −0.4 | | | 4.8 | 3.8 | | | 10.5 | 7.4 | | | 10.7 | 7.6 | |
| | | [0.1] | [−0.2] | | | [0.9] | [0.8] | | | [1.4] | [1.1] | | | [1.5] | [1.2] | |
| *R-Zone*$^{Bus.}$ ($\gamma^h$) | | | 5.3 | 9.0 | | | 7.8 | 17.9* | | | 19.4** | 33.7*** | | | 19.4** | 33.0** |
| | | | [0.8] | [1.1] | | | [1.3] | [2.1] | | | [2.8] | [3.3] | | | [2.6] | [3.1] |
| Sum of coefficients ($\beta^h + \delta^h + \gamma^h$) | 6.9 | 0.4 | 10.2 | 9.0 | 11.6 | 4.8 | 21.1 | 17.9 | 16.8 | 10.5 | 38.2 | 33.7 | 15.6 | 10.7 | 37.3 | 33.0 |
| $t$-Statistic ($\beta^h + \delta^h + \gamma^h$) | | | 1.2 | | | | 2.1 | | | | 3.2 | | | | 3.1 | |
| $R^2$ *(within)* | 1.6 | 0.0 | 1.9 | 1.1 | 2.5 | 0.7 | 3.6 | 2.3 | 3.8 | 2.4 | 7.8 | 6.1 | 2.8 | 2.1 | 6.2 | 4.8 |
| $N$ | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 |

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# A. Robustness

## Table V

Panel A: Business Sample Robustness Table

| | | $N$ | #Countries | Multiple Regression: Debt Growth $\beta$ | [$t$] | Price Growth $\delta$ | [$t$] | $R$-Zone $\gamma$ | [$t$] | Sum of Coef. | $R^2_{within}$ | Univariate: $R$-Zone $\gamma$ | [$t$] | $R^2_{withi}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline Sample | 1258 | 42 | 11.5 | [2.7**] | 7.4 | [1.1] | 19.4 | [2.8**] | 38.2 | 7.8 | 33.7 | [3.3***] | 6.1 |
| (i) | Rolling Sample | 1003 | 42 | 9.3 | [2.2*] | 8.2 | [1.1] | 16.6 | [2.6**] | 34.1 | 7.2 | 29.2 | [3.4***] | 5.8 |
| (ii) | Leaveout Sample | 1258 | 42 | 11.8 | [2.9**] | 7.7 | [1.1] | 16.4 | [2.3**] | 35.8 | 7.5 | 30.6 | [2.9**] | 5.6 |
| (iii) | Pre-2000 Sample | 677 | 24 | 15.1 | [3.8***] | −1.8 | [−0.9] | 23.2 | [2.2*] | 36.5 | 8.8 | 34.0 | [2.8**] | 6.4 |
| (iv) | Pre-2000 Sample, Pre-2000 cutoffs | 677 | 24 | 8.4 | [2.7**] | −1.1 | [−0.5] | 11.1 | [1.8] | 18.4 | 3.9 | 17.0 | [2.1*] | 2.9 |
| (v) | Jordà, Schularick and Taylor | 893 | 17 | 4.5 | [0.8] | 7.2 | [0.9] | 13.0 | [1.6] | 24.7 | 4.4 | 22.2 | [1.9*] | 3.2 |
| (vi) | Reinhart and Rogoff (2011) | 1013 | 36 | 14.4 | [1.6] | 5.1 | [0.9] | 12.9 | [1.4] | 32.4 | 6.5 | 28.6 | [3.1***] | 4.7 |
| (vii) | Bank Equity Crash | 1255 | 42 | 16.9 | [3.3***] | 18.5 | [2.1*] | 14.8 | [2.3**] | 50.3 | 9.1 | 41.7 | [7.1***] | 5.2 |
| (viii) | Bank Failures | 1258 | 42 | 11.2 | [2.5**] | 4.3 | [1.0] | 16.0 | [2.1*] | 31.4 | 5.9 | 27.7 | [3.1***] | 4.5 |
| (ix) | Panics | 1258 | 42 | 5.1 | [1.4] | 8.0 | [1.2] | 21.6 | [3.0**] | 34.7 | 8.4 | 31.5 | [3.2***] | 6.9 |
| (x) | Crisis (Bank Equity) | 1258 | 42 | 7.8 | [1.7] | 3.9 | [0.9] | 15.4 | [2.0*] | 27.1 | 4.9 | 24.2 | [2.8**] | 4.0 |
| (xi) | Developed Countries | 1057 | 26 | 12.6 | [2.6**] | 8.2 | [1.0] | 17.0 | [2.2*] | 37.9 | 8.2 | 32.9 | [3.0**] | 6.0 |
| (xii) | Developing Countries | 201 | 16 | 3.1 | [0.3] | 3.2 | [1.0] | 34.5 | [4.3***] | 40.8 | 6.7 | 39.0 | [4.6***] | 6.5 |

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## B. Business versus Household Credit-Market Overheating

$$Crisis_{i,t+1 \text{ to } t+h} = \alpha_i^{(h)} + \gamma^{Bus(h)} \cdot R\text{-}zone_{it}^{Bus} + \gamma^{HH(h)} \cdot R\text{-}zone_{it}^{HH} + \gamma^{Both(h)} \cdot R\text{-}zone_{it}^{Both} + \gamma^{Either(h)} \cdot R\text{-}zone_{it}^{Either} + \varepsilon_{i,t+1 \text{ to } t+h}, \tag{4}$$

| | Dependent Variable | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crisis within One Year | | | | Crisis within Two Years | | | | Crisis within Three Years | | | | Crisis within Four Years | | | |
| | (1.1) | (1.2) | (1.3) | (1.4) | (2.1) | (2.2) | (2.3) | (2.4) | (3.1) | (3.2) | (3.3) | (3.4) | (4.1) | (4.2) | (4.3) | (4.4) |
| $R\text{-}Zone^{Bus.}$ ($\gamma^{Bus,h}$) | 5.9 | 3.5 | | | 14.0* | 6.6 | | | 28.7*** | 22.2* | | | 28.1** | 23.2 | | |
| | [0.9] | [0.6] | | | [1.9] | [1.0] | | | [3.2] | [2.0] | | | [2.7] | [1.7] | | |
| $R\text{-}Zone^{HH}$ ($\gamma^{HH,h}$) | 10.4** | 9.2** | | | 18.6** | 14.8** | | | 24.8*** | 21.6** | | | 26.2*** | 23.6*** | | |
| | [2.3] | [2.3] | | | [2.7] | [2.3] | | | [3.5] | [2.7] | | | [4.5] | [3.3] | | |
| $R\text{-}Zone^{Bus.} \times R\text{-}Zone^{HH}$ ($\lambda^h$) | | 9.2 | 20.8 | | | 28.6*** | 48.2*** | | | 24.8 | 65.4*** | | | 19.0 | 62.4*** | |
| | | [1.1] | [1.6] | | | [3.3] | [5.3] | | | [1.7] | [8.0] | | | [1.2] | [8.7] | |
| $\max\{R\text{-}Zone^{Bus.}, R\text{-}Zone^{HH}\}$ ($\kappa^h$) | | | | 9.7* | | | | 17.1** | | | | 28.1*** | | | | 28.9*** |
| | | | | [1.7] | | | | [2.5] | | | | [3.4] | | | | [3.5] |
| $R^2$ (within) | 3.1 | 3.3 | 1.7 | 2.6 | 6.2 | 7.3 | 5.0 | 4.4 | 11.1 | 11.7 | 6.7 | 8.7 | 9.6 | 9.9 | 5.1 | 7.6 |
| Observations | 1084 | 1084 | 1084 | 1281 | 1084 | 1084 | 1084 | 1281 | 1084 | 1084 | 1084 | 1281 | 1084 | 1084 | 1084 | 1281 |

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## C. Local versus Global Credit-Market Overheating

$$Crisis_{i,t+1 \text{ to } t+h} = \alpha_i^{(h)} + \gamma^{Bus(h)} \cdot Local\ R\text{-}zone_{it}^{Bus} + \xi^{Bus(h)} \cdot Global\ R\text{-}zone_{t}^{Bus} + \gamma^{HH(h)} \cdot Local\ R\text{-}zone_{it}^{HH} + \xi^{HH(h)} \cdot Global\ R\text{-}zone_{t}^{HH} + \varepsilon_{i,t+1 \text{ to } t+h}, \quad (5)$$

| | *Dependent Variable* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crisis within One Year | | | Crisis within Two Years | | | Crisis within Three Years | | | Crisis within Four Years | | |
| | (1.1) | (1.2) | (1.3) | (2.1) | (2.2) | (2.3) | (3.1) | (3.2) | (3.3) | (4.1) | (4.2) | (4.3) |
| *Local R-Zone*$^{Bus.}$ ($\gamma^{Bus,h}$) | 1.6 | | −0.4 | 5.8 | | 4.5 | 18.3** | | 16.0* | 18.8* | | 17.2 |
| | [0.5] | | [−0.2] | [1.2] | | [1.0] | [2.4] | | [1.9] | [2.2] | | [1.8] |
| *Global R-Zone*$^{Bus.}$ ($\xi^{Bus,h}$) | 55.8* | | 48.6 | 91.2*** | | 56.5* | 116.0*** | | 77.0 | 107.3*** | | 36.4 |
| | [1.8] | | [1.4] | [4.1] | | [1.9] | [4.7] | | [1.8] | [5.6] | | [1.3] |
| *Local R-Zone*$^{HH}$ ($\gamma^{HH,h}$) | | 6.4** | 6.4** | | 10.0** | 9.6** | | 14.3*** | 13.1** | | 11.4*** | 10.6*** |
| | | [2.2] | [2.2] | | [2.7] | [2.6] | | [3.1] | [2.9] | | [3.4] | [3.2] |
| *Global R-Zone*$^{HH.}$ ($\xi^{HH,h}$) | | 26 | 6.1 | | 56.2** | 31.5* | | 76.6*** | 39.4** | | 97.3*** | 75.8*** |
| | | [1.4] | [0.9] | | [2.7] | [1.9] | | [4.9] | [2.4] | | [7.3] | [4.9] |
| $R^2$ *(within)* | 6.0 | 4.9 | 7.3 | 9.3 | 10.4 | 12.6 | 14.3 | 14.5 | 19.2 | 10.7 | 16.1 | 18.2 |
| Observations | 1258 | 1107 | 1084 | 1258 | 1107 | 1084 | 1258 | 1107 | 1084 | 1258 | 1107 | 1084 |

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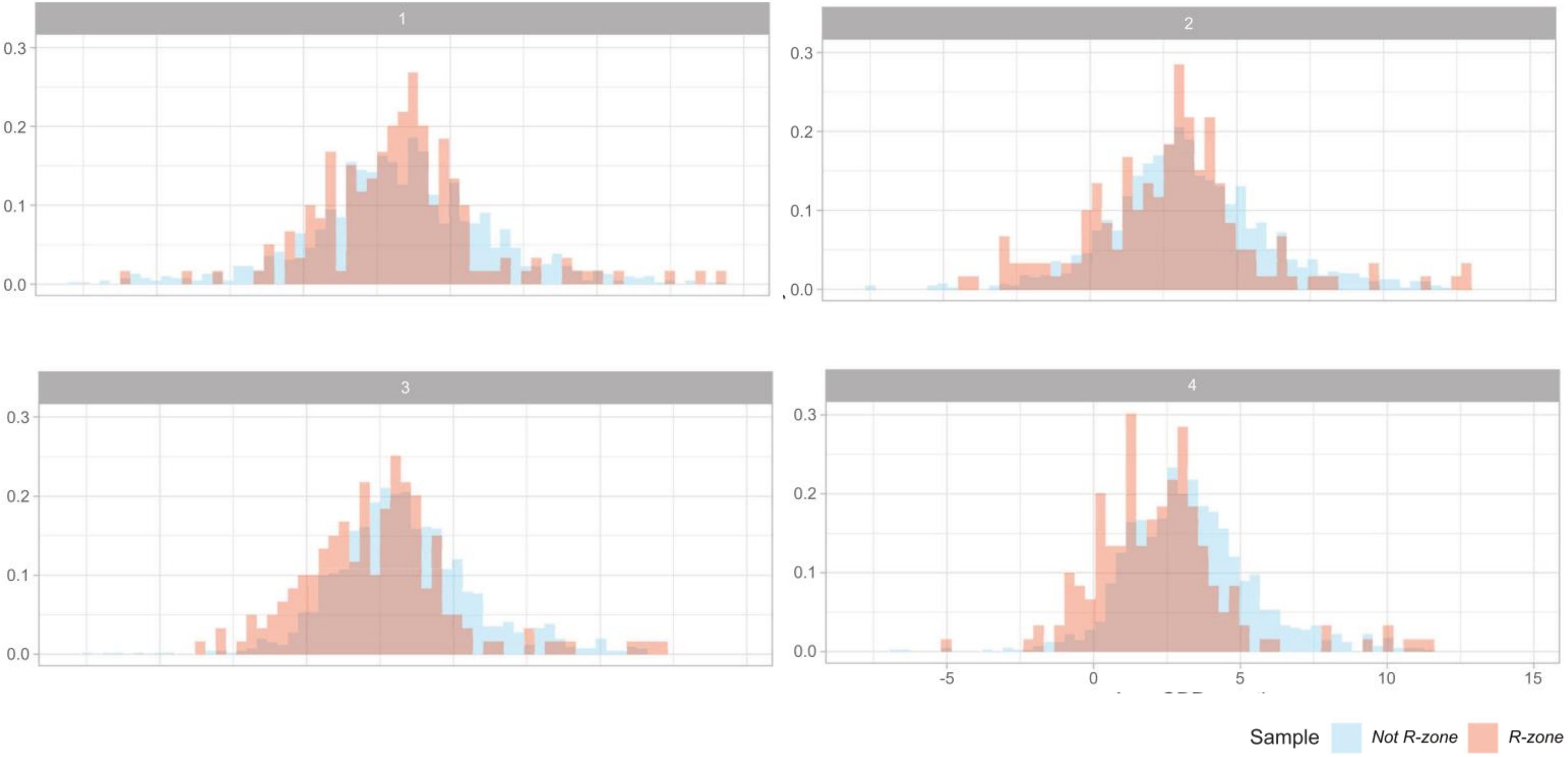
# III. Credit-Market Overheating and Future Economic Growth

Two hypotheses drive thisanalysis.

First, because the R-zone predicts financial crises, and financial crises are associated with output declines, at some horizon the R-zone likely predicts lower output growth.

Second, the R-zone is a strong but imperfect predictor of crises and may predict weak economic growth even when not followed by a crisis.




GDP growth following red zone events.

金融危机爆发后通常与实体经济活动的大幅收缩有关

$$Contract_{it+1\text{ to }t+h} = \alpha_i^{(h)} + \beta^{(h)} \cdot \Delta_3 X_{it} + \varepsilon_{i,t+1\text{ to }t+h},$$

Panel A: Probability of Severe Economic Decline by Business Debt Growth and Equity Price Growth

| | *Economic Decline Frequency* Debt Quintile | | | | | *Diff. from Median* Debt Quintile | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **One-Year Horizon** | | | | | | | | | | |
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 9.9 | 4.9 | 2.7 | 10.6 | 27.5 | 8.7** | 3.7* | 1.6 | 9.5* | 26.4** |
| 2 | 1.2 | 1.1 | 1.1 | 2.4 | 4.5 | 0.0 | −0.1 | 0.0 | 1.2 | 3.3 |
| 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | −1.1 | −1.1 | −1.1 | −1.1 | −1.1 |
| **Two-Year Horizon** | | | | | | | | | | |
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 11.3 | 4.9 | 5.5 | 14.1 | 31.2 | 6.7* | 0.3 | 0.9 | 9.6 | 26.6*** |
| 2 | 2.4 | 3.2 | 4.5 | 8.3 | 9.0 | −2.2 | −1.4 | 0.0 | 3.8 | 4.4 |
| 3 | 3.1 | 5.3 | 3.3 | 7.2 | 14.7 | −1.4 | 0.8 | −1.2 | 2.7 | 10.1 |
| **Three-Year Horizon** | | | | | | | | | | |
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 14.1 | 6.1 | 8.2 | 16.5 | 33.9 | 8.4* | 0.4 | 2.5 | 10.8 | 28.3*** |
| 2 | 2.4 | 3.2 | 5.7 | 9.5 | 11.9 | −3.3 | −2.5 | 0.0 | 3.8 | 6.3 |
| 3 | 11.5 | 16.0 | 8.9 | 13.3 | 28.0 | 5.8 | 10.3 | 3.2 | 7.6 | 22.3* |
| **Four-Year Horizon** | | | | | | | | | | |
| Price Tercile | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 | 14.1 | 7.3 | 8.2 | 17.6 | 33.9 | 7.3* | 0.5 | 1.4 | 10.8 | 27.1*** |
| 2 | 3.5 | 6.3 | 6.8 | 13.1 | 11.9 | −3.3 | −0.5 | 0.0 | 6.3 | 5.1 |
| 3 | 22.9 | 22.7 | 13.3 | 20.5 | 40.0 | 16.1 | 15.8* | 6.5 | 13.7* | 33.2* |

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虽然R-zone指标对三年内危机的到来具有相当大的预测能力，但仍然存在很大的预测误差

R-zone未能对某些危机发出信号，同时产生错误警报。这就提出了一个问题:为了避免或减轻金融危机的严重性，必须有多强的可预测性才能保证采取先发制人的政策行动。

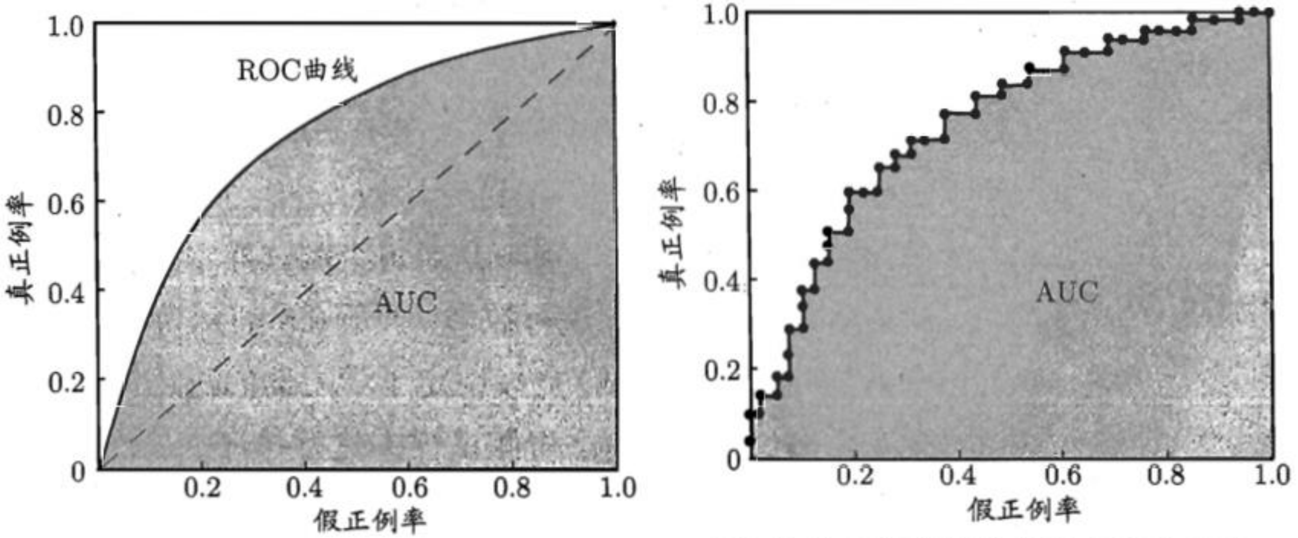
## A. Assessing Predictive Efficacy

| 真实情况 | 预测结果 | |
|---|---|---|
| | 正例 | 反例 |
| 正例 | *TP* (真正例) | *FN* (假反例) |
| 反例 | *FP* (假正例) | *TN* (真反例) |

$$\text{TPR} = \frac{TP}{TP + FN}$$

$$\text{FPR} = \frac{FP}{TN + FP}$$

受试者工作特征曲线（ROC）




(a) ROC 曲线与 AUC

(b) 基于有限样例绘制的 ROC 曲线与 AUC

A. Assessing Predictive Efficacy

| | **Crisis within three years**: | **No crisis within three years**: |
|---|---|---|
| | $Crisis_{i,t+1 \text{ to } t+3} = 1$ | $Crisis_{i,t+1 \text{ to } t+3} = 0$ |
| ***R-zone***: $R\text{-}zone_{it} = 1$ | *True Positives* (#*TP*) | *False Positives* (#*FP*) |
| **No *R-zone***: $R\text{-}zone_{it} = 0$ | *False Negatives* (#*FN*) | *True Negatives* (#*TN*) |

$$PPV = \frac{TP}{TP + FP}$$

$$TPR = \frac{TP}{TP + FN}$$

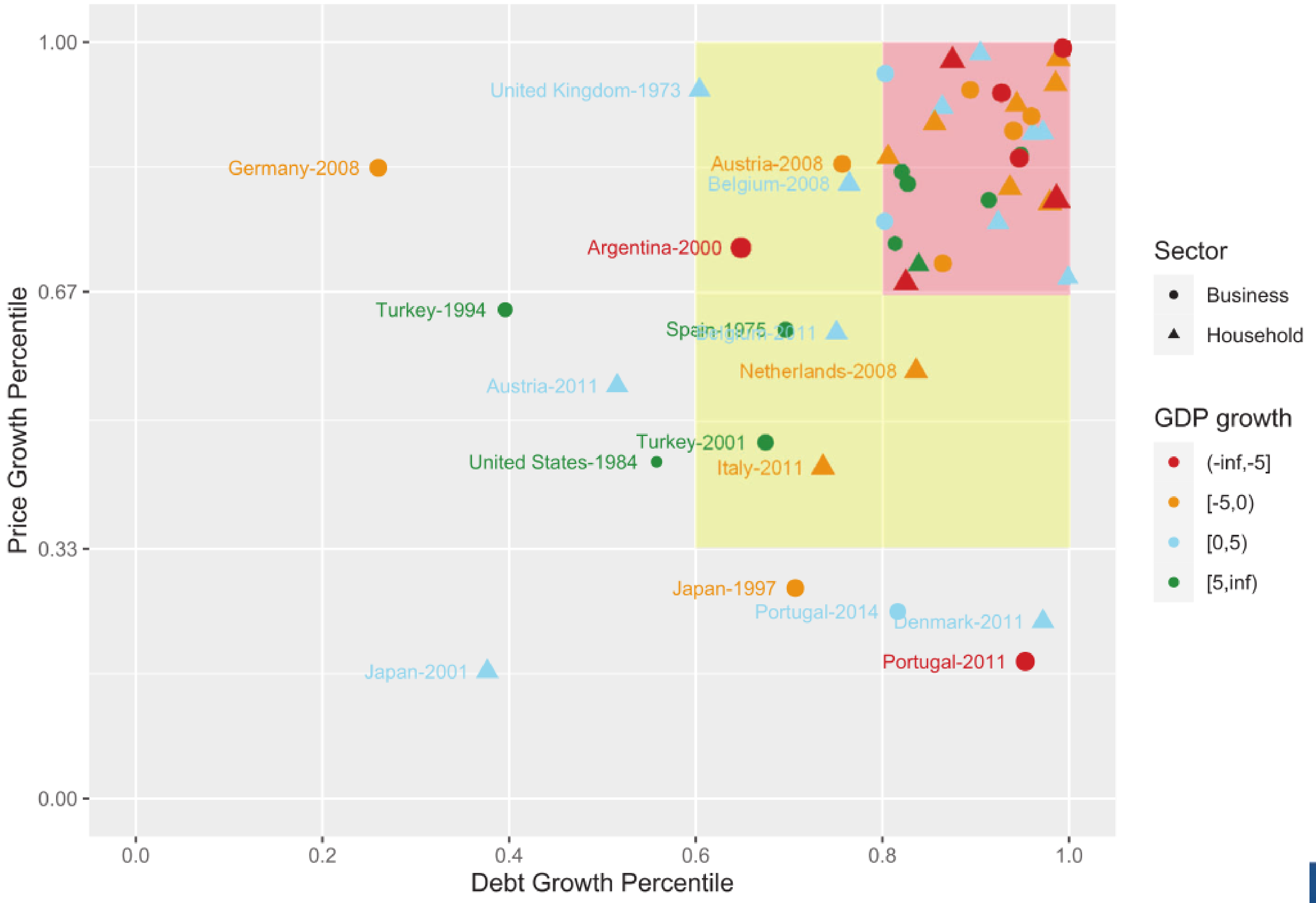
$$TNR = \frac{TN}{TN + FP}$$

## A. Assessing Predictive Efficacy

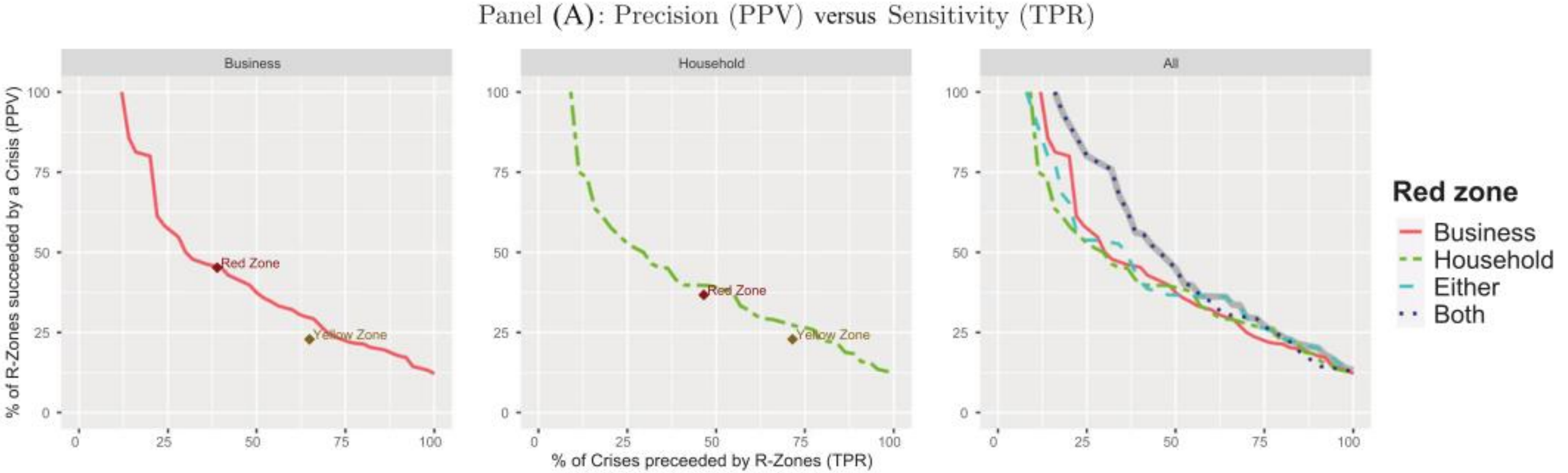
| Panel A: *R-Zone* | Business | Household | Either | Both |
|---|---|---|---|---|
| | *Type* | | | |
| #*R-Zone* Events followed by a Crisis | 34 | 42 | 61 | 15 |
| #*R-Zone* Events | 75 | 114 | 170 | 19 |
| %*R-Zone* Events followed by a Crisis (PPV) | 45.3 | 36.8 | 35.9 | 78.9 |
| #Crises Preceded by *R-Zone* | 20 | 21 | 32 | 7 |
| #Crises | 50 | 44 | 50 | 44 |
| % of Crises preceded by *R-Zone* (TPR) | 40.0 | 47.7 | 64.0 | 15.9 |
| #Noncrises not Preceded by *R-Zone* | 1077 | 897 | 969 | 1010 |
| #Noncrises | 1208 | 1063 | 1231 | 1040 |
| % of Noncrises not preceded by *R-Zone* (TNR) | 89.2 | 84.4 | 78.7 | 97.1 |
| Time to Crisis (years) | 2.9 | 3.7 | 3.6 | 3.0 |

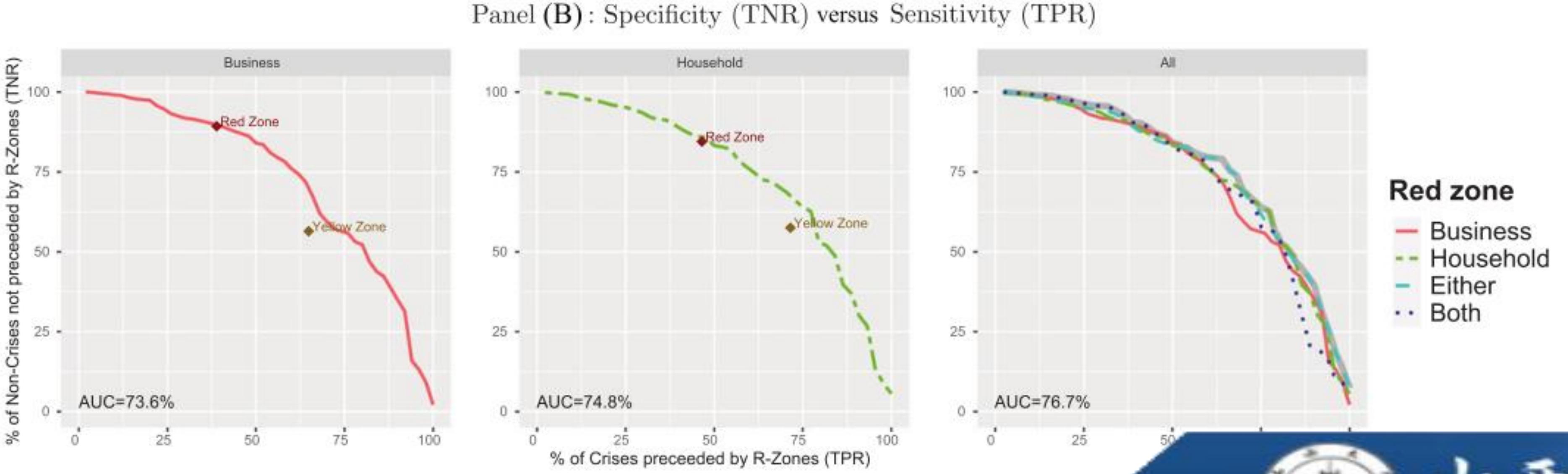
| Panel B: *Y-Zone* | Business | Household | Either | Both |
|---|---|---|---|---|
| | *Type* | | | |
| #*Y-Zone* Events followed by a Crisis | 71 | 77 | 103 | 45 |
| #*Y-Zone* Events | 309 | 335 | 515 | 129 |
| %*Y-Zone* Events followed by a Crisis (PPV) | 23.0 | 23.0 | 20.0 | 34.9 |
| #Crises Preceded by *Y-Zone* | 33 | 32 | 41 | 22 |
| #Crises | 50 | 44 | 50 | 44 |
| % of Crises Preceded by *Y-Zone* (TPR) | 66.0 | 72.7 | 82.0 | 50.0 |
| #Noncrises not Preceded by *Y-Zone* | 680 | 610 | 506 | 812 |
| #Noncrises | 1208 | 1063 | 1231 | 1040 |
| % of Noncrises not preceded by *Y-Zone* (TNR) | 56.3 | 57.4 | 41.1 | 78.1 |
| Time to Crisis (years) | 3.9 | 5.9 | 6.3 | 3.5 |

# A. Assessing Predictive Efficacy



## B. Mapping the Trade-Off between False Positive and False Negative Errors



$$\log\left(GDP_{i,t+h}/GDP_{i,t}\right) = \alpha_i^{(h)} + \gamma^{TP(h)} \cdot R\text{-}zone_{i,t} \times Crisis_{i,t+1 \text{ to } t+3} + \gamma^{FP(h)} \cdot R\text{-}zone_{i,t} \times \left(1 - Crisis_{i,t+1 \text{ to } t+3}\right) + \varepsilon_{i,t+1 \text{ to } t+h}, \quad (6)$$

Panel A: Cumulative GDP Growth Following False and True Positives in the Business *R-Zone*

| | *Dependent Variable* | | | |
|---|---|---|---|---|
| | One-Year Log GDP Growth (1) | Two-Year Log GDP Growth (2) | Three-Year Log GDP Growth (3) | Four-Year Log GDP Growth (4) |
| True Positives ($\gamma^{h,tp}$) | 0.7 | −1.4 | −4.7*** | −8.6*** |
| | [1.1] | [−1.1] | [−3.3] | [−5.3] |
| False Positives ($\gamma^{h,fp}$) | 1.1* | 1.1 | 1.3 | 2.1 |
| | [2.0] | [ 1.0] | [ 1.0] | [ 1.5] |
| $R^2$ (within) | 0.5 | 0.4 | 1.4 | 3.1 |
| $N$ | 1258 | 1258 | 1258 | 1258 |

## D. Are Crises Sufficiently Predictable to Warrant Early Action by Policymakers?

- *True negative*: If the risk of a crisis is truly low and the test predicts low risk, the policymaker does not take the preventative action and total real economic output is $Y_G > 0$. If the policymaker chooses a test with a *TPR* given by $\tau_{TPR}$, the unconditional probability of a true negative is $(1-p) \times T_{TNR}(\tau_{TPR})$.
- *False positive*: If the risk of a crisis is truly low but the test predicts high risk, the policymaker takes the action, leading output to fall to $Y_G - C_{FP}$. The cost of this false alarm, $C_{FP} > 0$, would be large if one thinks unnecessary actions to lean against the wind have a large social cost when the risk of a crisis is not truly high. The unconditional probability of a false positive is $(1-p) \times (1 - T_{TNR}(\tau_{TPR}))$.
- *True positive*: If the risk of a crisis is high and the test predicts high risk, the policymaker takes the action and real output is $Y_B > 0$. The probability of a true positive is $p \times \tau_{TPR}$.
- *False negative*: If the risk of a crisis is truly elevated but the test predicts low risk, the policymaker fails to take the preventative action and output falls to $Y_B - C_{FN}$. The cost of this false negative error, $C_{FN} > 0$, would be large if one thinks that the preventative action yields large benefits when the risk of a crisis is truly elevated. The unconditional probability of a true positive is $p \times \tau_{TPR}$. 修改为 $p \times (1-\tau_{TPR})$

D. Are Crises Sufficiently Predictable to Warrant Early Action by Policymakers?

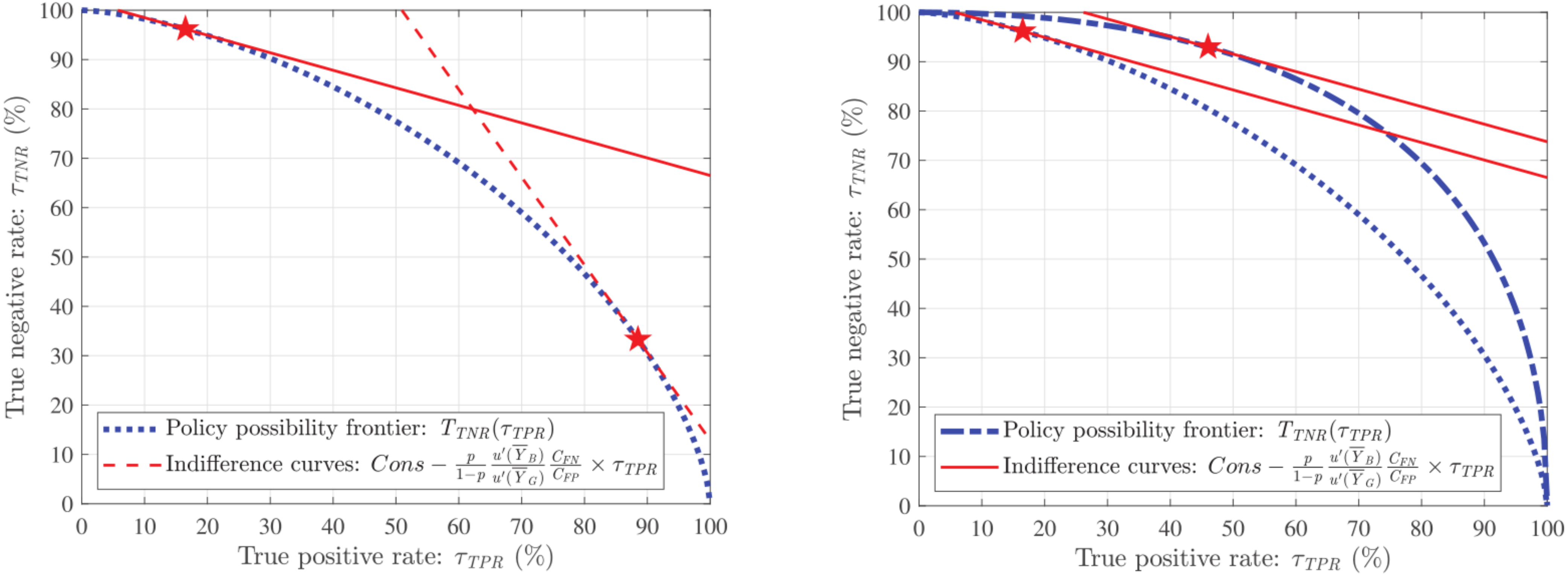
$$\max_{\tau_{TPR}\in[0,1]} \left\{p \times \left[\tau_{TPR} \times u\left(Y_B\right) + \left(1-\tau_{TPR}\right) \times u\left(Y_B - C_{FN}\right)\right] + (1-p) \times \left[T_{TNR}\left(\tau_{TPR}\right) \times u\left(Y_G\right) + \left(1 - T_{TNR}\left(\tau_{TPR}\right)\right) \times u\left(Y_G - C_{FP}\right)\right]\right\}. \quad (7)$$

The first-order condition

$$\overbrace{T'_{TNR}\left(\tau^*_{TPR}\right)}^{\text{Slope of policy possibility frontier}} = \overbrace{-\frac{p}{1-p}\frac{u(Y_B)-u\left(Y_B-C_{FN}\right)}{u(Y_G)-u\left(Y_G-C_{FP}\right)}}^{\text{Slope of policy indifference curves}} = \overbrace{-\frac{p}{1-p}\frac{C_{FN}}{C_{FP}}\frac{u'\left(\bar{Y}_B\right)}{u'\left(\bar{Y}_G\right)}}^{\text{Slope of policy indifference curves}}, \quad (8)$$

Panel A: Baseline Position of the Policy Production Frontier

Panel B: Outward Shift in the Policy Production Frontier




$$\textit{Indifference-Curve}_{TNR}(\tau_{TPR}) = Const - \frac{p}{1-p}\frac{u'(\bar{Y}_L)}{u'(\bar{Y}_H)}\frac{c_{FN}}{c_{FP}} \times \tau_{TPR}.$$

D. Are Crises Sufficiently Predictable to Warrant Early Action by Policymakers?

$$T'_{TNR}\left(\tau^{*}_{TPR}\right) = -\frac{p}{1-p}\frac{u(Y_B)-u(Y_B-C_{FN})}{u(Y_G)-u(Y_G-C_{FP})} = -\frac{p}{1-p}\frac{C_{FN}}{C_{FP}}\frac{u'(\bar{Y}_B)}{u'(\bar{Y}_G)}, \quad (8)$$

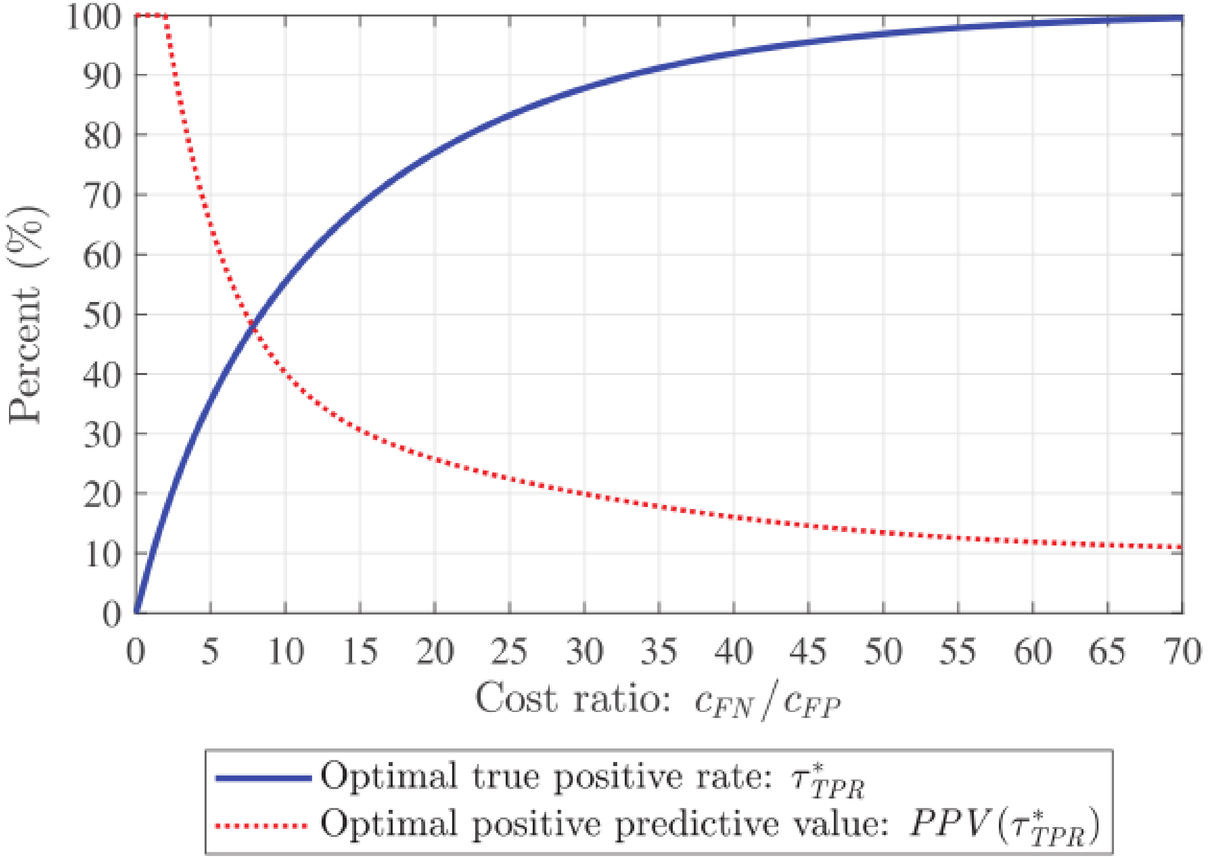
$$\frac{C_{FN}}{C_{FP}} = \frac{C_{crisis}}{Y_G} \times \frac{c_{FN}}{c_{FP}}$$

$C_{crisis}$：通过采取早期预防措施可以减轻的金融危机成本

$Y_G$：决策者对虚假警报采取行动时损失的非危机产出

$$T'_{TNR}\left(\tau^{*}_{TPR}\right) = -\frac{p}{1-p} \times \frac{u'(Y_B)}{u'(\bar{Y}_G)} \times \frac{C_{Crisis}}{Y_G} \times \frac{c_{FN}}{c_{FP}}$$

$$T'_{TNR}\left(\tau^*_{TPR}\right) = -\frac{p}{1-p} \times \frac{u'\left(Y_B\right)}{u'\left(\bar{Y}_G\right)} \times \frac{C_{Crisis}}{Y_G} \times \frac{c_{FN}}{c_{FP}} = -\frac{0.04}{0.96} \times 1 \times 1.5 \times \frac{c_{FN}}{c_{FP}}. \quad (9)$$




We set CCrisis/YG = 1.5 for concreteness

假设政策制定者是风险中性的 → $\frac{u'(\bar{Y}_B)}{u'(\bar{Y}_G)} = 1$

# Ⅴ. Conclusion

1、可以使用简单线性预测回归中的过去信贷增长预测危机

2、伴随着资产价格飙升的大规模信贷扩张时，可预测程度上升

3、企业和家庭信贷市场过热是两个独立现象，独立地预测了未来危机的到来

4、信贷市场过热具有全球成分，并在各国之间相互关联

5、R-zone事件预测了GDP的收缩

6、在促使政策制定者采取先发制人的行动可与cFN/cFP 相联系

谢谢大家