The Term Structure of Growth-at-Risk

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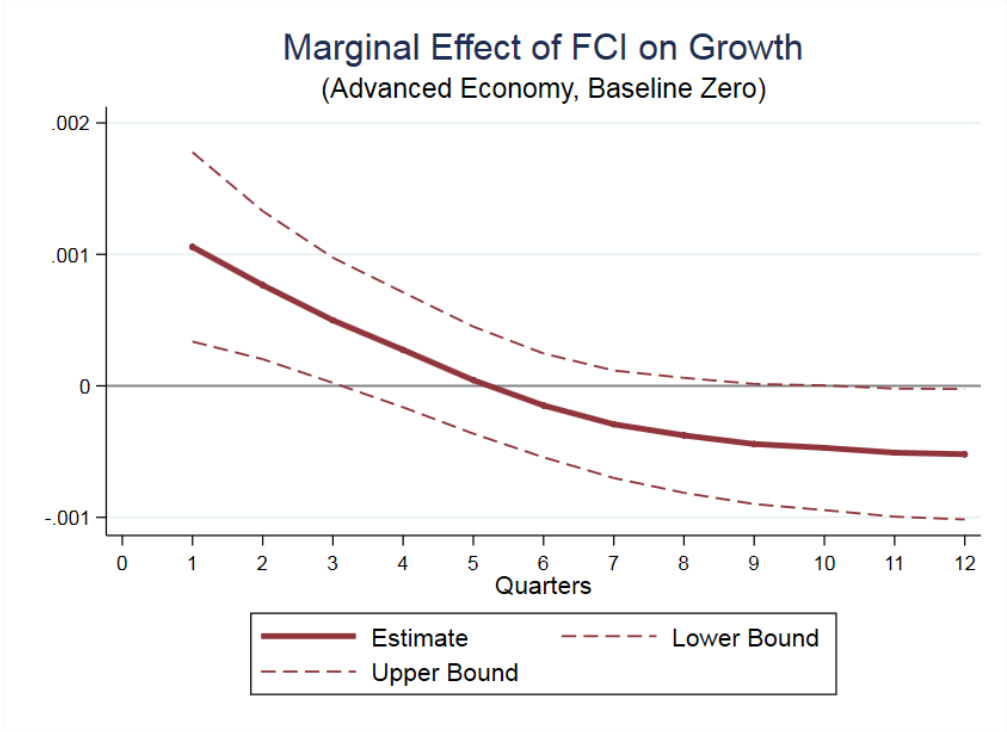
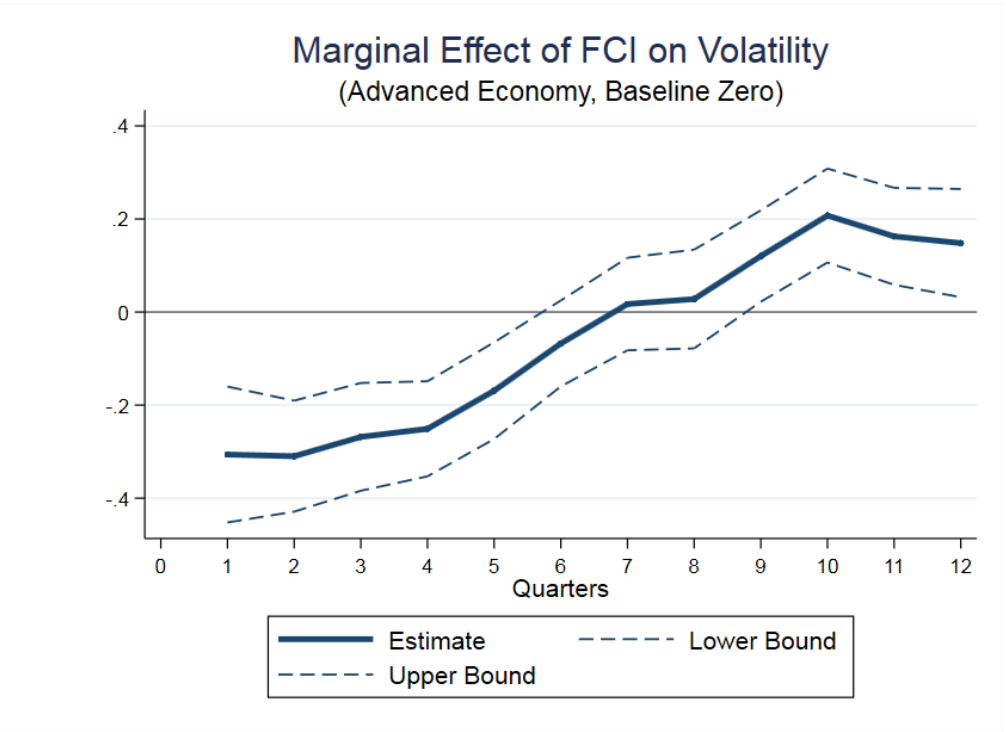
Outline

- Financial conditions affect the distribution of growth, and effects are time-varying
- Consistent with endogenous risk-taking behavior
- Empirical model of output growth with heteroskedastic volatility
- Local projections estimation methods
- 11 advanced economies, 10 emerging markets
- Develop term structure of Growth-at-risk (GaR)
  - Lower 5^{th} percentile from the distribution of expected growth
  - Projection horizons 1 to 12 quarters ahead

Looser financial conditions imply …

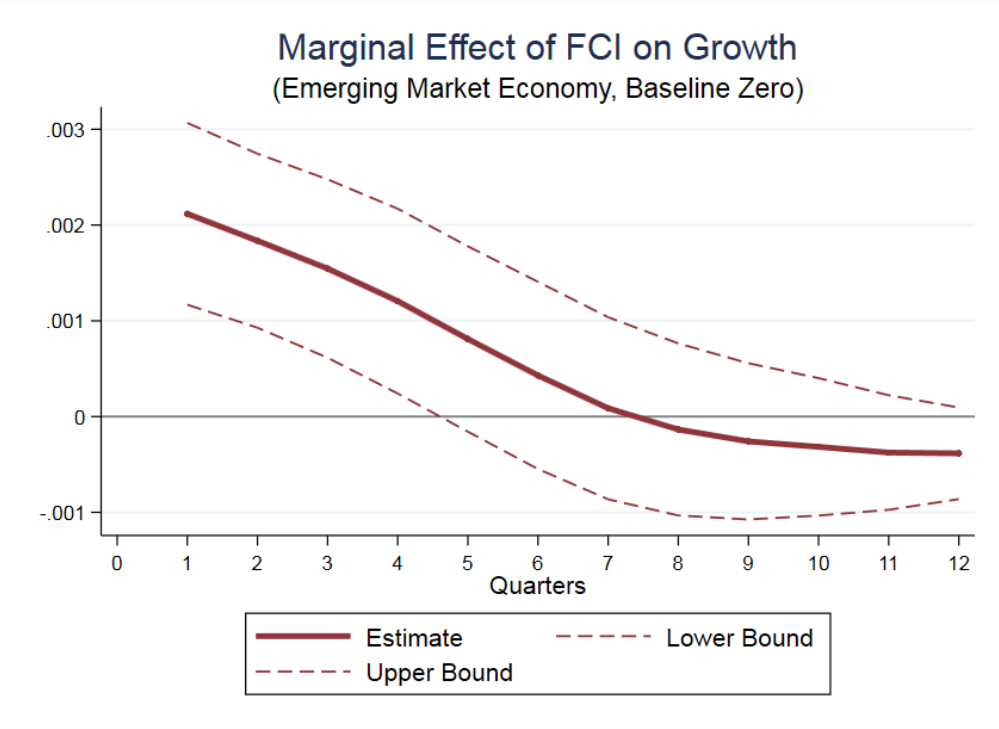


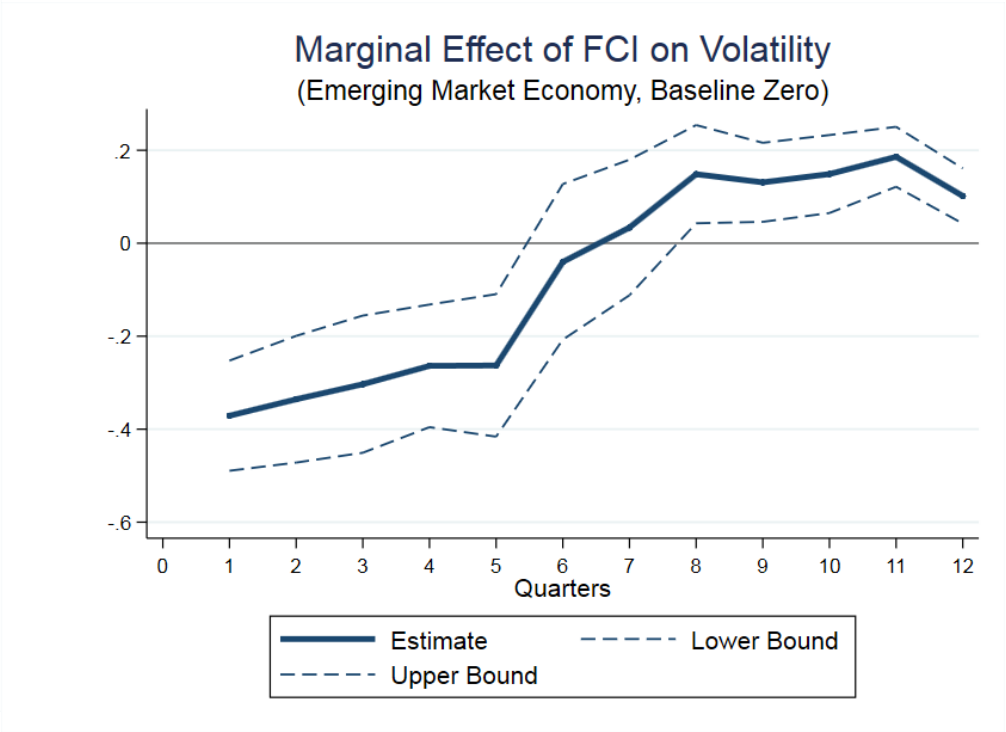


Higher GDP, lower volatility in the near term …

… but lower GDP, higher volatility in the medium term in AEs

Same results for emerging market economies





Key results and implications

- Looser financial conditions forecast higher growth and lower volatility at short horizons
- And lower growth and higher volatility at medium horizons
- Strong intra-temporal inverse correlation -- growth and volatility
- Term structure of GaR – conditional future growth at the 5^{th} percentile – suggests an inter-temporal tradeoff
  - Substantial for advanced economies
- Implications for macroeconomic models and policymaking
- GaR expresses financial stability risks in a common metric for all macroeconomic policymakers

Empirical model of expected GDP growth

$$\Delta y_{i,t+h} = \gamma_0^{(h)} + \gamma_{i,1}^{(h)} + \gamma_2^{(h)} x_{i,t} + \gamma_3^{(h)} \Delta y_{i,t} + \gamma_4^{(h)} \pi_{i,t} + \gamma_5^{(h)} \lambda_{i,t} x_{i,t} + \varepsilon_{i,t+h} \quad \text{with } h=1,\ldots,12 \qquad (1)$$

$$\ln \varepsilon_{i,t+h}^2 = \beta_0^{(h)} + \beta_{i,1}^{(h)} + \beta_2^{(h)} x_{i,t} + \beta_3^{(h)} \pi_{i,t} + \beta_4^{(h)} \lambda_{i,t} x_{i,t} + \nu_{i,t+h}, \qquad (2)$$

λ is a financial vulnerability – we define it as a credit boom

- Expected growth depends on financial conditions $x_{i,t}$, economic conditions $\Delta y_{i,t}$, inflation $\pi_{i,t}$, with heteroskedastic volatility
- Volatility depends on financial conditions and inflation
- Allows for nonlinear effect for financial conditions with λ

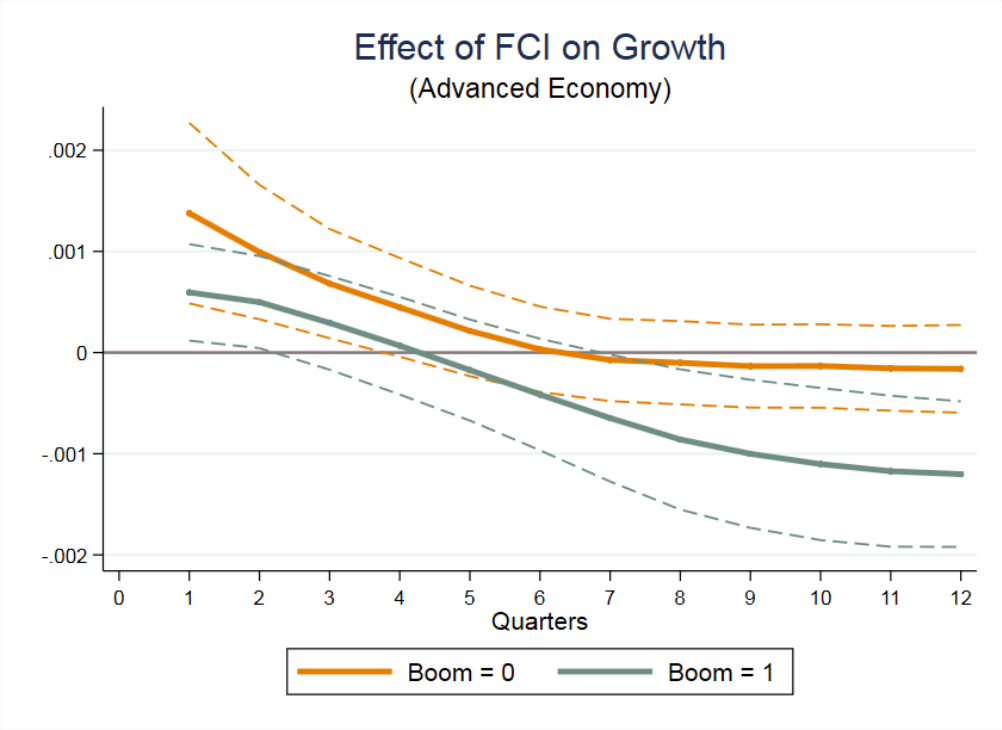
Data

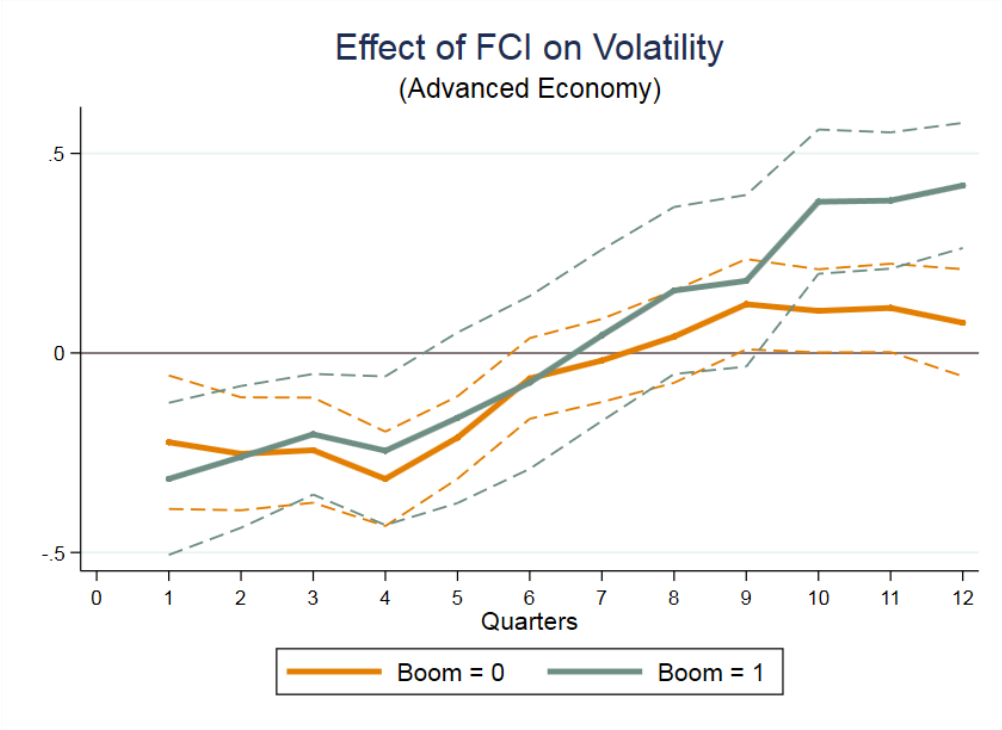
- FCI constructed for the GFSR, Oct. 2017, based on up to 19 variables
  - Key advantage is consistent construction across many countries
  - Higher FCI is looser financial conditions
- Credit-to-GDP gap from BIS (also credit-to-GDP growth)
- GDP and inflation from International Financial Statistics
- 11 advanced economies, 1973 to 2016
  - AUS, CAN, CHE, DEU, ESP, FRA, GBR, ITA, JPN, SWE, USA
- 10 emerging market economies, 1996 to 2016
  - BRA, CHL, CHN, IDN, IND, KOR, MEX, RUS, TUR, ZAF

Could results be driven by a common shock?

- Would affect FCI quickly, while GDP adjusts with a lag
- Test if effect depends on a financial vulnerability, credit-to-GDP gap
- Would be consistent with endogenous risk-taking
- Define λ to be a credit boom – high FCI and high credit gap
  - λ =1 if Credit-to-GDP gap > 0 and FCI is in the top quartile
  - λ =0 else
- Test if effect of FCI is greater in a credit boom – if credit boom magnifies effects on output and volatility, more consistent with endogenous risk-taking

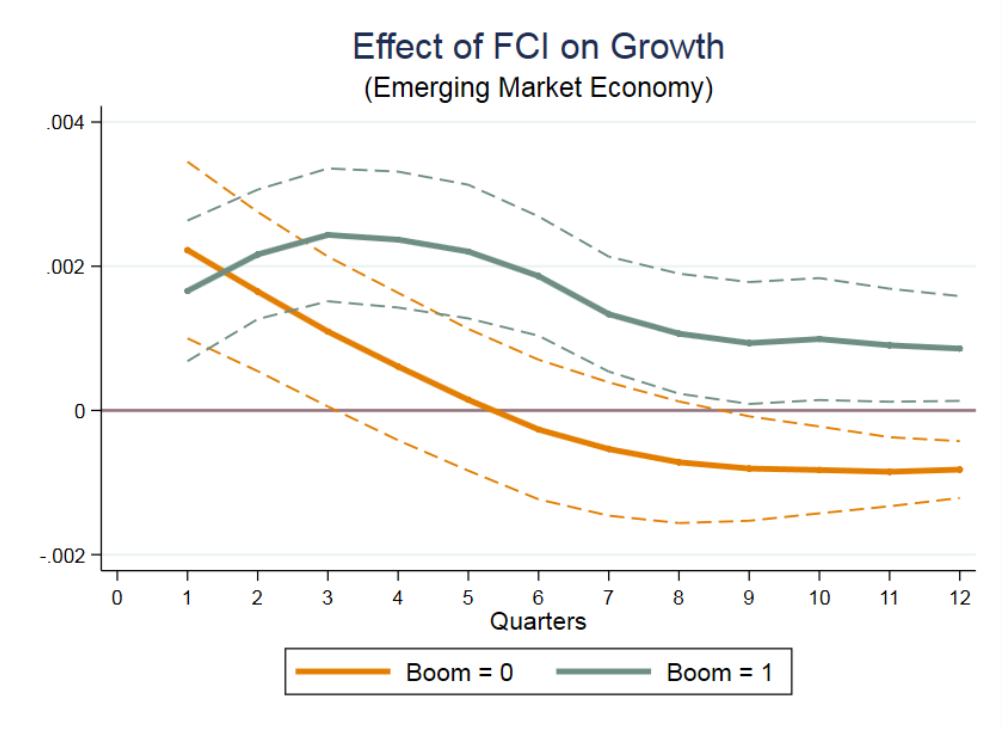
Interaction with credit boom - AEs

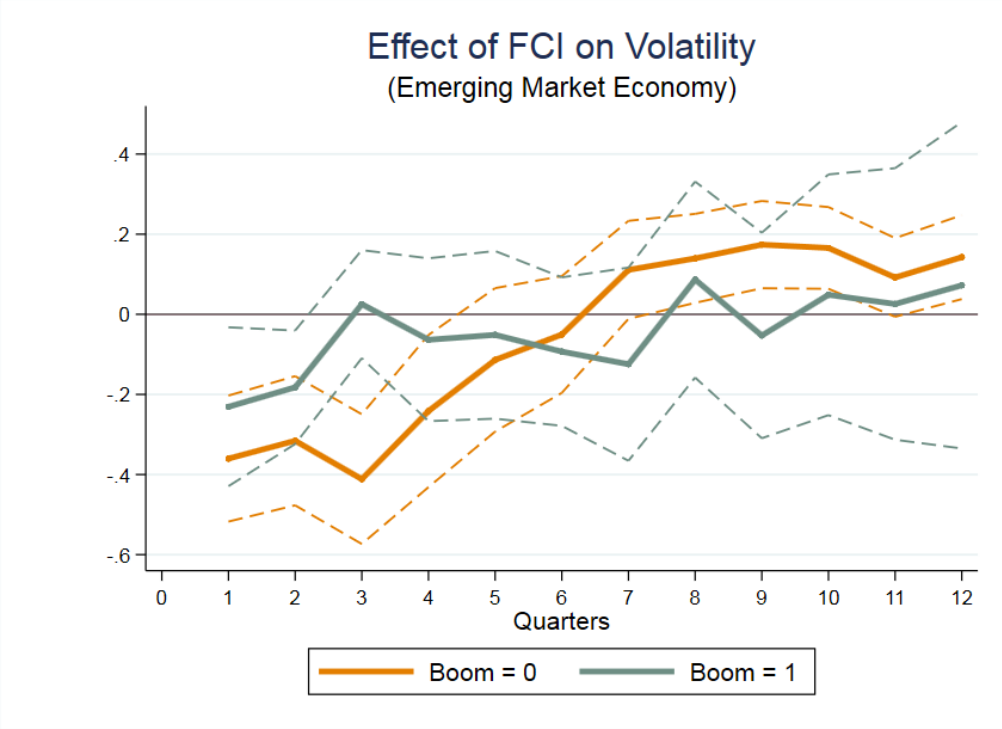




Higher FCIs in a credit boom imply lower growth and higher volatility in the medium term
Effects of FCI in a credit boom are not significantly different in the near term than other periods
Both show higher FCIs imply higher growth and lower volatility in the near term

Interaction with credit boom - EMEs





Same results for FCI if not a credit boom

… If in a credit boom, not lower growth or high volatility in the medium run

Define Growth-at-risk (GaR)

$$\Pr\left(\Delta y_{i,t+h} \le GaR_{i,h}\left(\alpha \middle| \Omega_t\right)\right) = \alpha \qquad (3)$$

where $GaR_{i,h}\left(\alpha \middle| \Omega_t\right)$ is growth at risk for country *i* in *h* quarters in the future at a α probability.

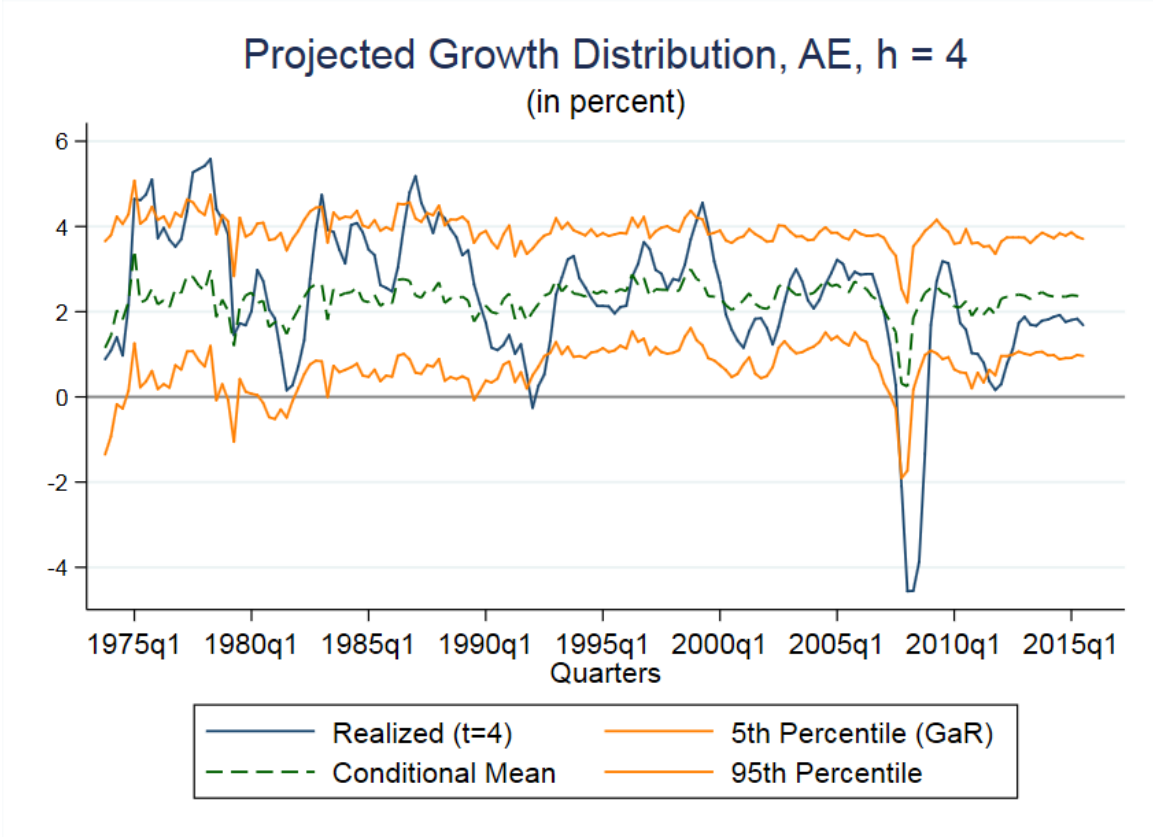
GaR defined by α=.05 is the expected growth at the lower 5th percentile of the GDP growth distribution

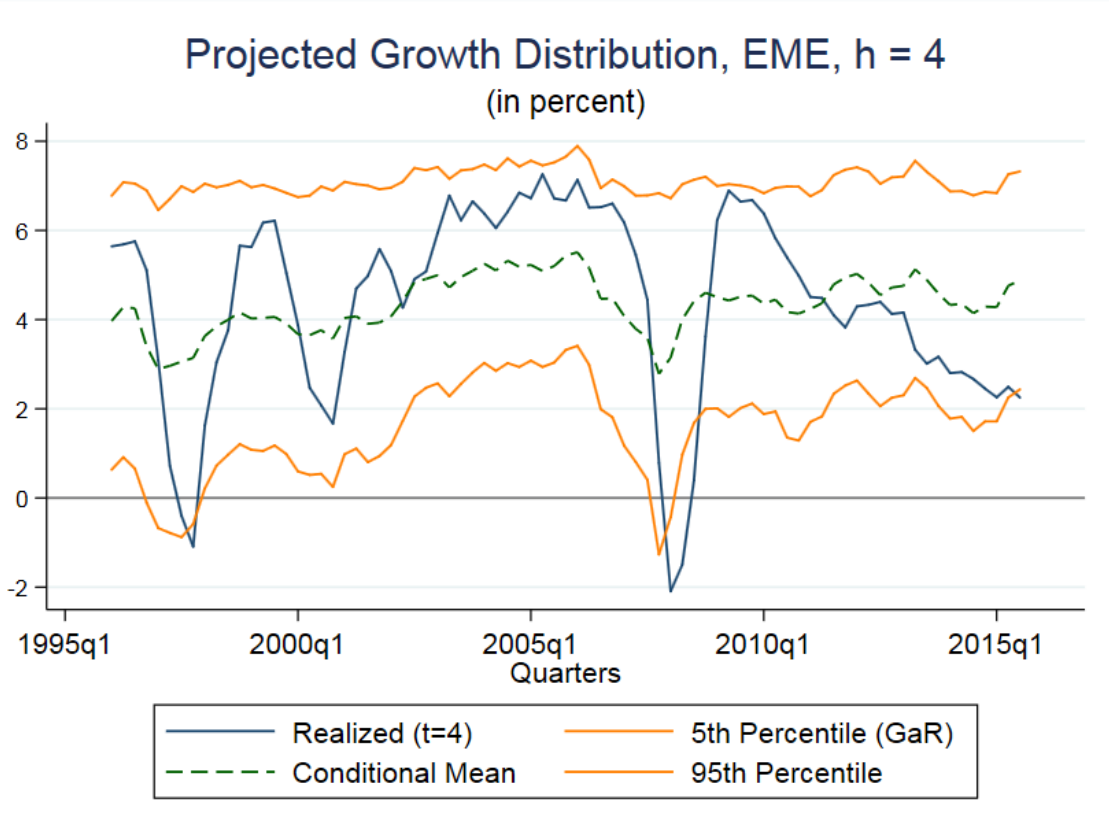
There is a 5 percent probability that growth would be equal to or less than GaR

To calculate:

$$GaR_{i,t+h}\left(\alpha\right) = E\left(\Delta y_{i,t+h} \mid \Omega_t\right) + N^{-1}\left(\alpha\right) Vol\left(\Delta y_{i,t+h} \mid \Omega_t\right) \qquad (5)$$

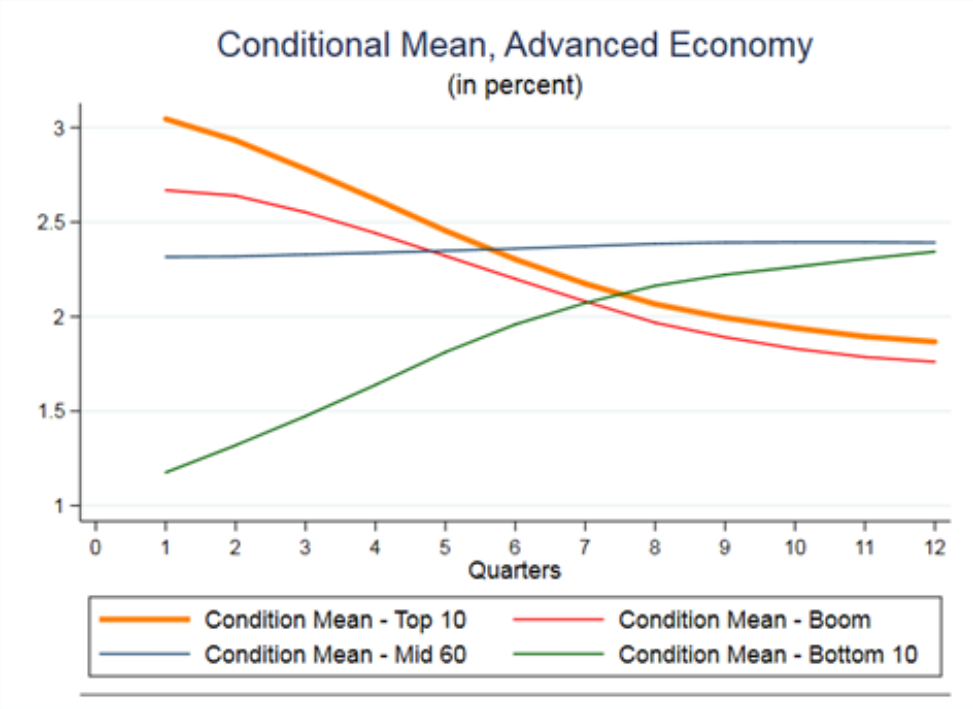
Average GaR for four-quarter horizon, AEs and EMEs

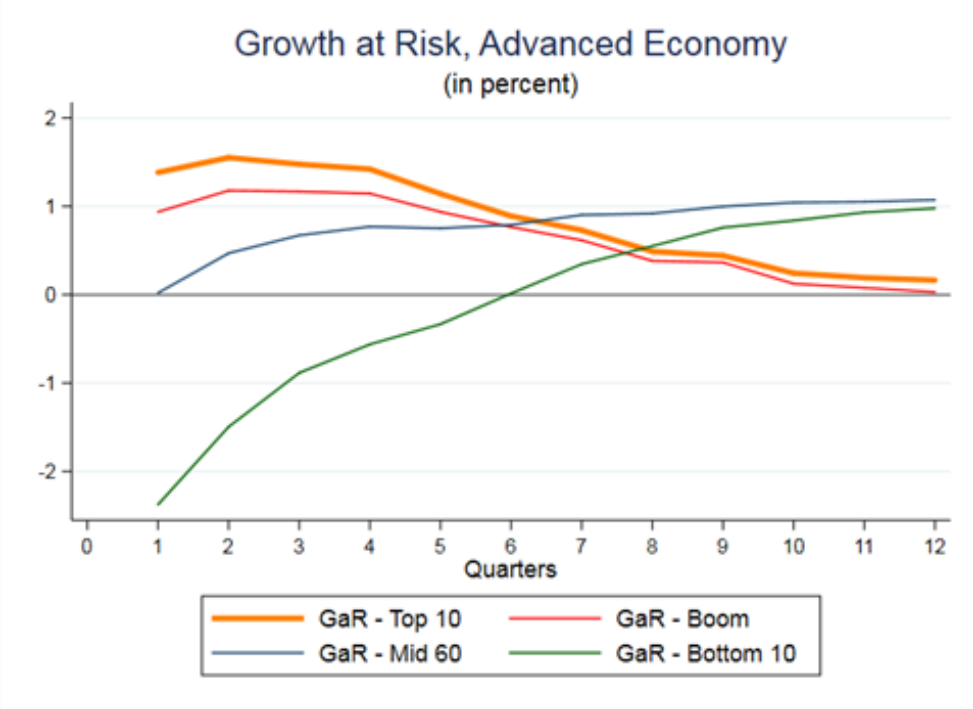




- Lower 5th percentile GaR is more volatile than the 95th percentile

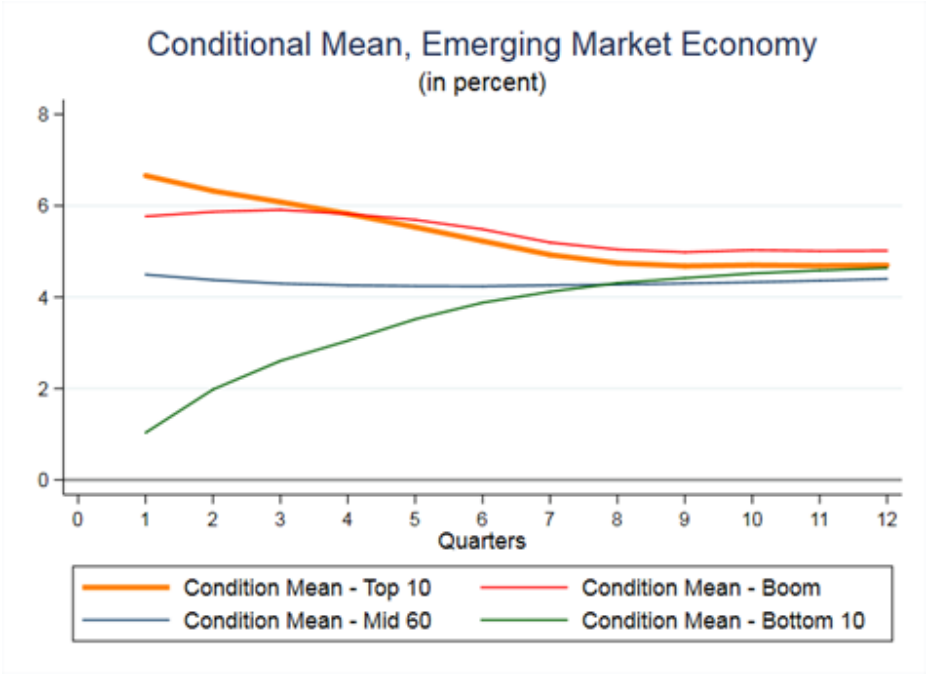
Looser FCI … higher GaR in the near term

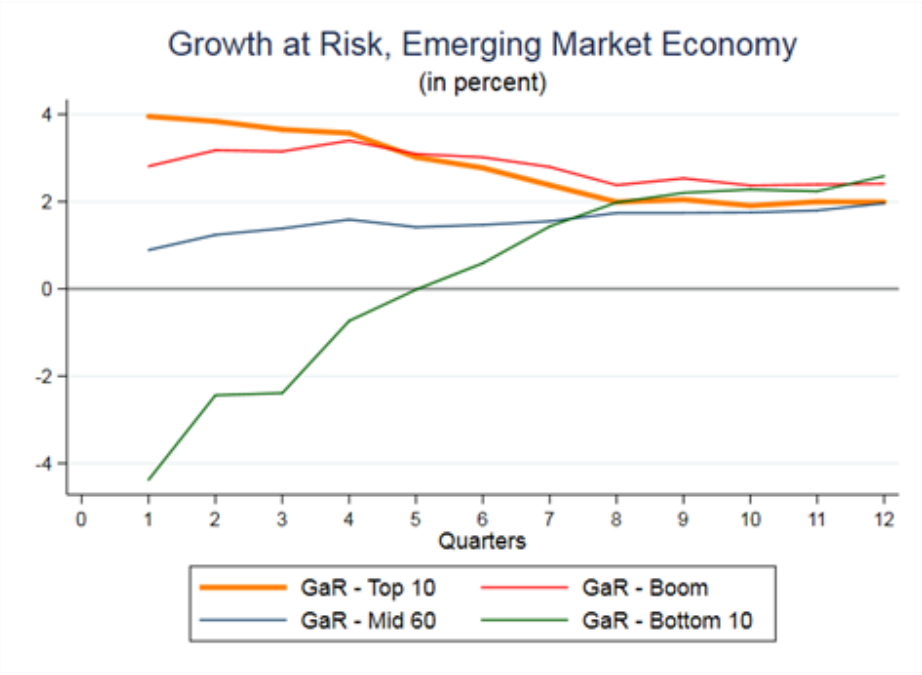




- But lower growth and GaR in the medium term
- Inter-temporal tradeoff is substantial
- Credit boom (relative to "typical") implies higher growth and GaR in the near term
  … but 5 percent probability of a recession at 12 quarters

Looser FCI also higher GaR in the near-term in EMEs





- Contour over the projection horizon is similar to the AEs
- But size of decline is less substantial
- Model does not fit EMEs as well – financial conditions less significant, …

Robustness and next steps

- Robustness
  - Credit growth four-year moving average, instead of credit gap
  - SUR
  - Alternative financial vulnerability measures
    - External debt-to-GDP for EMEs
    - Growth in bank assets-to-GDP
- Next steps
  - Test an alternative FCI
  - For EMEs, need to incorporate some additional variables, like commodity prices, that might not be captured well in FCIs
  - Additional analysis with quantile regressions

Summary and conclusions

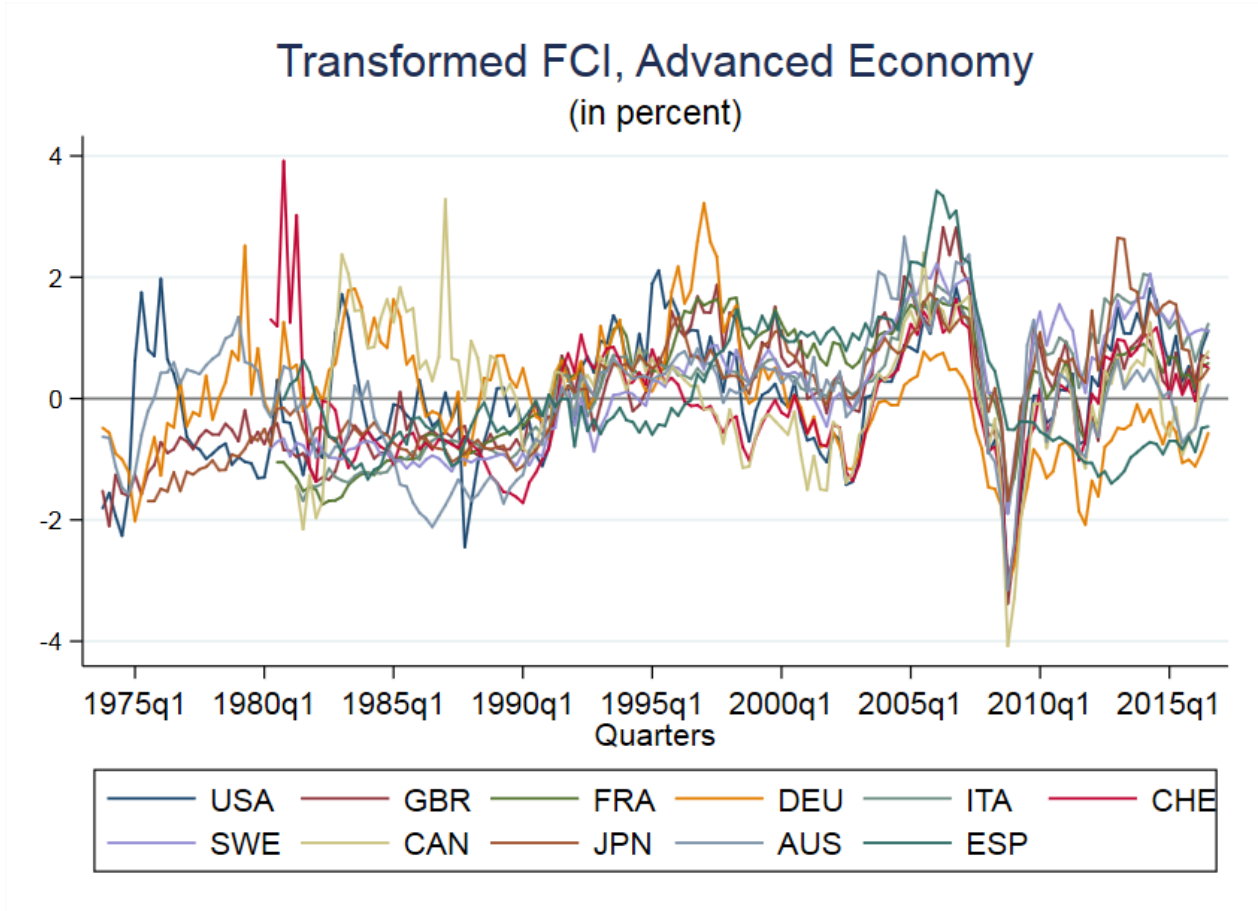
- Strong inverse correlation between mean and volatility
- GaR shows an intertemporal risk-return tradeoff
- Consistent with models of endogenous risk-taking
- Implications for macro models and policymaking

End

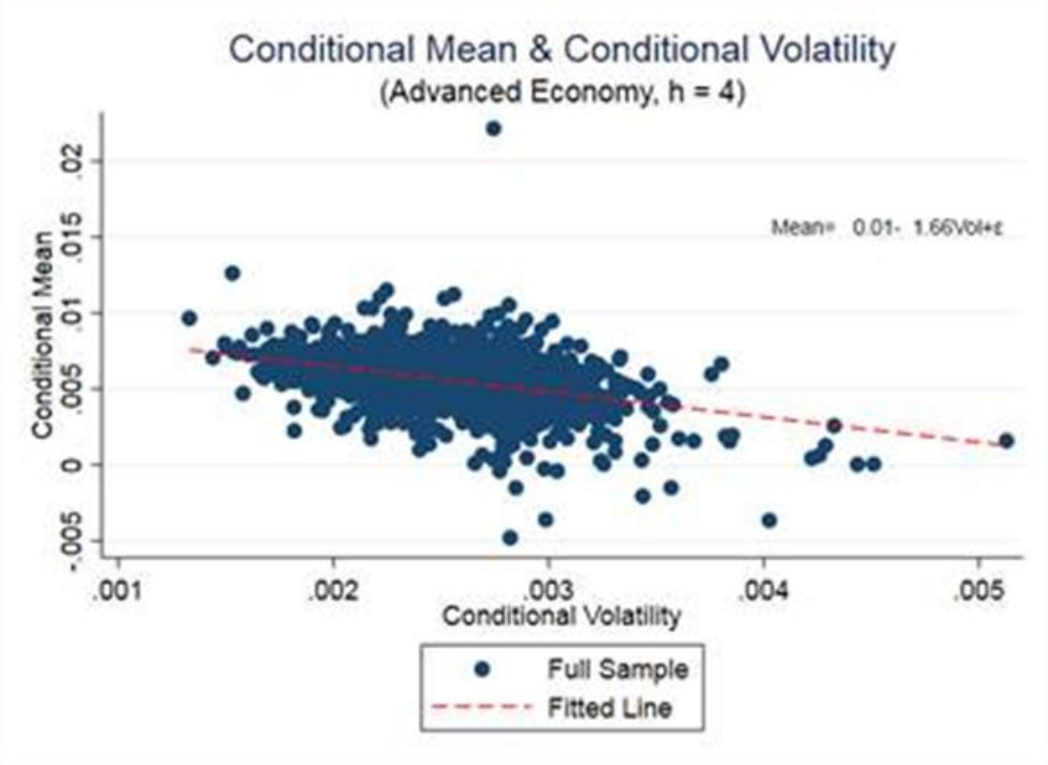
Sample statistics

AEs	Mean	Std dev	N
Growth rate (quarterly)	.0056	.0091	1718
Inflation rate	3.48	3.49	1718
FCI (transformed)	.069	.991	1718
Boom	.14	.35	1718
Credit-to-GDP gap	.014	.108	1718

EMEs	Mean	Std dev	N
Growth rate (quarterly)	.011	.015	741
Inflation rate	7.31	9.54	741
FCI (transformed)	.033	1.11	741
Boom	.143	.35	741
Credit-to-GDP gap	.015	.103	741


Transformed FCI, Advanced Economy
(in percent)
4
2
0
-2
-4
1975q1
1980q1
1985q1
1990q1
1995q1
2000q1
2005q1
2010q1
2015q1
Quarters
USA
GBR
FRA
DEU
ITA
CHE
SWE
CAN
JPN
AUS
ESP

Intra-temporal conditional mean and volatility are inversely correlated



Quantile regressions – preliminary results

- Estimation method has important advantages
- Gaussian distribution and two-step approach much easier to work with
- Can express concepts, which are essential for policymaking
- Want to test robustness to using quantile regressions (Adrian et al, 2016)
- Preliminary – no fixed effects, standard errors, no interaction

Figure 17. Term structures of median and GaR from quantile regressions, by initial FCI, AEs

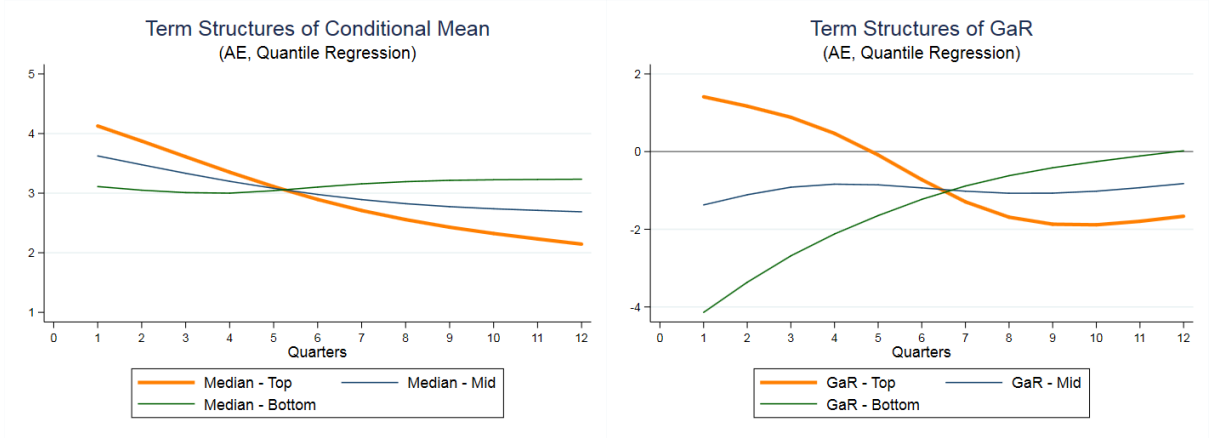


Figure 18. Term structures of median and GaR from quantile regressions, by initial FCI, EMEs