

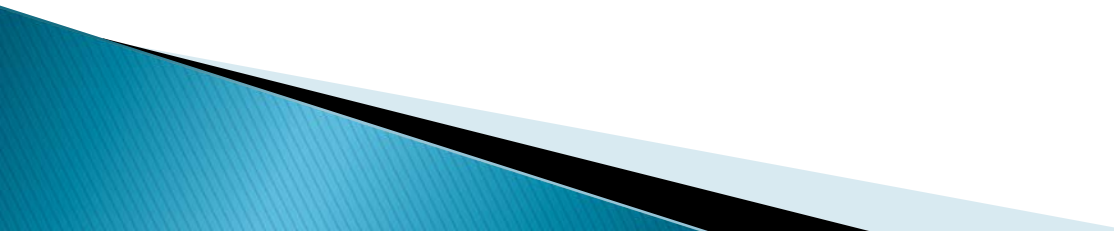
# Assessing the Linkages Between Financial Stress and Business Cycles

Adrian Pagan\* and Tim Robinson\*\*

UTS and QUT

\*\* RBA

# Paper is about

- ▶ What we didn't do.
  - ▶ What we did do.
  - ▶ What we had hoped to do.
  - ▶ What we think we learned
- 

GFC (NAC) led to interest in connections between financial stress and business cycle

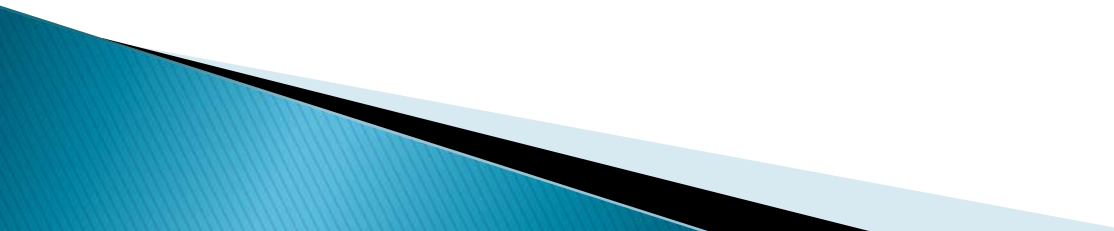
- What financial conditions contribute to the generation of a business cycle
- Can this information be used to predict recessions
- What type of features need to be accounted for in models of the cycle?

### *Design of Models*

General strategy has been to

- Select a base macro-economic model
- Augment it with some financial factors

# What Should Base Model Look Like?

- ▶ Some prefer augmenting a single equation for output etc with “credit conditions”
  - ▶ Base model is just a single equation or loosely specified set of equations
  - ▶ Muellbauer does this in various papers (summarized in BIS working paper)
  - ▶ Credit conditions are generally determined outside of model
- 

Do standard models of consumption allow a role for credit

$$c_t = \alpha E_t c_{t+1} + (1 - \alpha)c_{t-1} + \theta r_t$$

$r_t$  = real rate of interest

Can re-write as


$$\Delta c_t = \frac{\alpha}{1 - \alpha} E_t \Delta c_{t+1} + \frac{\theta}{1 - \alpha} r_t.$$

1.  $E_t \Delta c_{t+1}$  will depend on all variables in model so credit might affect it

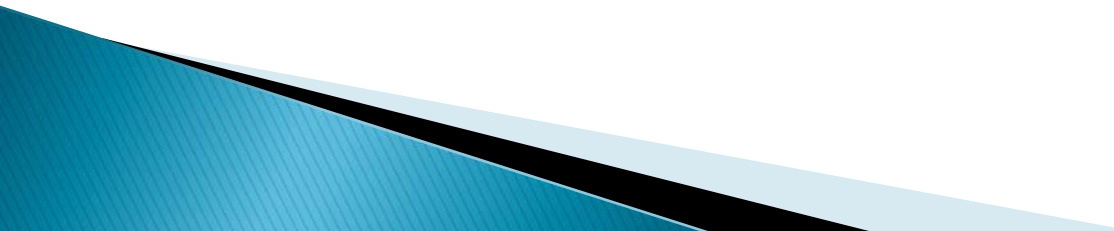
2. Might also be true of  $r_t$  - given determined by Taylor rule difficult

But central banks had trouble stabilizing S/R interest rate at target levels in GFC

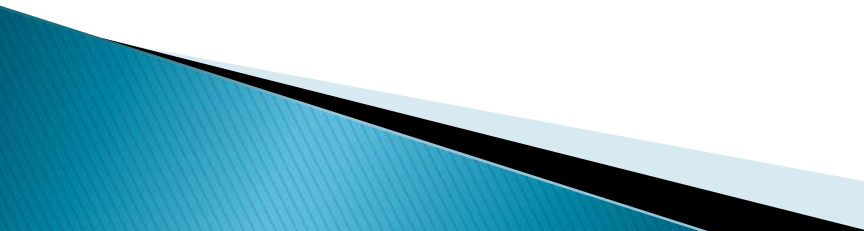
# What is Minimal Set of Variables of “Complete Model”?

- ▶ Investment, wages, prices, asset prices, consumption
  - ▶ Might also allow for residential investment, consumer durables and inventories as latter had issues in GFC
  - ▶ Some financial sector is always present. Often reduced to a single interest rate or two ( short plus long rate or overseas rate if open economy)
  - ▶ Recent work on expanding modelling of the financial sector to be added on
- 

# Financial Sector Generalizations

- ▶ Whether one makes behaviour of financial intermediaries (FI's) explicit
  - ▶ How one models the demand for credit
  - ▶ How one models the supply of credit
  - ▶ How one determines the degree of leverage
  - ▶ Role of Collateral in supply of credit
- 

# Credit and Collateral

- ▶ Collateral generally handled by introducing an asset used in production and also demanded for services
  - ▶ Price of asset then causes variations in available credit
  - ▶ Mostly the asset has been “houses and land” so residential investment affected
  - ▶ If houses introduced may need mortgage types, equity draw-downs etc
  - ▶ Could think that collateral makes credit cheaper
- 

Originally had hoped to integrate many of the themes into one model

One standard "complete" macro model is Smets and Wouters (2007)

We will use that

Goz added on a financial accelerator to capture effects on investment

We will follow that literature and ask how it does in terms of accounting for recessions

## *Credit and Fixed Investment*

Generally handled via financial accelerator.

- Lenders and borrowers distinguished by different degrees of patience
- External finance premium replaces explicit modelling of FI

Essentially governs credit availability

- Ext finance premium depends on leverage
- Often shock added to be supply of credit

## *Evidence Used*

Empirical relations between cycles and credit

Source is International Monetary Fund (2009).

1. First 2 years of expansion credit growth is weak  $<$  output growth.
2. Restricted credit weakens recovery in output.
3. Recessions with a financial crisis are of longer duration.
4. Annual output growth predicted by measure of financial stress. Real investment growth even better
5. Probability of recession increases markedly once ext finance premium  $>$  "crisis level"

Need to locate turning points in activity

Use BBQ program (Matlab version)

Available at <http://www.ncer.edu.au/data/>

Methods are methodological. Used for  
any model

# The GOZ Model

Smets-Wouters (SW) plus

$$E_t r_{t+1}^K = \frac{1 - \delta}{\bar{R}_K + (1 - \delta)} E_t q_{t+1} + \frac{\bar{R}_K}{\bar{R}_K + (1 - \delta)} E_t mpk$$

$$s_t = E_t r_{t+1}^K - (r_t - E_t \pi_{t+1})$$

$$s_t = \chi(q_t + k_t - n_t) + \varepsilon_t^{fd}$$

$$n_t = \frac{\bar{K}}{\bar{N}} (r_t^K - E_{t-1} r_t^K) + E_{t-1} r_t^K + \theta n_{t-1} + \varepsilon_t^{NW}$$

$r_t^K$  = rate of return to capital,  $q_t$  = Tobin's  $Q$ ,  $mpk_t$  = marginal product of capital

$s_t$  = external finance premium,  $K_t$  = capital stock,  $N_t$  = entrepreneurs' net worth

$\theta$  = survival rate of entrepreneurs

External finance premium varies with the degree of leverage.

Quarterly per capita U.S. GDP data over the period 1973:1-2009:4

Table 1: Cycle Characteristics: Data and SW M

		Data		SW
Expan Dur		13.6		15.4
Contract Dur		4.8		4.5
Expan Amp		9.2		9.5
Contract Amp		-2.8		-1.7
Expan Cum Amp		132.4		125.5
Contact Cum Amp		-8.1		-5.98

Quite a good match to the business cycle characteristics

Although expansions are longer and recessions less severe

Effects of credit upon the average cycle is relatively small

Note: cycle is for per capita GDP

Cycle much longer if not per capita



Table 2: Cycle Characteristics: GOZ and SW M

		GOZ		SW
Expan Dur		14.2		15.4
Contract Dur		4.3		4.5
Expan Amp		8.9		9.5
Contract Amp		-1.6		-1.7
Expan Cum Amp		107.9		125.5
Contact Cum Amp		-5.6		-5.9

## *Some experiments*

1. Double standard deviation of credit supply shocks

- Has very small effect upon the cycle.

2. Quadruple - expansion length to 12.8 quarters, amplitude of recessions to -1.9%.

But produces premia  $> 1000$  basis points.

Never observed?

Probability of a recession = .72

Is this too small for such an extreme case?

3. Double  $\chi$  (elasticity of premium to leverage)

- relatively small effects, but durations and amplitudes closer to data.

Back out credit growth rates

$$\Delta \ln D_t^* = \Delta q_t^* + \Delta k_t^* + \gamma_t^* + 100 \Delta \ln(1 - r_t^{-1})$$

$$r_t = \exp((q_t^* + k^* - n^* / 100) + \ln(1.3634))$$

\* indicates measured in percentage terms

How does the model do?

1. Credit growth over 1st 8 quarters of expansion =  $-2.6 < 4.8$  in output

But hides enormous variation.

Many simulations in which opposite

Growth rates in credit extremely volatile

Standard deviation = 5.86 versus only .69 for output.

In data also seems very volatile

Comes from  $100\Delta \ln(1 - r_t^{-1})$  term

2. Recession indicator:  $R_t = 1$  if economy is in recession,  $=0$  otherwise

Compute  $\Pr(R_t|s_t)$ .

Fit probit model  $\Pr(R_t|s_t) = \Phi(s_t)$ ,  $\Phi(\cdot) =$  cumulative standard normal distribution function.

Also do to data with  $s_t = Baa$  spread  
unconditional probability of a recession over 1953:2-2009:3 was .12

Regression  $R_t$  on 1 and  $x_t$ , where  $R_t$  =recession indicator.

Linear probability model

$$R_t - \bar{R} = (x_t - \bar{x})\beta$$

$$\hat{\beta} = \frac{\bar{R}(\bar{x}_R - \bar{x})}{\text{var}(x_t)}$$

$\bar{x}_R$  = mean  $x_t$  in recessions

Hence the prediction of  $R_t, \hat{R}_{tg}$

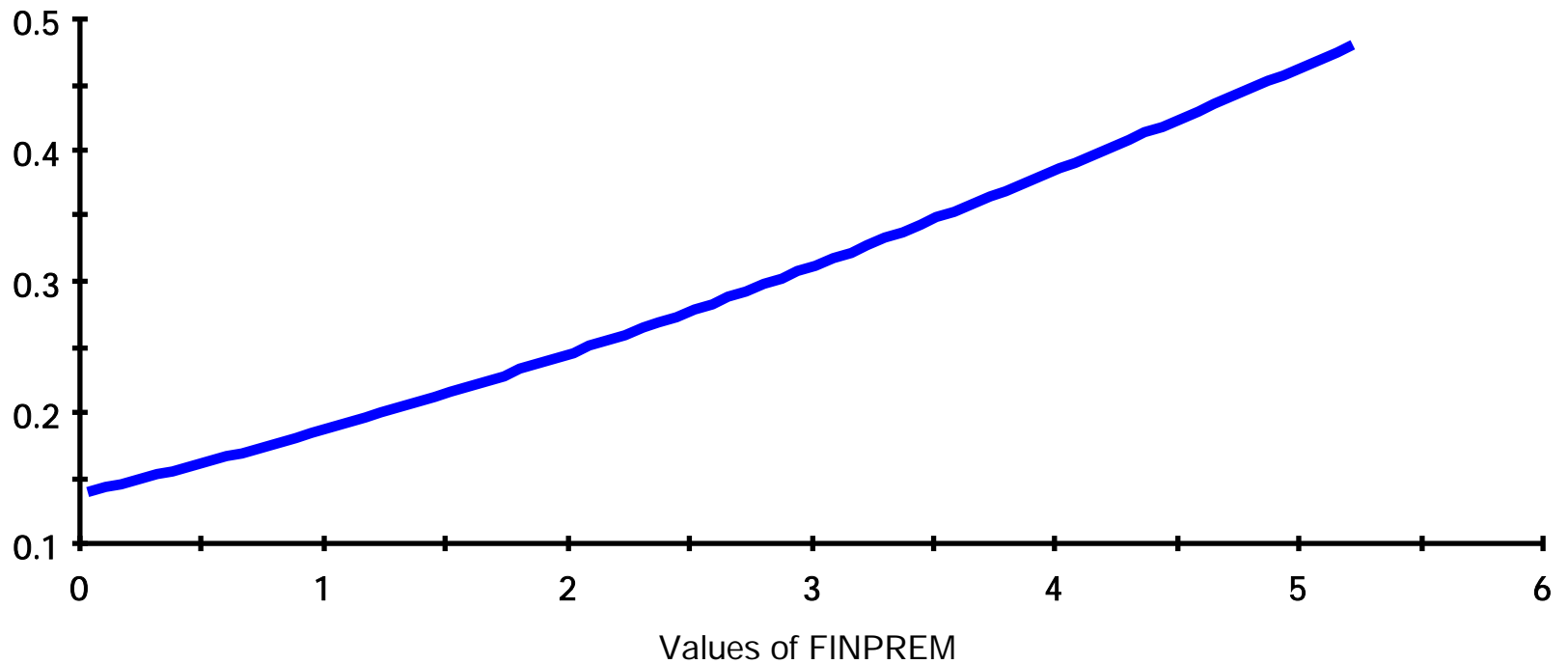
$$= \bar{R} \left( 1 + (x_t - \bar{x}) \frac{(\bar{x}_R - \bar{x})}{\text{var}(x_t)} \right)$$

Cond Prob multiple uncond prob

Multiple depends on

- Extent to which  $x_t$  is below its sample mean and  $\bar{x}_R < \bar{x}$
- Magnitude of t test  $t_{\bar{x}} = \frac{(\bar{x}_R - \bar{x})}{sd(x_t)}$
- $sd(x_t)$  – variability in  $x_t$

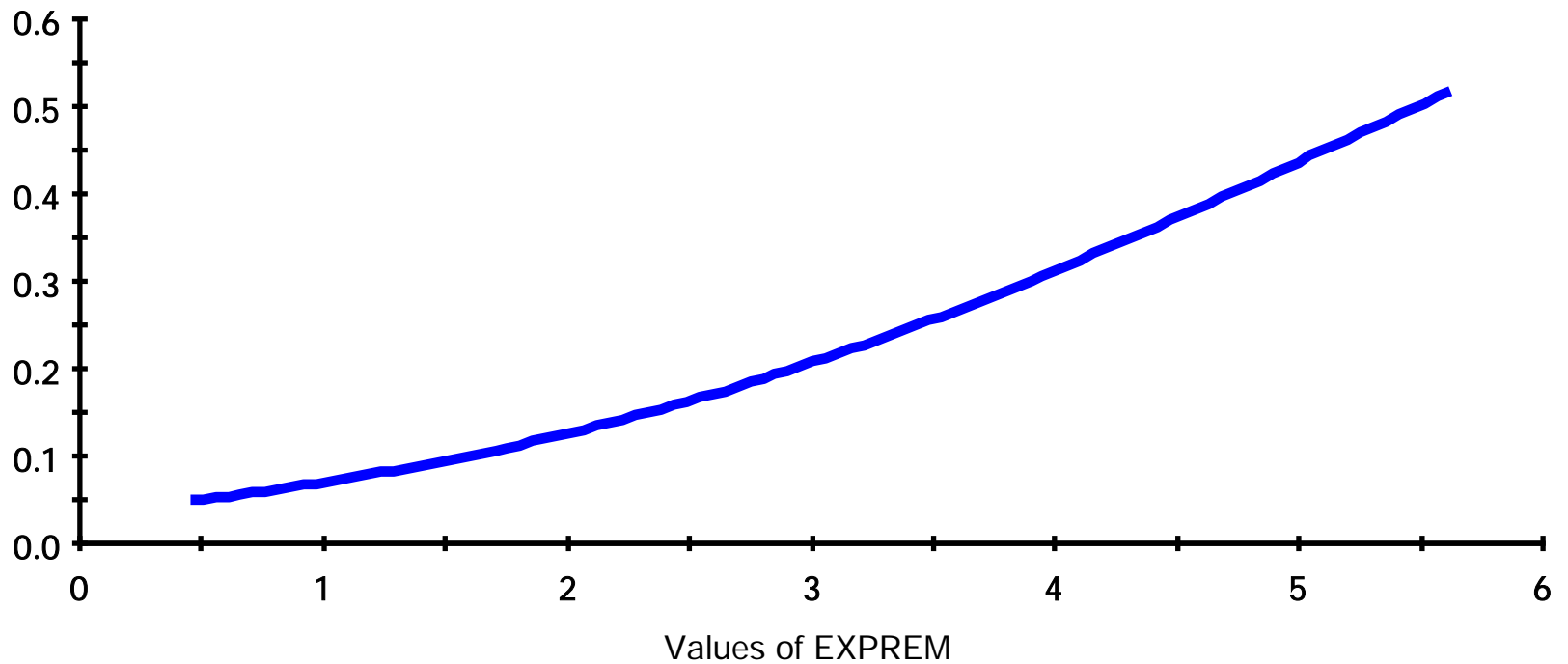
Fig 1 : Prob of Recession as Function of External Finance Premium



PROBR

Sample from 27 to 100

Fig 2 Probability of Recession Given External Premium in Data



PROBR

Sample from 1 to 100

*... pointed to the spread between AAA corporates and BAA corporates. "It is a good leading indicator.... The spread was about 100 bp's before the credit drama started and now it is actually smaller... (I)t is a fifteen-month low in the spread."  
(Laksman )*

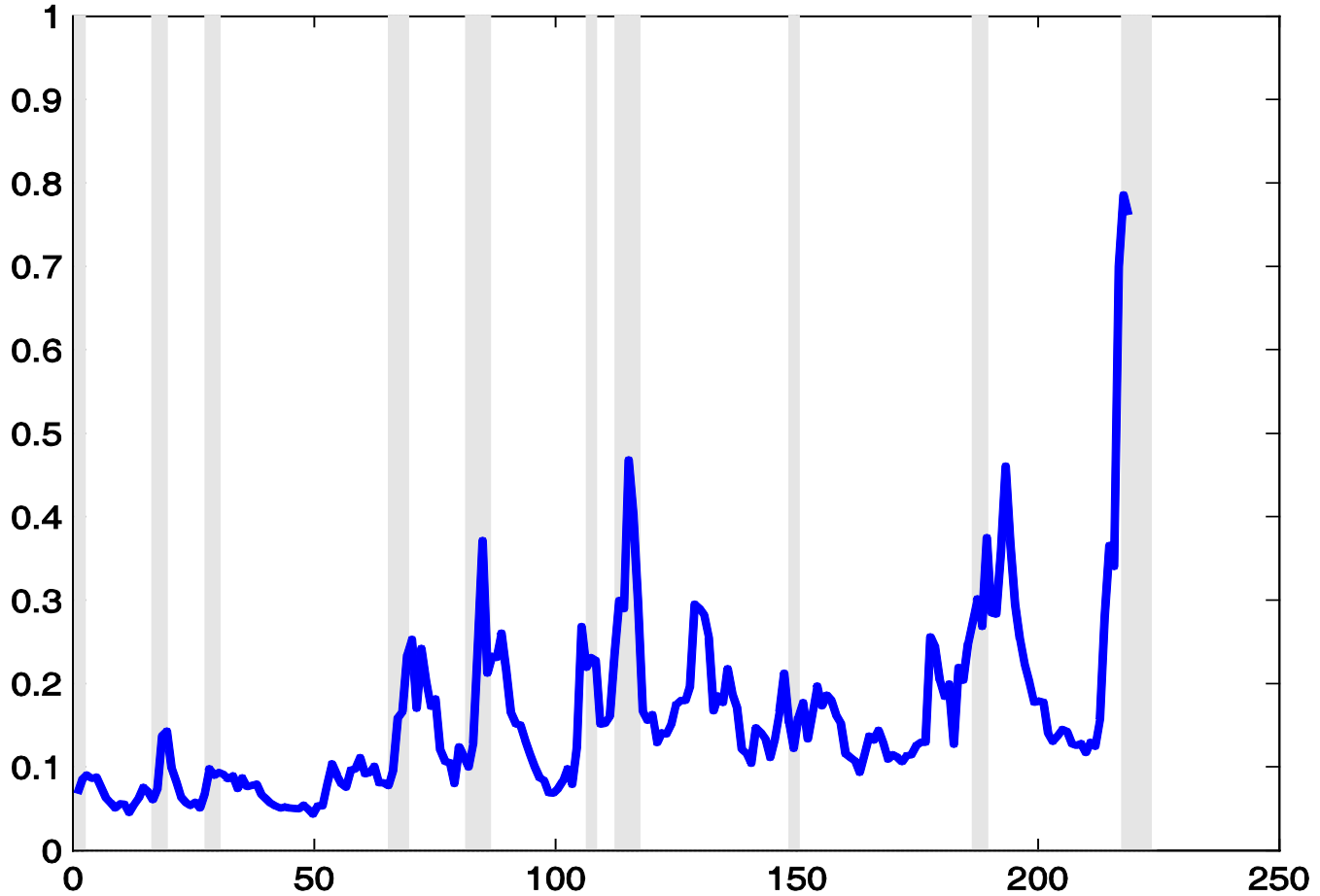
Baa spread highly significant in a Probit model ( t ratio of 4),

Adds little to the predictive power.

In 2008:1 prob = .27 (uncond = .12)

Adds to list of things that don't work

Fig 3 Prob GDP Recession and Recession Periods for US



3. Given recession does duration depend upon magnitude of the external finance premium?

Compute  $\Pr(R_{t+m} = 1 | R_t = 1, s_t)$

Table 3 Prob of Recess for  $m$  Periods as Ext Pr

Ext prem(basis points)		$m = 1$	$m = 2$	$m =$
25		.70	.38	.16
300		.72	.42	.20
485		.74	.46	.23

Duration of recession varies with external finance premium

But rise is small

May be some issues about credit growth

Persistence in

$\{\ln(1 - (1/r_t)) - \ln(1 - (1/r_{t-1}))\}$  quite different in data than model

*Investment:*

expansions 12 quarters long, recessions  
= 6.5.

Close to GDP in total cycle length

Prob investment recession

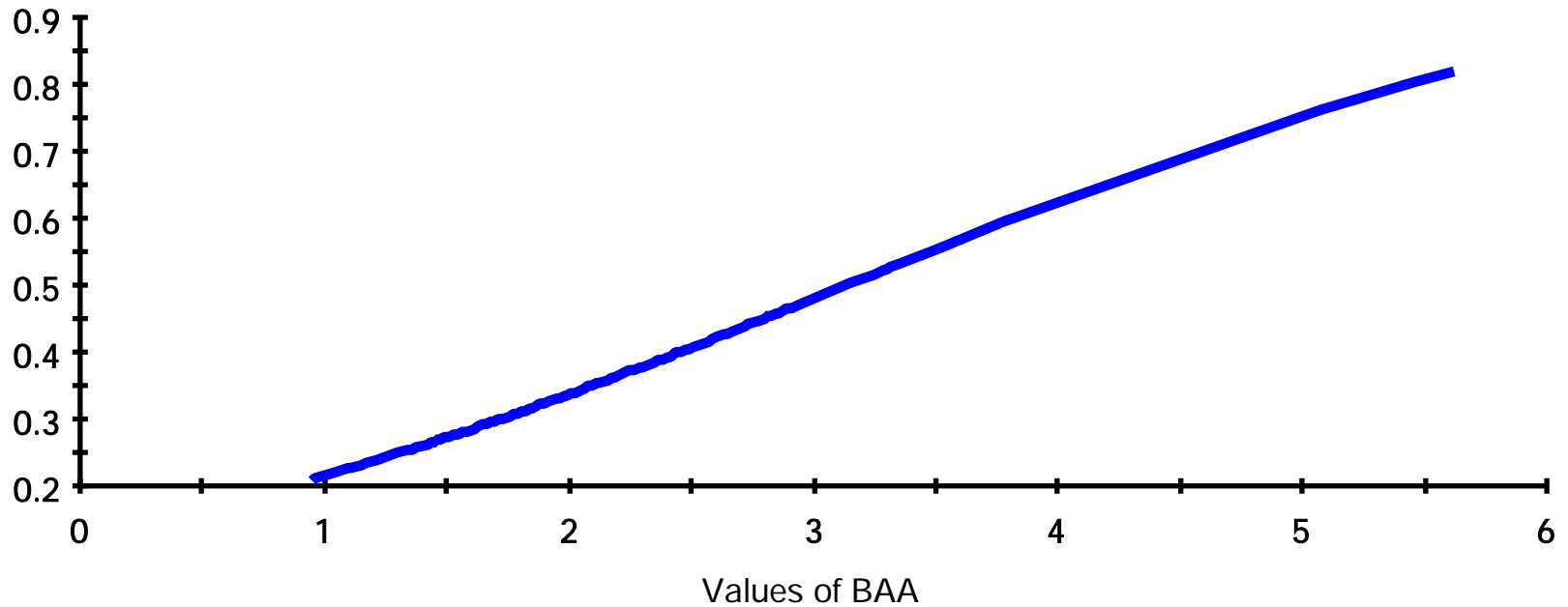
= .45 when spread = 200 basis points

= .58 when spread is 300 points

= .83 when 520 basis points.

Even stronger than data ( not GOZ  
spread)

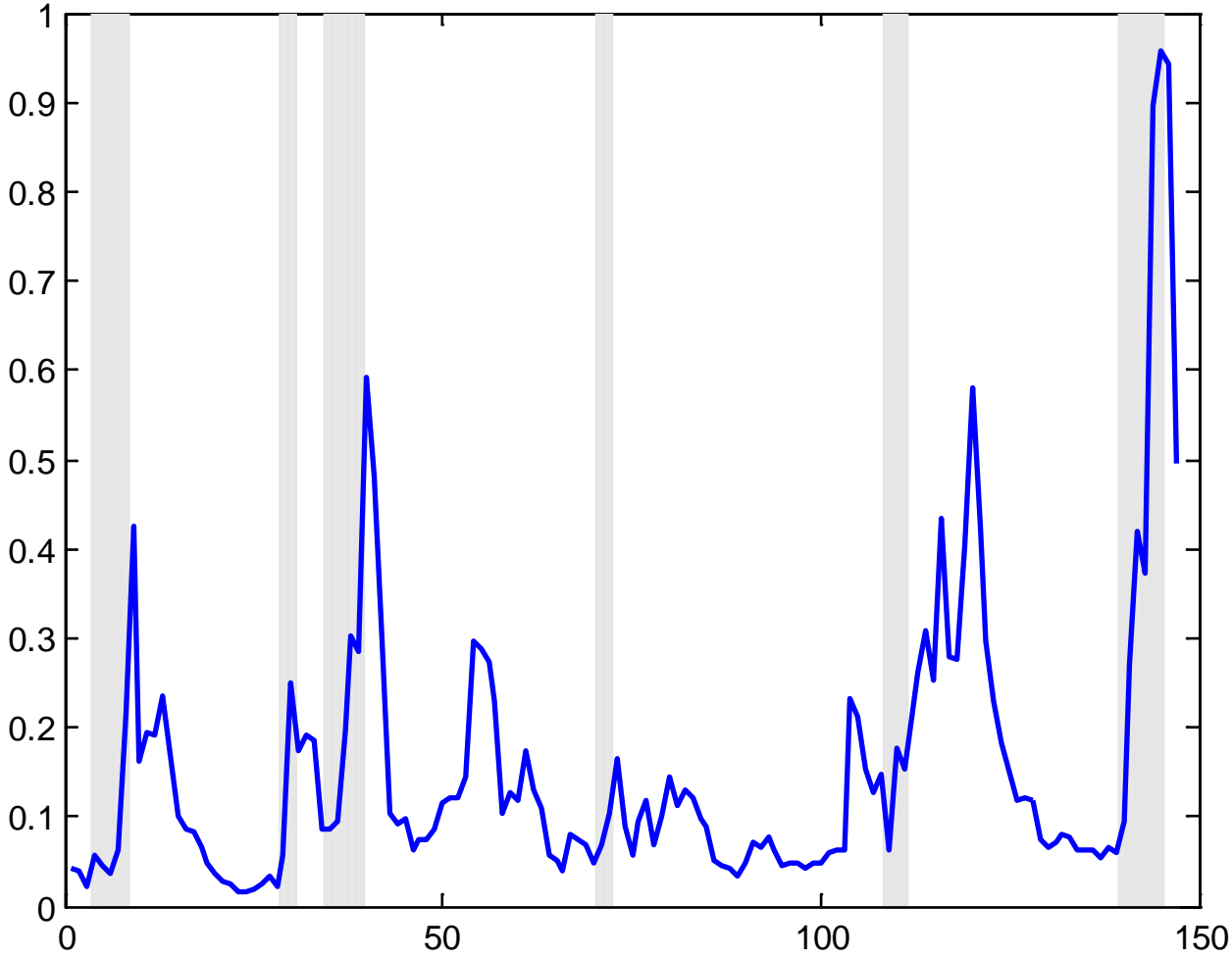
Fig 5 Probability of an Investment Recession as a Function of Baa Spread - Data



PROBRINV

Sample from 1973Q1 to 2009Q4

Prob Invest Recession and Recession Periods for US ( grey shadir



Why is prob output recession <<  
investment?

Fixed Investment is only 10% of GDP

Needs large neg invest growth rate in  
investment to cause neg growth in  
output.

So probably really need to add in  
residential I, consumer durables etc

# Other Issues

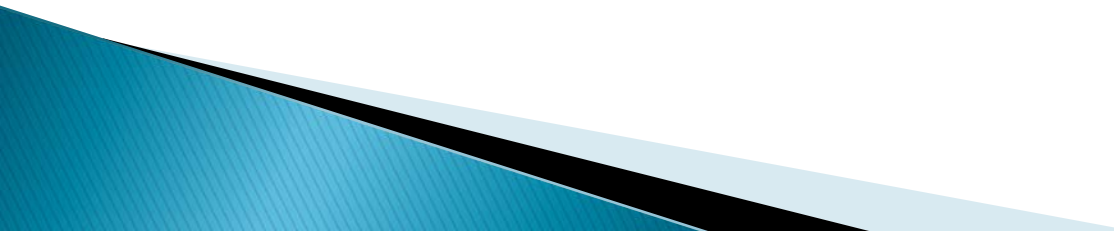
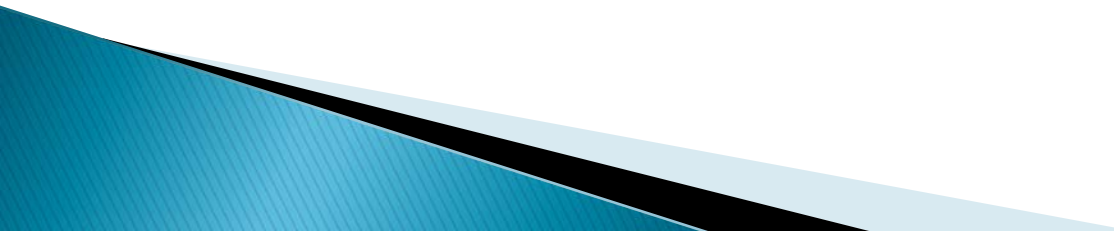
- ▶ Future shocks key to business cycle outcomes
  - ▶ Investigate by setting contemporaneous shocks to zero
  - ▶ Effect of this is very large
  - ▶ Still get recession but shows past is of minor importance. Hence problem for models.
  - ▶ Also look at whether (i) Model produces double dip recession (ii) Are they after credit crunch?
- 

Table 2: Cycle Characteristics: GOZ and SW M

		GOZ	GOZ <sup>-</sup>	SW
Expan Dur		14.2	30.8	15.4
Contract Dur		4.3	3.7	4.5
Expan Amp		8.9	14.6	9.5
Contract Amp		-1.6	-.74	-1.7
Expan Cum Amp		107.9	506	125.5
Contact Cum Amp		-5.6	-2.1	-5.9

# Double Dips

- ▶ Of 103 cycles in the GOZ simulations 5 produce “double dips”, where a double dip means a short expansion ( $\leq 6$  quarters)
  - ▶ In fact the shortest expansion was 6 quarters
  - ▶ There were 5 double dips, so rare
  - ▶ Of the 5, 4 were associated with a high external finance premia ( $> 600$  basis points) initiating first recession
- 

*Financial Linkages in Model with  
Stochastic Permanent Components*

AR(1) technology in GOZ model close to unity.

So impose it.

Want to do this to compare to existing models with unit roots - Liu et al (2009).

Some issues about how to do this.

Table 4: Cycle Characteristics: Unit Root GOZ

		GOZ	Data	SW
Expan Dur		14.2	13.6	14.5
Contract Dur		4.6	4.8	4.3
Expan Amp		9.4	9.2	8.8
Contract Amp		-2.0	-2.8	-1.4
Expan Cum Amp		105	132	101
Contact Cum Amp		-7.0	-8.1	-3.3

## *The VECM Representation of a DSGE Model*

What type of VECM would we get from the models above?

Liu et al (2009) present an estimated VECM and try to determine facts from it

Difficult to use VECM.

Theirs is problematic

3 permanent components in their model.

- Unit root in general technology
- Unit root in preferences
- Unit root in investment specific technology leading to permanent component in relative prices.

Understand problems by looking at simple RBC model with habit persistence

In GOZ et al model single  $I(1)$  factor responsible for permanent components

Thus permanent comp of consumption, investment .. = perm component of technology ( $A_t^P$ ).

$y_{t-1} = \ln Y_{t-1} - \ln A_{t-1}^P$  will be error correction terms

Use this to convert GOZ models to VECM

Equations are in Christensen, Hurn, Pagan (2010)

Example: RBC model in which there is habit persistence and preference shocks.

No serial correlation in growth in technology

$c_t, k_t, y_t$  will be the ECM terms in system composed of  $l_t, \ln C_t, \ln K_t, \ln y_t$  and  $r_t$ .

VECM solution

$$\Delta \ln Y_t = -y_{t-1} - .04k_{t-1} - 1.26c_{t-1} + e_{1t}$$

$$l_t = -.48k_{t-1} - 1.8c_{t-1} + e_{2t}$$

$$\Delta \ln K_t = -.07k_{t-1} - .19c_{t-1} + e_{3t}$$

$$\Delta \ln C_t = .44k_{t-1} - .46c_{t-1} + e_{4t}$$

$$r_t = -.4k_{t-1} - .04c_{t-1}$$

ECM terms  $c_{t-1}, k_{t-1}, y_{t-1}$  are latent, since  $\alpha_{t-1}^p$  is not known.

Assume  $\ln Y_t, \ln C_t$  and  $\ln K_t$  are observable

$$\begin{aligned}k_{t-1} &= \ln K_{t-1} - \alpha_{t-1}^p \\ &= \ln K_{t-1} - \ln Y_{t-1} + \ln Y_{t-1} - \alpha_{t-1}^p \\ &= \ln K_{t-1} - \ln Y_{t-1} + y_{t-1},\end{aligned}$$

$$\Rightarrow \Delta \ln C_t = .44(\ln K_{t-1} - \ln Y_{t-1}) - .46(\ln C_{t-1} - Y_t) - .02y_{t-1} + e_{4t}.$$

$y_t = \ln Y_t - a_{t-1}^p = \ln Y_t - \ln Y_t^p$  is transitory component of output.

Use only  $\ln Y_t, \ln K_t, \ln C_t + 2$  ECM terms  
( $\ln K_{t-1} - \ln Y_{t-1}$ ), ( $\ln C_{t-1} - Y_{t-1}$ )

Specification error as transitory output  
omitted

Important: maybe not in  $\Delta \ln C_t$  equation  
as coeff on  $y_{t-1}$  is small

Turns out true

But not for  $\Delta \ln Y_t$  equation

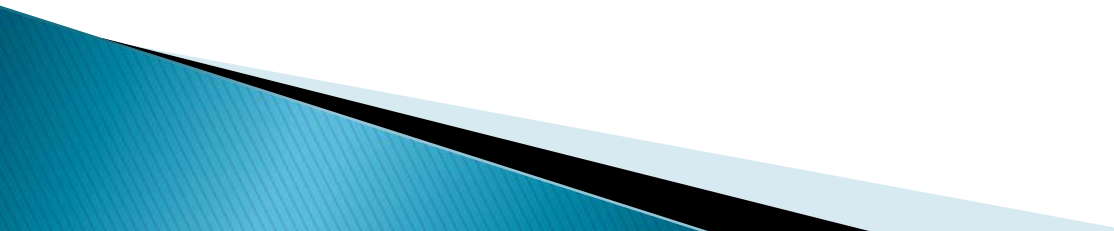
If  $\ln K_t$  omitted from the VECM system

Then  $\Delta \ln Y_t, \Delta \ln C_t + 1$  ECM term

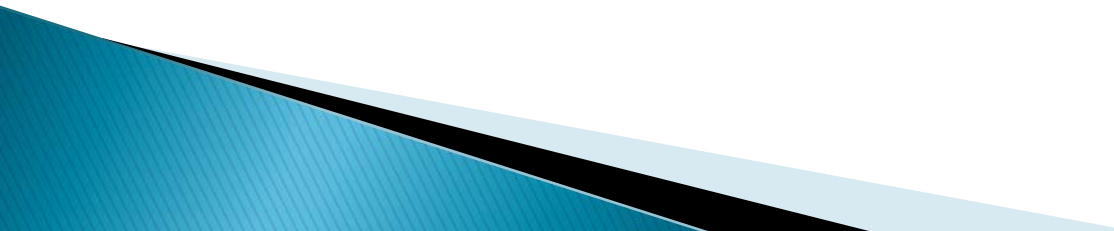
$\ln C_t - \ln Y_t$

Transitory capital missing.

# Conclusions

- ▶ External Finance premium works the right way
  - ▶ Fixed Investment is certainly affected in models
  - ▶ Problem is that too small a percentage of GDP to be only impact
  - ▶ Need to expand to consumer durables, residential investment
  - ▶ But then need collateral etc in models
- 

# Conclusions

- ▶ Well established literature on impact of credit upon expenditures
  - ▶ Question is whether we need to expand financial sector to produce inter-bank market, leveraging by financial institutions
  - ▶ May depend on the country as not everyone experienced the GFC in the same way ( why it is NAC)
- 

CODE NAME: "IT."



IT'S REVOLUTIONARY.



MANY SAID IT WAS  
JUST SCIENCE FICTION.



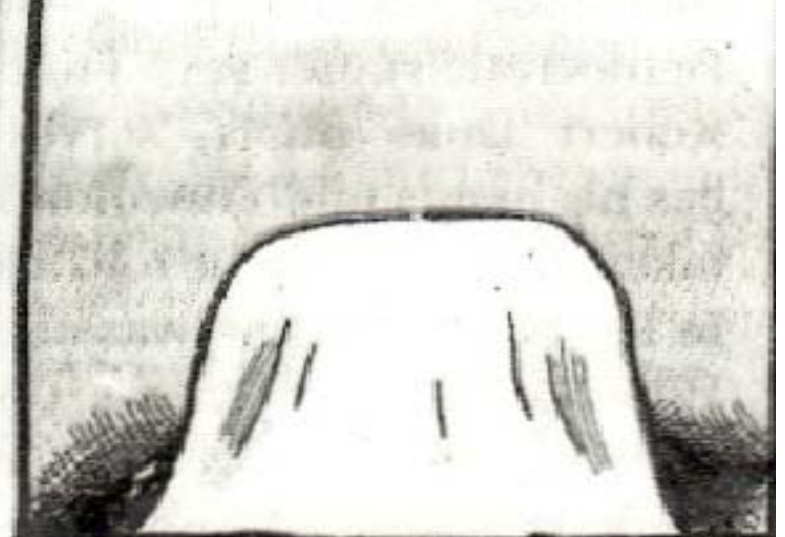
IT DEFIED ALL  
CONVENTIONAL WISDOM.



TALES

©2001 THE NEW REPUBLIC

NO ONE ALIVE COULD  
ENVISION SUCH A THING.



BUT IT'S BACK

THE  
BUSINESS CYCLE



YOU SHOULD PUT  
WARNING BELL ON THAT

12/3  
LTD