UNIVERSITY OF EDINBURGH
Business School

Explaining Aggregate Consumer Delinquency Behaviour Over Time

Jonathan Crook John Banasik
Credit Research Centre University of Edinburgh

UNIVERSITY OF EDINBURGH
Business School

The Literature

- Ability to pay hypothesis (Gross and Souleles 2002)
- Strategic default hypothesis (for secured debt) Kau et al (1995, 1994), Lambrecht et al (1997)

Increasing default rates for credit cards in the US explained by (Gross and Souleles 2002):

- Increase in % of borrowers that are high risk
- Increased willingness to default

Evidence

Cross-Section (duration models)

Credit Card holders

Gross & Souleles (2002)

Not related to delinquency: Unemployment rate in area of residence, per capita income, house prices in region

Marginally related: borrower's predicted risk

Residual variance ascribed to reduces stigma of defaulting

Agarwal (2003)

Was related to delinquency: borrower's predicted risk, unemployment rate in area of residence 6 months earlier, account balance 3 months earlier.

UNIVERSITY OF EDINBURGH
Business School

Cross Sectional (duration models) contd.

Mortgages

Lambrecht (1997)
Evidence more in favour of ability to pay than strategic default hypothesis.

Deng (1993)
Evidence in favour of both hypotheses

Teo (2004)
Characteristics of mortgage and of state of macroeconomy effected hazard rate, but neither characteristics of property bought nor of borrowers did- support for both hypotheses.

Time Series Evidence

Bank Instalment debt delinquency

Sullivan (1987) Data for 1975-86

Explained by debt burden (ability to pay) , growth rate of debt, share of consumer debt issued by banks (willingness to lend).

Bank Cards and Auto Loans delinquency

Sullivan (1987) Data for 1975-86
Explained by debt burden (willingness to pay), growth rate, unemployment rate.

But – no interest rates, misspecification

Grieb et al (2001) Data for 1981-1999
Explained by debt:income ratio (capacity to pay). No effect detected for job market conditions.

Consumers default on credit card debt before other debt.

Time Series Evidence (contd.)

Mortgages delinquency (UK)

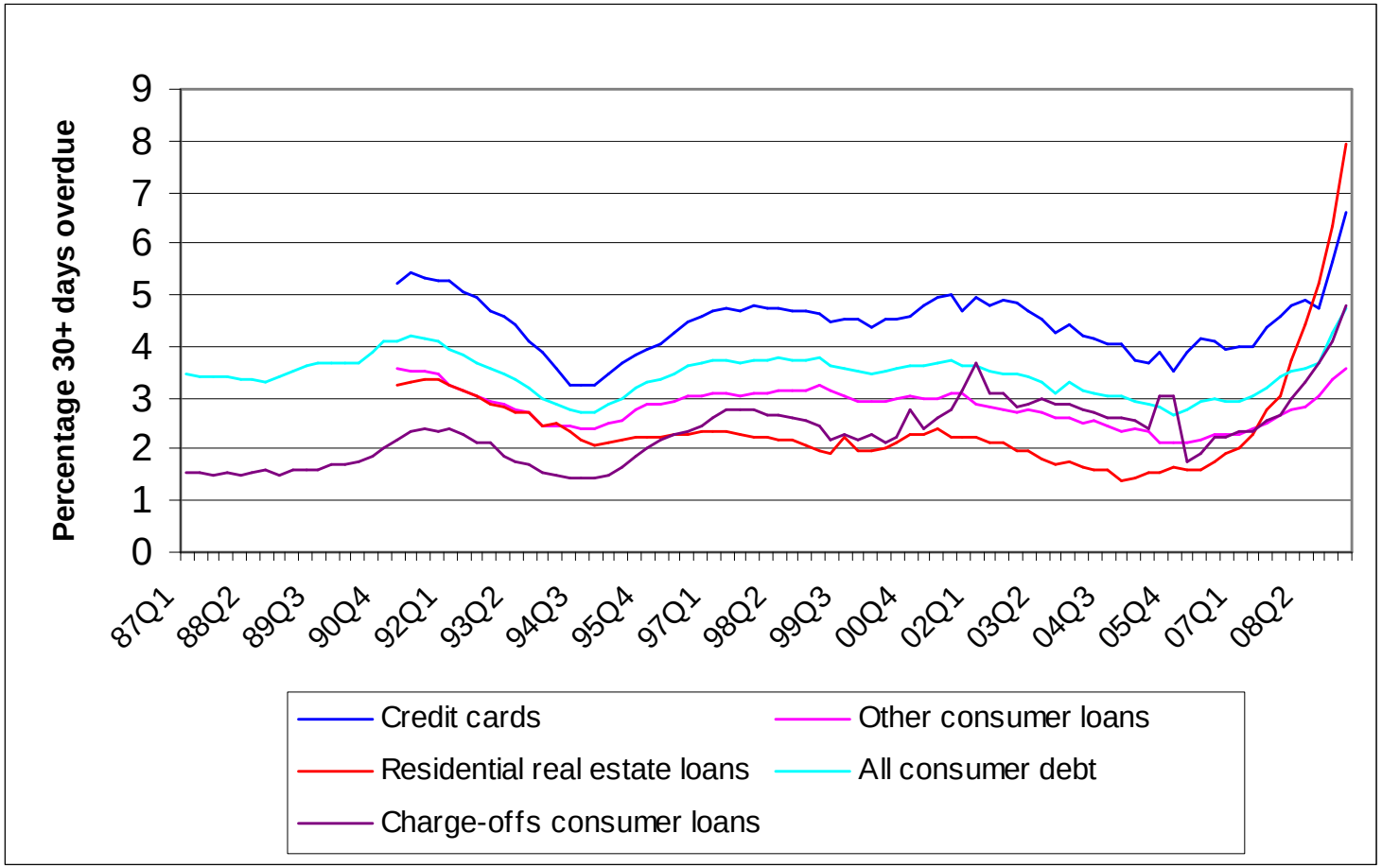
Whitley et al (2004)

Explained by mortgage income gearing, unemployment, loan to value ratio for first time buyers. But data issues, no diagnostics, lack of rationale for structure.

Figueira et al (2005) Data for 1993-2001

Long run relationship with unemployment rate, loan to income ratio for first time buyers, unwithdrawn equity, debt: service ratio. But short period; does not cover recent crisis, no tests of predictive performance

US Delinquency and Charge-Off Rates



UNIVERSITY OF EDINBURGH
Business School

Table 1 Repayments Transition Matrix

		1	2	3	4
No credit	1	v_{11}	v_{12}	v_{13}	v_{14}
Up to date	2	v_{21}	v_{22}	v_{23}	v_{24}
30+ overdue	3	v_{31}	v_{32}	v_{33}	v_{34}
Charged off	4	v_{41}	v_{42}	v_{43}	v_{44}

V_{im} = volume of credit that moves from state i at end of period t to state m end of period t+1

Change in stock of 30+ overdue debt = $v_{23} - (v_{31} + v_{32}) - v_{34}$

Let $d_t = v_{23}$, = volume that becomes overdue
$p_t = (v_{31} + v_{32})$ = volume that is no longer overdue because is on track
$c_t = v_{34}$ = volume that is no longer overdue because is charged off

Change in stock of 30+ overdue debt = $S_t - S_{t-1} = (d_t - p_t) - c_t$

UNIVERSITY OF EDINBURGH
Business School

Long Run Equilibrium Model

Assume volume of 30+ overdue is explained in equilibrium by

*	Nominal interest rates	ability to repay
*	Personal disposable income	ability to repay
*	Volume of debt outstanding	
*	Expectations about future income	desire for future debt
*	Real house prices	strategic default

Assume linear long run relationship

$$S_t = \delta + \delta' \mathbf{x_t} + \varepsilon_t$$

Estimation

- Regressing S_t on x_t may be a spurious regression. So we look to see if there is a cointegrating relationship.

- A series is integrated order d if: after differencing it d times it has a stationary invertible non- deterministic ARMA representation.

- Variables in vector x are cointegrated of order d,b, CI(d,b), if all of the variables are I(d) and there exists a linear combination of them, $y_t=\delta' x_t$, which is I(d-b). δ' is the cointegrating vector.

- If d=b=1 and y and x are cointegrated, then there exists a long run relationship between levels of y and x over time.

Engle Granger representation Theorem:

If variables in the x_t vector and y_t are integrated order 1, and if a cointegrating vector exists, there is a vector error correction representation of the model $y_t=\alpha' x_t$ which can be written as

$$\Delta y_t = \beta' \Delta \mathbf{x_{t-1}} + \theta_1 (y_{t-1} - \delta - \delta' \mathbf{x_{t-1}}) + \varepsilon_t$$

The Model

We assumed $$S_t = \delta + \delta' \mathbf{x_t} + \varepsilon_t$$

Vector error correction representation is:

$$\Delta S_t = \beta' \Delta \mathbf{x_{t-1}} + \theta_1 (S_{t-1} - \delta - \delta' \mathbf{x_{t-1}}) + \varepsilon_t$$

UNIVERSITY OF EDINBURGH
Business School

Procedures

- Test each variable to see if integrated order 1: Phillips –Perron test
- Test to see if there exists a cointegarting vector: Johansen ML test
- If there is a cointegating vector, estimate it: Johansen ML estimates
- Estimate the shortrun dynamic model: OLS, tested down to a parsimonious form

$$\Delta S_t = \alpha + \sum_{l=1}^{4} \Delta S_{t-l} + \sum_{l=0}^{4} \beta_{1l}.\Delta ri_{t-l} + \sum_{l=0}^{4} \beta_{2l} \Delta pdi_{t-l} + \sum_{l=0}^{4} \beta_{3l} \Delta ccout_{t-l} + \sum_{l=0}^{4} \beta_{4l} \Delta (optimism)_{t-l}$$

$$+ \theta_1 (S_{t-1} - \delta_1 - \delta_2 ri_{t-1} - \delta_3 pdi_{t-1} - \delta_4 ccout_{t-1} - \delta_5 (optmism)_{t-1}) + \varepsilon_t$$

Data

Consumer loans and mortgage loans made by US commercial banks
(from FRB)

All variables seasonally adjusted by authors using X12, unless already sa by data source.

Delinquency = 30+ days overdue.

- Volume of delinquent debt outstanding for total consumer debt (1987Q1-2008Q1)
- Delinquency rates (ie volume delinquent/debt outstanding) for

  * credit cards (1991Q1-2008Q1)

  * other consumer loans

  * loans on residential real estate

UNIVERSITY OF EDINBURGH
Business School

Phillips-Perron Unit Root Tests

	Levels (with trend)	Differences (without trend)
Consumer delinquency types:		
Bank consumer credit total	-1.067	-5.569**
Bank credit card	-1.143	-5.763**
Other bank consumer credit	-1.198	-5.154**
Mortgage loan	3.462	-3.914**
Explanatory variables		
Consumer credit outstanding	-1.979	-6.579**
Personal loan interest rate	-2.782	-8.607**
Consumer sentiment index	-1.958	-12.984**
Personal disposable income	-2.125	-13.134**
House price index	1.666	-4.250**
Real estate credit outstanding	-0.971	-7.213**
Mortgage interest rate	-3.578*	-9.848**
Total debt outstanding to households	-1.466	-3.494*
Credit card interest rate	-2.494	-6.964**

Test period: 1987Q1 – 2009Q1 for all variables except sentiment index which is 1987Q1-2008Q4.

* = significant at 5% one sided test (MacKinnon)
** = significant at 1% one sided test (MacKinnon)
In all cases bandwidth 4 (Newey-West using Bartlett Kernel)

UNIVERSITY OF EDINBURGH
Business School

Johansen Co-Integration Tests

H_0:	Trace Statistic	5% cv	Max-Eigenvalue Statistic	5% cv
Consumer Credit				
Total volume (Lnrdelsa) equation				
r = 0	75.65	63.88	36.10	32.12
r ≤ 1	39.56	42.92	20.39	25.82
r ≤ 2	19.17	25.87	16.69	19.39
r ≤ 3	2.48	12.52	2.48	12.52
Default rate on credit cards (Lnccsa) equation				
r = 0	66.28	63.88	37.02	32.12
r ≤ 1	29.27	42.92	14.43	25.82
r ≤ 2	14.83	25.87	10.24	19.39
r ≤ 3	4.59	12.52	4.59	12.52
r ≤ 4				
Default rate on other loans (Lnosa) equation				
r = 0	80.52	63.88	44.21	32.12
r ≤ 1	36.31	42.92	16.02	25.82
r ≤ 2	20.29	25.87	13.83	19.39
r ≤ 3	6.46	12.52	6.46	12.52
r ≤ 4				
Residential Real Estate Loans				
Default rate (Lnrnsa) equation				
r = 0	119.78	88.80	41.01	38.33
r ≤ 1	78.77	63.88	35.45	32.11
r ≤ 2	43.32	42.92	22.71	25.82
r ≤ 3	20.61	25.87	10.91	19.39
r ≤ 4	9.71	12.52	9.71	12.52

* = significance at 5%; ** = significance at 1%. Lags in ECM: 4

UNIVERSITY OF EDINBURGH
Business School

Cointegrating Vectors (normalised)

Dependent Variable	Consumer Credit			Residential
	Total Volume	Credit Card Rate	Other rate	Real estate Rate
Independent variable (logs)				
Personal loan interest rate	3.42**			
Credit card interest rate		1.05*		
Mortgage interest rate				4.44**
Consumer credit outstanding	2.48**			
Total debt outstanding to hhs		3.29**	0.33	
Personal disposable income				
Consumer sentiment index	0.25	4.15**	2.64**	-1.22
Real house price index				-1.29
Trend	0.0006	-0.042**	-0.005	0.058**
Constant	-32.97	-71.13	-17.23	2.02

UNIVERSITY OF EDINBURGH
Business School

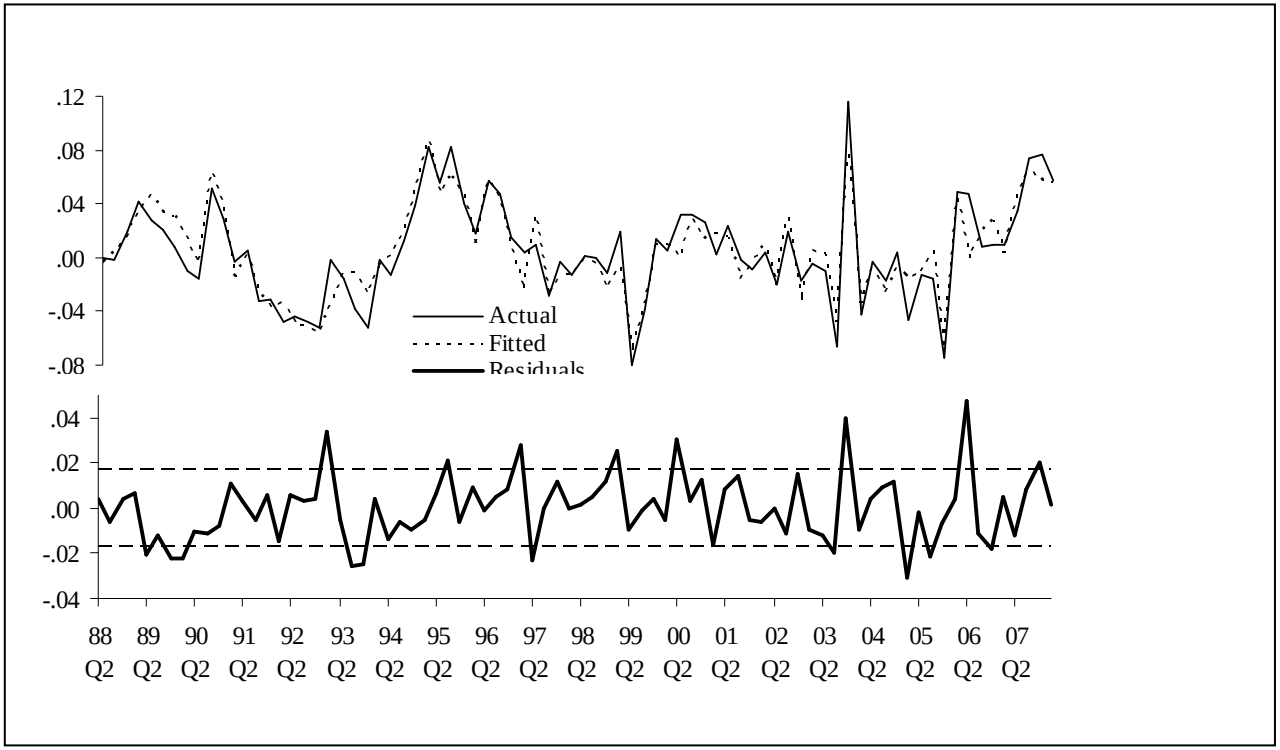
Short Run Dynamic Model (Parsimonious Form)
Δ(log)delinquent volume

	Coefficient	t-stat
Δdel volume		
Lag 0		
Lag 1	0.258	2.70**
Lag 2		
Lag 3		
Lag 4	0.202	2.15*
Δpers loan int rate		
Lag 0	0.221	2.19*
Lag 1	-0.530	-4.55**
Lag 2		
Lag 3		
Lag 4	-0.451	-3.44**
Δcon credit outstanding		
Lag 0	1.174	7.09**
Lag 1	-0.859	-4.28**
Lag 2		
Lag 3		
Lag 4	-0.901	-4.62**
Adj R^2	0.798	

	Coefficient	t-stat
Δoptimism		
Lag 0	-0.167	-2.52*
Lag 1		
Lag 2	-0.122	-1.75
Lag 3	-0.153	-2.07*
Lag 4	0.141	1.98
Δ (nominal) house price		
Lag 0		
Lag 1	-0.744	-2.89**
Lag 2		
Lag 3		
Lag 4		
Δ (nominal) house price		
Lag 0		
Lag 1		
Lag 2		
Lag3		
Lag 4	0.124	1.98
ECM (lag 1)	-0.137	-6.21**
DW	2.296	

** = signif at 1%, * = signif at 5%. All variables in logs.

Changes in (log) Volume of Delinquent Credit



UNIVERSITY OF EDINBURGH
Business School

Short Run Dynamic Model (Parsimonious Form)
Δdelinquency rates

	Credit Cards		Other	
	Coeff	t-stat	Coeff	t-stat
Δdep variable				
Lag 0				
Lag 1	0.277	2.54*	0.296**	3.22
Lag 2	0.410	4.32**		
Lag 3			0.273**	2.87
Lag 4				
Δpers loan int rate				
Lag 0				
Lag 1			0.398*	2.37*
Lag 2				
Lag 3				
Lag 4				
Δcredit card int rate				
Lag 0				
Lag 1	0.996**	4.38		
Lag 2	-0.460	-1.85		
Lag 3				
Lag 4				
Adj R^2	0.53		0.54	
DW	2.11		2.10	

	Credit Cards		Other	
	Coeff	t-stat	Coeff	t-stat
Δtotal hh debt outstanding				
Lag 0				
Lag 1				
Lag 2				
Lag 3				
Lag 4	-0.2711	-3.06**		
Δpersonal disposable income				
Lag 0	-0.961	-2.80**		
Δoptimism				
Lag 0				
Lag 1	-0.581	-3.57**		
Lag 2			-0.196	1.70
Lag 3			-0.271	2.29
Lag 4	0.288	1.98		
Δhouse price index				
Lag 0	-2.281	-5.46**		
ECM Lag1	-0.138	-4.03**	-0.155	-4.99

UNIVERSITY OF EDINBURGH
Business School

Short Run Dynamic Model (Parsimonious Form)
Δmortgage delinquency rate

	Coefficient	t-stat
Δdel rate		
Lag 0		
Lag 1		
Lag 2		
Lag 3		
Lag 4		
Δpers loan int rate		
Lag 0		
Lag 1		
Lag 2	0.647	2.29*
Lag 3		
Lag 4		
Δmortgage int rate		
Lag 0	0.516	4.83**
Lag 1	-0.433	-4.57**
Lag 2	-0.310	-3.20
Lag 3	-0.391	-3.67
Lag 4		

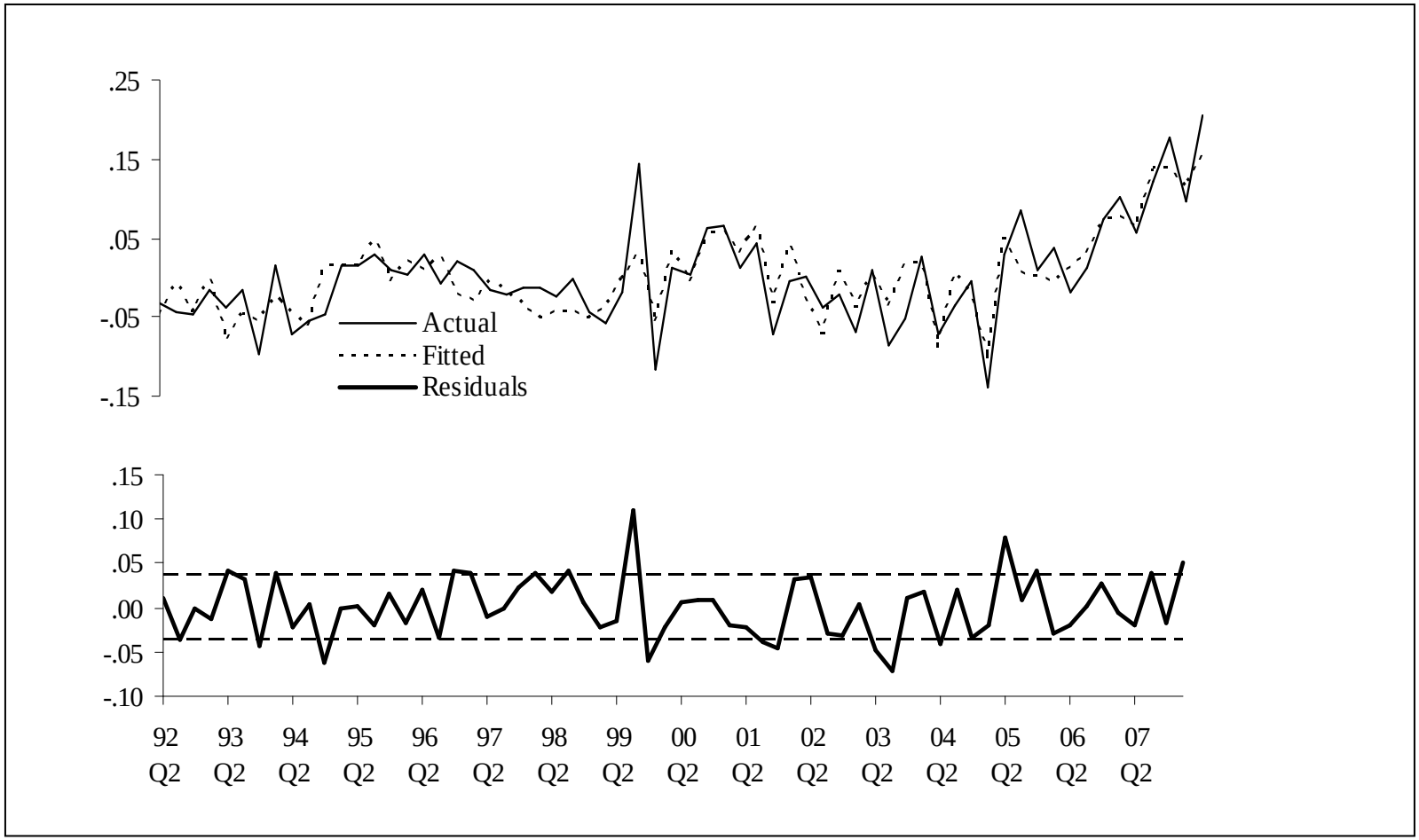
	Coefficient	t-stat
Δreal house price index		
Lag 0		
Lag 1	-3.404	-4.761**
Lag 2		
Lag 3		
Lag 4		
Δ personal disposable income		
Lag 0	-2.40	-4.13**
Lag 1		
Lag 2		
Lag 3		
Lag 4		
ECM (del rate)		
Lag 1	-0.106	-7.25**
ECM (mortgage debt)		
Lag 1	0.400	2.31*

Adj R^2	0.663	DW	2.233

** = signif at 1%, * = signif at 5%.

UNIVERSITY OF EDINBURGH
Business School

Changes in (Log) Default Rates for Real Estate Loans



Shock Responses to Volume of Delinquent Consumer Debt

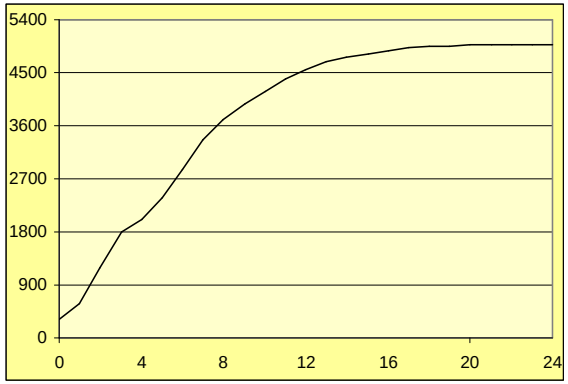
We examine the effects of a permanent shock of approx 1 sd

	Delinquent Debt Volume $00 million	Interest Rate Annual %	Debt Outstanding $00 million	Unemploy-ment Rate %	House Price Index	Sentiment
Minimum	**128.5**	**11.6**	**4117.5**	**3.9**	**142.1**	**110.4**
Maximum	**236.9**	**15.7**	**6702.3**	**7.6**	**384.8**	**139.0**
Mean	**178.2**	**13.5**	**5248.5**	**5.5**	**230.3**	**230.3**
Standard Deviation	**21.8**	**1.10**	**688.1**	**.91**	**74.3**	**6.34**
Shock		**1.00**	**700.0**	**1.00**	**75.0**	**15.00**
Delinquency Impact ($ million)						
Initial		**321**	**4417**	**0.0**	**0.0**	**–331**
Long-run		**4983**	**6473**	**0.0**	**0.0**	**507**

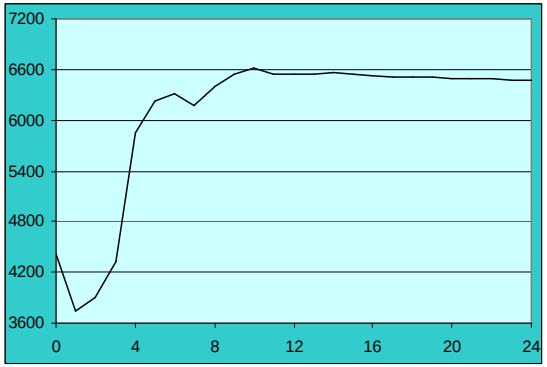
UNIVERSITY OF EDINBURGH
Business School

Cumulative Impact To Volume Of Delinquent Consumer Debt From Various Shocks Over 24 Months ($million)

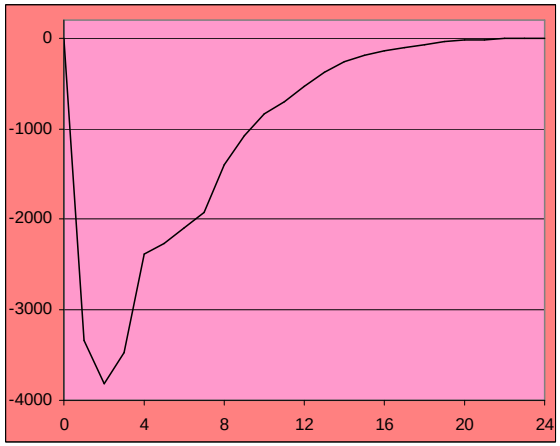
Interest rate rises by 1%



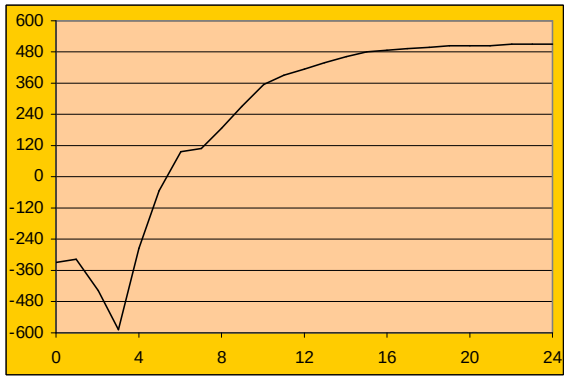
Mortgage debt increases by $70,000million



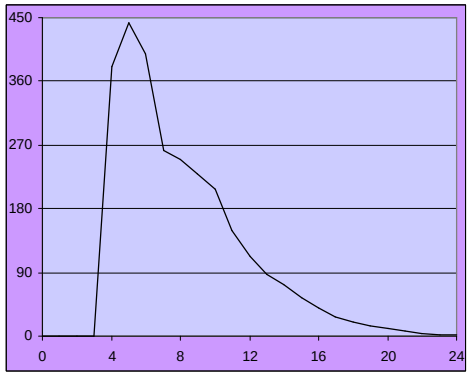
House price index increases by 75



Sentiment index rises by 15.00



Unemployment rate increases by 1%



Forecasting Performance

We compared m-step ahead forecasts from

- Short-run dynamic econometric model

  Each explanatory variable forecast using an ARIMA (p,q) model

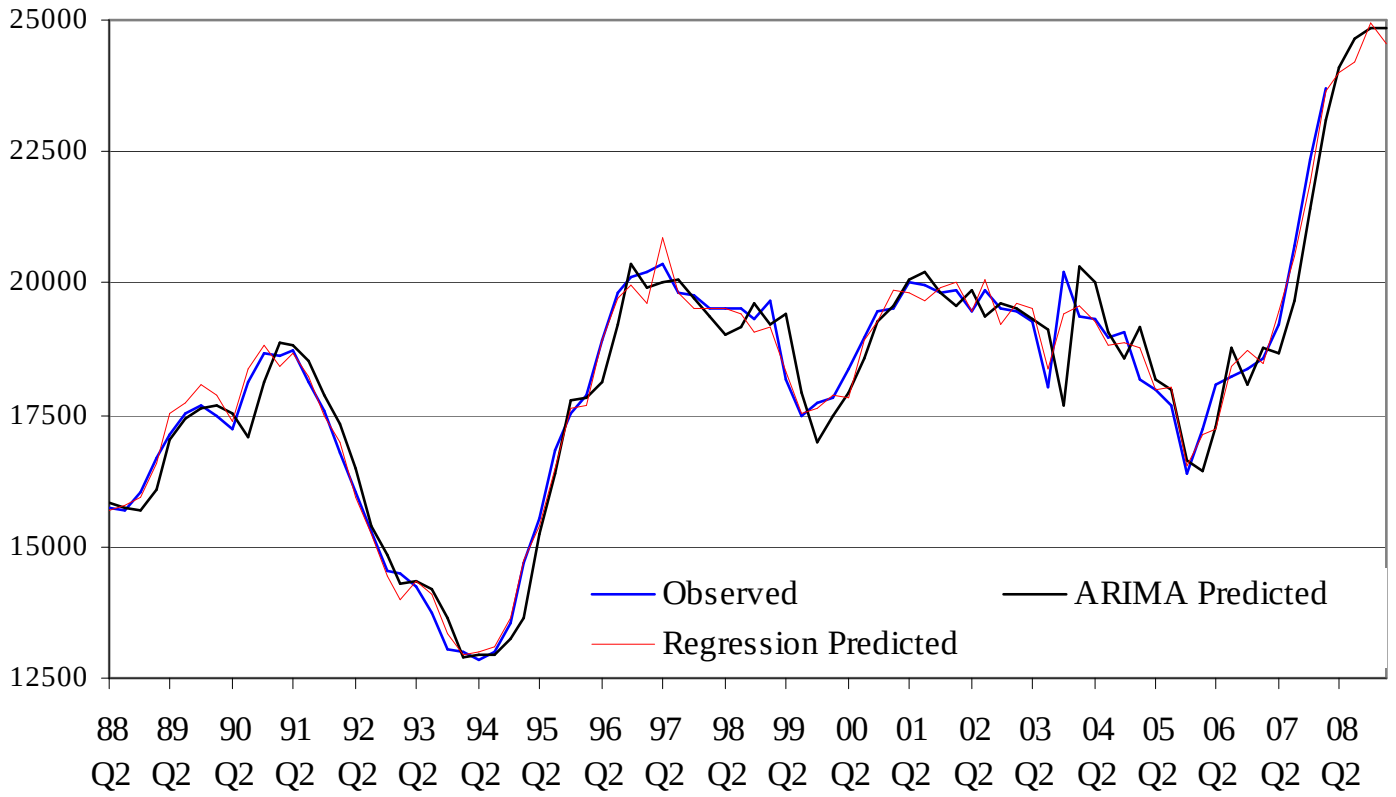
- ARIMA (p,q) model

$$y_t = \alpha + \phi_1 y_{t-1} + \phi_2 y_{t-2} + ... + \phi_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - ... - \theta_q y_{t-q}$$

Forecasts compared for ex-sample period 2008Q2 – 2009Q1.

UNIVERSITY OF EDINBURGH
Business School

Tracking Behaviour of Alternative Models of Delinquency Volume



UNIVERSITY OF EDINBURGH
Business School

Comparison of Regression Forecasts with ARMA Benchmarks

Ex-sample Forecasts	"Actual" Values	ARIMA Forecast	ARIMA Errors	Regression Forecast	Regression Errors
2008 Q2	24264	24094	171	23999	266
2008 Q3	25111	24675	436	24216	895
2008 Q4	29974	24865	5109	24960	5014
2009 Q1	33733	24832	8901	24568	9165
Ex-sample RMSE			5137		5244
In-sample RMSE			562		268

UNIVERSITY OF EDINBURGH
Business School

Conclusions

* We found long run relationships between

- Volume of delinquent debt and personal loan interest rate, consumer debt outstanding
- Delinquency rates on credit cards and interest rates, optimism, total household debt
- Delinquency rates on mortgages and mortgage rate.

* These relationships are consistent with

- more debt outstanding increasing loan portfolio risk
- little evidence of adverse selection
- optimism causing people to borrow more and do not maintain payments
- reduced stigma associated with delinquency on cards, more on mortgages

*No evidence found to support the strategic default hypothesis in long run

* Also found

- Delinquency rates adjust to long run equilibrium faster in consume credit markets than in residential loan markets

- Forecasting accuracy of regression short run dynamic model is comparable to an ARIMA model

UNIVERSITY OF EDINBURGH
Business School

Implications for Recent Crisis

- Strong evidence that short run changes in real estate delinquency is correlated with changes in real house prices in current and previous quarters.
- No evidence there is a long run eqilibrium relationship between real estate delinquency and house prices.
- But we could not gain a series to represent the ‘quality of loans granted’ over a sufficiently long time period to incorporate it.
- In unreported work we found the elasticities and models began to change from mid-2005 onwards.