Firm Default and Aggregate Fluctuations

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Motivation

- Why study the causes of corporate bankruptcy?
  - Asset prices
  - Start-up and ending of firm fundamental economic event
  - Belief they tend to cluster in certain periods
  - Impact on banks and credit availability
  - Real effects in macroeconomy
  - Policy implications for central banks and financial supervisors
- Need to understand driving forces behind bankruptcies and clustering
- Std approach in finance: explain default with firm specific information
  - Macroeconomic and industry influences not or little accounted for

Why would aggregate fluctuations affect firm default?

- Trivial ....
  - ..... affects both firms' and banks' behavior
- Depends....
  - ..... on frequency of data and forecast horizon
  - Monitoring intensity dependent on business cycle
    - Rajan (1994), Povel Singh Winton (2005), Favara (2006)
  - Corporate governance rules: manipulation of annual reports
    - Degeorge et al. (1999), Leuz et al. (2003), Shen and Chih (2005)
  - Some evidence that macro can predict development of firms
    - Pesaran, Schuermann et al (2007), Nickell Perraudin et al (2000), Carling et al. (2006)

Intro to standard methodology

- Typical approach
  - Probit or logit model, sometimes duration
- Limitations:
  - No long panels available
  - Typically only publicly quoted firms (U.S.)
  - Models of default or bankruptcy
    * Assume comovement driven captured by common (firm-specific) risk factors
    * Altman [1968, 1971, 1973, 1984], Frydman, Altman and Kao [1985], Li [1999], Shumway [2001]

What we do

- Our questions
  - Can we explain firm default (individual/industry-level/economy-wide) with a parsimonious model? What are key variables?
    - In particular: Do macroeconomic variables affect firm default behavior over and above firm-specific and industry information?
- Compare model that includes macro with "standard" model w/o macro
  - Estimate default-risk models for industries, at one-digit level
- Test in-sample and out-of-sample
  - Along time-series dimension:1-step ahead prediction performance; comparison with economy-wide model and some standard t/s models
  - Along cross-section dimension: pseudo R^2, decile test, distribution test on predicted PD percentiles

What we find

1. The firm-level default-risk (logit) model can replicate the high/low default risk in the beginning/end of the 1990s
   - Firm-specific variables do a good job risk-ranking firms
   - Macro variables are essential for determining absolute default risk
   - Estimation of default risk model on aggregate time-series data is not informative
   - Even Swedish banking crisis can be "explained" with model
2. The effects of aggregate fluctuations are surprisingly similar across industries
3. Out-of-sample performance equally good for industry and eco-wide models
   - Both in time–series and cross-section dimension

$\Longrightarrow$ Macro seems to have "structural" effect

Rest of the presentation

1. Data
2. Model of firm default
    1. Presentation of results
    2. Role of macro
    3. Robustness across industries
    4. In- and out-of sample prediction performance
3. Concluding remarks

Data

- National credit bureau, Upplysningscentralen: all incorporated Swedish firms
  - In-sample period 1990Q1 - 1999Q4: 8,106,138 observations on ≈200,000 firms
  - Out-of-sample 2000Q1-2002Q4: 2,614,248 observations
- Annual report data: National Patent Office
- Payment remarks data:
  - Reported by banks, tax authorities, firms, stored by UC: 61 credit/tax related events
- Data frequency: Daily for payment remarks, annually for accounting data
- Default definiton:
  - One of following events occurred: bankruptcy, suspension of payments, negotiated a debt resettlement, undergoing reconstruction, no assets present at seizure

- Important selection tool for balance sheet variables: graphing variables against default rate
  - Computing default rates and variable values as averages over an interval of +/- 5000 sorted observations
- Truncate balance sheet variables
  - $1st$ and $99th$ percentiles
- Replace missing values for balance sheets variables
  - For individual firms: with their own mean
  - For defaulting/non-defaulting obs with mean for defaulting/non-defaulting firms.
  - Tested other methods: linear projection, bootstrapping: results not sensitive to method

Model of firm default

- Logit model: $y_i^\tau = x_i(\tau)\beta + \varepsilon_i^\tau$
  - $y_i^\tau = \begin{cases} 1 \text{ if } x_i(\tau)\beta + \varepsilon_i^\tau \geq 0 \text{ (firm defaults)} \\ 0 \text{ if } x_i(\tau)\beta + \varepsilon_i^\tau < 0 \text{ (firm stays in business)} \end{cases}$
  - Assume $x_i(\tau)$ and ε_i^τ are stochastically independent
  - Also assume independence of the errors between both loans and time points, i.e.:
    - $f\left(\varepsilon_i^\tau, \varepsilon_j^\tau\right) = f\left(\varepsilon_i^\tau\right) f\left(\varepsilon_j^\tau\right)$ for $i \neq j$ and
    - $f\left(\varepsilon_i^\tau, \varepsilon_i^{\tau+l}\right) = f\left(\varepsilon_i^\tau\right) f\left(\varepsilon_i^{\tau+l}\right)$ for $l \neq 0$.
  - Richer specification of systematic part makes assumption more credible
- Estimate model over period $1990Q1 - 1999Q4$
  - Table 2: Only firm-specific variables as regressors
  - Table 3: Both firm-specific variables and macro variables as regressors

Table 2: Only firm-specific regressors

- Pseudo R^2
- Pseudo $R^2|ecow.coef$
  - Indicates cross-sectional quality of industry model by checking explanatory power per industry when economy-wide model's coefficients are used
  - In-sample the industry models outperform economy-wide model
- Aggregate R^2: Take average of all obs per quarter in industry $\Rightarrow$ evaluate time-series fit using predicted (average) values from industry-specific model as regressors
  - Intuition for higher values: you lift out idiosyncratic variation from data
  - In general $\approx .50$, except for Bank, Finance & Insurance, and Transport
- Aggregate $R^2|ecow.coef$: Use economy-wide coefficients to estimate average default rates per industry for each point-in-time

Table 2: Regression results 1990Q1-1999Q4 for the default risk model estimated with only firm-specific variables

	Agriculture	Manu-facturing	Construction	Retail	Hotel & Restaurant	Transport	Bank. Finance & Insurance	Real Estate	Consulting & Rental	Not Classified	Economy Wide
Firm-specific Variables [a]											
EBITDA/TA	-1.308	-1.419	-1.472	-0.957	-0.856	-1.148	-0.361	-0.738	-0.857	-1.069	-0.949
	(0.115)	(0.045)	(0.053)	(0.024)	(0.040)	(0.056)	(0.098)	(0.059)	(0.030)	(0.028)	(0.012)
TL/TA	0.989	1.104	0.599	0.636	0.205	0.753	0.185	0.726	0.342	0.160	0.491
	(0.082)	(0.034)	(0.041)	(0.016)	(0.028)	(0.046)	(0.054)	(0.030)	(0.023)	(0.021)	(0.008)
LA/TL	-0.317	-0.488	-0.493	-0.373	-0.092	-0.192	-0.180	-0.317	-0.247	0.011	-0.251
	(0.093)	(0.040)	(0.042)	(0.020)	(0.041)	(0.036)	(0.052)	(0.035)	(0.017)	(0.009)	(0.008)
I/TS	0.069	0.325	-0.177	0.274	1.315	0.040	0.014	0.053	0.340	0.083	0.124
	(0.049)	(0.036)	(0.044)	(0.016)	(0.310)	(0.240)	(0.055)	(0.009)	(0.041)	(0.021)	(0.006)
TL/TS	0.177	0.128	0.306	0.157	0.237	0.091	0.038	0.068	0.202	0.358	0.164
	(0.025)	(0.006)	(0.008)	(0.004)	(0.013)	(0.010)	(0.015)	(0.006)	(0.006)	(0.006)	(0.002)
IP/(IP+EBITDA)	0.094	0.103	0.055	0.061	0.003	0.194	0.070	0.180	0.045	0.145	0.088
	(0.037)	(0.013)	(0.014)	(0.007)	(0.019)	(0.025)	(0.052)	(0.017)	(0.012)	(0.014)	(0.004)
Payment remark[d]	1.284	1.449	1.691	1.523	1.531	1.682	2.239	1.604	1.775	2.512	1.712
	(0.123)	(0.045)	(0.045)	(0.028)	(0.058)	(0.061)	(0.157)	(0.053)	(0.036)	(0.044)	(0.015)
Paym remark tax arrears	2.796	2.216	2.461	2.449	2.380	2.837	3.108	2.419	2.848	2.693	2.566
	(0.078)	(0.028)	(0.029)	(0.017)	(0.040)	(0.041)	(0.110)	(0.033)	(0.024)	(0.027)	(0.009)
Divident	-2.310	-1.912	-1.900	-2.119	-1.667	-1.755	-1.180	-1.710	-1.754	-2.204	-2.004
	(0.401)	(0.114)	(0.111)	(0.076)	(0.219)	(0.178)	(0.296)	(0.139)	(0.085)	(0.132)	(0.039)
TTLFS	4.161	3.695	4.046	3.643	3.371	3.918	3.720	3.615	3.796	3.333	3.670
	(0.072)	(0.027)	(0.029)	(0.016)	(0.039)	(0.038)	(0.097)	(0.030)	(0.022)	(0.022)	(0.009)
Mean log-likelihood	-0.024	-0.044	-0.044	-0.051	-0.071	-0.036	-0.025	-0.061	-0.032	-0.058	-0.046
Pseudo R^2	0.39	0.29	0.36	0.32	0.31	0.38	0.40	0.33	0.38	0.41	0.34
Pseudo R^2 | ecow.coef [b]	0.35	0.28	0.36	0.31	0.30	0.38	0.32	0.32	0.37	0.39	0.34
Aggregate R^2	0.50	0.51	0.47	0.53	0.52	0.38	0.27	0.52	0.45	0.56	0.49
Aggregate R^2| ecow.coef [b]	-2.09	0.39	0.37	0.42	0.39	0.27	-1.97	0.49	0.02	0.46	0.49
Number of obs	219,604	1,035,359	848,658	2,161,664	251,693	515,674	99,363	473,831	1,739,890	760,402	8,106,138

Notes: Standard errors in parentheses. The variables are not scaled, so the importance of a variable cannot be interpreted directly from the size of the parameter estimate. [a] See Subsection 2.1 for exact definition of these variables. [b] Pseudo R^2. | ecow.coef is the Pseudo R^2 value calculated for each industry using the estimated coefficients in the Economy Wide model (i.e., the coefficients in the last column in the table above). The pseudo R^2 values are calculated according to McFadden (1974). [d] Dummy equals one if either a bankruptcy petition was submitted, a court order to pay a debt was issued (because of absence during the court hearing), property was seized, or the firm had a non-performing loan.

Table 2: only firm-specific vars

	Economy Wide
Firm-specific Variables [a]	
EBITDA/TA	-0.949
	(0.012)
TL/TA	0.491
	(0.008)
LA/TL	-0.251
	(0.008)
I/TS	0.124
	(0.006)
TL/TS	0.164
	(0.002)
IP/(IP+EBITDA)	0.088
	(0.004)
Payment remark[d]	1.712
	(0.015)
Paym remark tax arrears	2.566
	(0.009)
Divident	-2.004
	(0.039)
TTLFS	3.670
	(0.009)
Mean log-likelihood	-0.046
Pseudo R^2	0.34
Pseudo R^2 | ecow.coef. [b]	0.34
Aggregate R^2	0.49
Aggregate R^2 | ecow.coef [b]	0.49
Number of obs	8,106,138

Table 3: Also macro regressors included

- Pseudo R^2 and Pseudo $R^2|ecow.coef$:
  - Not much affected: in-sample the industry models still outperform economy-wide model
  - R^2 levels only marginally higher
- Aggregate R^2:
  - Rises to approximately .90!
  - Intuition for higher values: macro picks up variation over time in default rates while ignoring idiosyncratic noise
- Aggregate $R^2|ecow.coef$:

Table 3: Regression results 1990Q1-1999Q4 for the default risk model estimated with both firm-specific and macro variables

	Agriculture	Manu-facturing	Construction	Retail	Hotel & Restaurant	Transport	Bank, Finance & Insurance	Real Estate	Consulting & Rental	Not Classified	Economy Wide
Firm-specific variables [a]											
EBITDA/TA	-1.323 (-0.025)	-1.412 (0.006)	-1.420 (0.008)	-0.950 (0.004)	-0.850 (0.013)	-1.159 (0.011)	-0.373 (0.015)	-0.673 (0.006)	-0.880 (0.006)	-1.073 (0.006)	-0.954 (0.002)
TL/TA	0.960 (0.082)	1.088 (0.035)	0.591 (0.042)	0.629 (0.016)	0.201 (0.028)	0.734 (0.046)	0.168 (0.055)	0.734 (0.031)	0.317 (0.024)	0.146 (0.021)	0.480 (0.008)
LA/TL	-0.327 (0.093)	-0.476 (0.040)	-0.478 (0.042)	-0.371 (0.020)	-0.091 (0.040)	-0.190 (0.036)	-0.168 (0.049)	-0.299 (0.033)	-0.233 (0.017)	0.011 (0.009)	-0.237 (0.008)
I/TS	0.021 (0.050)	0.323 (0.036)	-0.207 (0.044)	0.264 (0.017)	1.310 (0.310)	0.206 (0.240)	0.008 (0.056)	0.047 (0.009)	0.297 (0.041)	0.067 (0.021)	0.115 (0.006)
TL/TS	0.167 (0.025)	0.124 (0.006)	0.301 (0.008)	0.148 (0.004)	0.224 (0.013)	0.082 (0.011)	0.040 (0.015)	0.064 (0.006)	0.198 (0.006)	0.353 (0.006)	0.162 (0.002)
IP/(IP+EBITDA)	0.089 (0.037)	0.092 (0.013)	0.048 (0.014)	0.054 (0.007)	-0.002 (0.019)	0.174 (0.025)	0.054 (0.053)	0.157 (0.017)	0.039 (0.012)	0.138 (0.014)	0.079 (0.004)
Payment remark[d]	1.449 (0.125)	1.604 (0.046)	1.854 (0.046)	1.643 (0.028)	1.616 (0.059)	1.815 (0.062)	2.369 (0.159)	1.773 (0.053)	1.894 (0.037)	2.592 (0.044)	1.838 (0.015)
Paym remark tax arrears	2.910 (0.081)	2.361 (0.029)	2.652 (0.030)	2.579 (0.018)	2.468 (0.041)	2.951 (0.042)	3.210 (0.112)	2.538 (0.034)	2.997 (0.025)	2.786 (0.027)	2.698 (0.010)
Dividend	-2.168 (0.400)	-1.674 (0.114)	-1.627 (0.111)	-1.922 (0.076)	-1.493 (0.219)	-1.549 (0.179)	-0.977 (0.296)	-1.444 (0.140)	-1.579 (0.085)	-2.077 (0.133)	-1.809 (0.039)
TTLFS	4.070 (0.073)	3.593 (0.027)	3.941 (0.029)	3.551 (0.016)	3.278 (0.040)	3.864 (0.039)	3.680 (0.097)	3.460 (0.030)	3.720 (0.022)	3.300 (0.022)	3.587 (0.009)
Macro variables [b]											
Output gap	-0.128 (0.020)	-0.120 (0.007)	-0.156 (0.007)	-0.104 (0.004)	-0.111 (0.010)	-0.126 (0.010)	-0.129 (0.029)	-0.187 (0.008)	-0.120 (0.006)	-0.040 (0.006)	-0.115 (0.002)
Nominal interest rate	0.058 (0.015)	0.072 (0.005)	0.088 (0.006)	0.073 (0.003)	0.048 (0.008)	0.050 (0.008)	0.093 (0.021)	0.082 (0.006)	0.073 (0.005)	0.060 (0.005)	0.072 (0.002)
GDP inflation	-0.022 (0.021)	0.014 (0.007)	-0.034 (0.008)	0.016 (0.005)	0.036 (0.012)	0.024 (0.012)	-0.053 (0.033)	-0.013 (0.009)	0.006 (0.007)	0.011 (0.008)	0.006 (0.003)
Real exchange rate	0.000 (0.005)	-0.011 (0.002)	-0.002 (0.002)	-0.003 (0.001)	0.000 (0.002)	-0.010 (0.002)	-0.011 (0.007)	-0.007 (0.002)	-0.008 (0.001)	-0.009 (0.001)	-0.006 (0.001)
Mean log-likelihood	-0.024	-0.043	-0.043	-0.050	-0.070	-0.035	-0.025	-0.059	-0.031	-0.058	-0.045
Pseudo R^2.	0.40	0.30	0.38	0.33	0.31	0.39	0.42	0.35	0.39	0.41	0.35
Pseudo R^2 | ecow.coeffs. [c]	0.36	0.29	0.37	0.32	0.30	0.39	0.34	0.34	0.38	0.39	0.35
Aggregate R^2	0.88	0.95	0.95	0.97	0.85	0.89	0.84	0.86	0.94	0.83	0.96
Aggregate R^2| ecow.coeffs. [c]	-2.01	0.87	0.89	0.90	0.63	0.71	-1.82	0.78	0.34	0.55	0.96
Number of obs	219,604	1,035,359	848,658	2,161,664	251,693	515,674	99,363	473,831	1,739,890	760,402	8,106,138

Notes: Standard errors in parentheses. The variables are not scaled, so the importance of a variable cannot be interpreted directly from the size of the parameter estimate. [a] See Subsection 2.1 for exact definition of these variables. [b] See Subsection 2.2 for definition and sources. [c] Pseudo R^2. | ecow.coeffs. is the Pseudo R^2 value calculated for each industry using the estimated coefficients in the Economy Wide model (i.e., the coefficients in the last column in the table above). The pseudo R^2 values are calculated according to McFadden (1974). [d] Dummy equals one if either a bankruptcy petition was submitted, a court order to pay a debt was issued (because of absence during the court hearing), property was seized, or the firm had a non-performing loan.

Table 3: firm-specific and macro variables

	Economy Wide
Firm-specific variables [a]	
EBITDA/TA	-0.954 (0.002)
TL/TA	0.480 (0.008)
LA/TL	-0.237 (0.008)
I/TS	0.115 (0.006)
TL/TS	0.162 (0.002)
IP/(IP+EBITDA)	0.079 (0.004)
Payment remark[a]	1.838 (0.015)
Paym remark tax arrears	2.698 (0.010)
Dividend	-1.809 (0.039)
TTLFS	3.587 (0.009)
Macro variables [b]	
Output gap	-0.115 (0.002)
Nominal interest rate	0.072 (0.002)
GDP inflation	0.006 (0.003)
Real exchange rate	-0.006 (0.001)
Mean log-likelihood	-0.045
Pseudo R^2.	0.35
Pseudo R^2. | ecow.coeffs. [c]	0.35
Aggregate R^2	0.96
Aggregate R^2 | ecow.coeffs. [c]	0.96
Number of obs	8,106,138

Table 3: firm-specific and macro variables

	Economy Wide
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Macro variables [b]	
Output gap	-0.115 (0.002)
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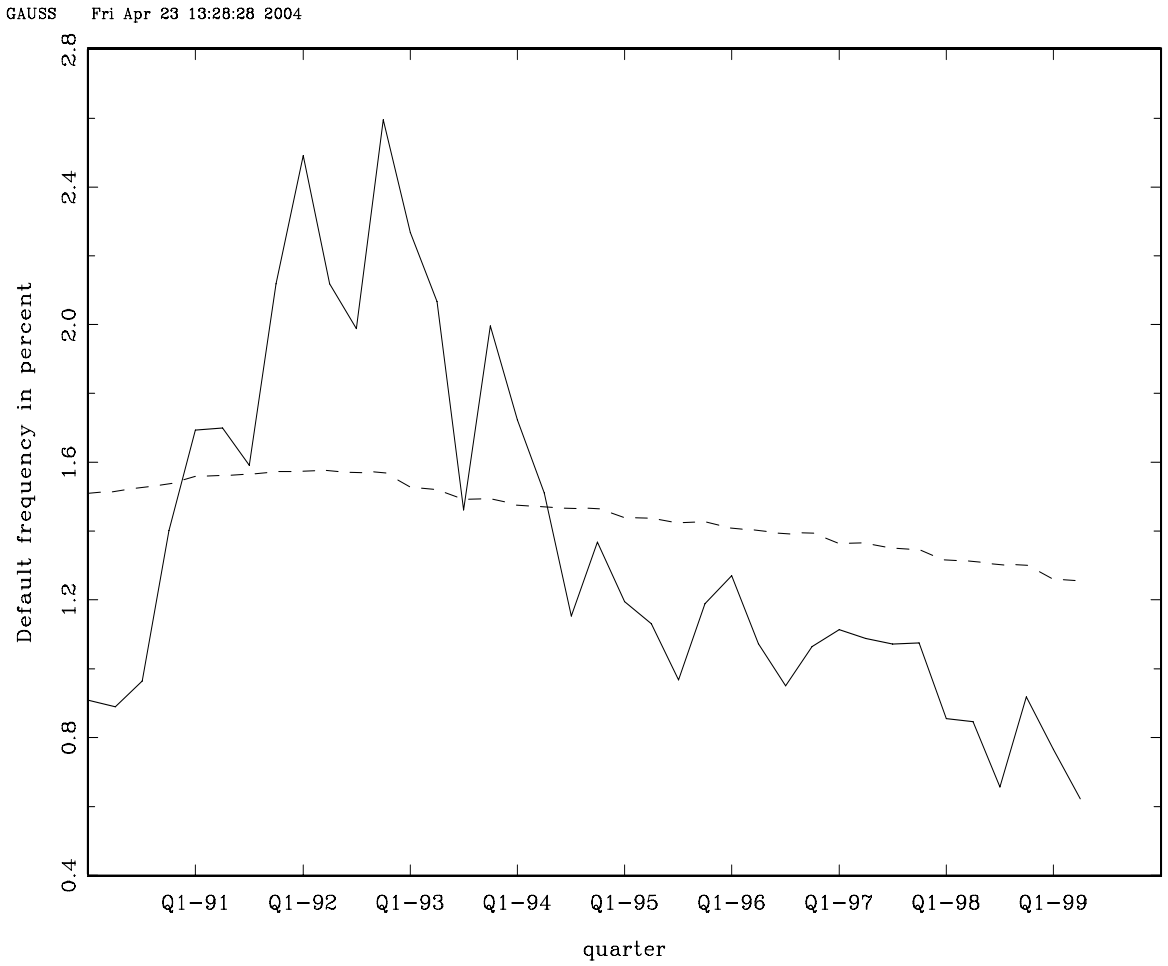
Aggregate R^2	0.96
Aggregate R^2 | ecow.coeffs. [c]	0.96
Number of obs	8,106,138



Actual and predicted mean default rates - conditional on firm-specific informationa only

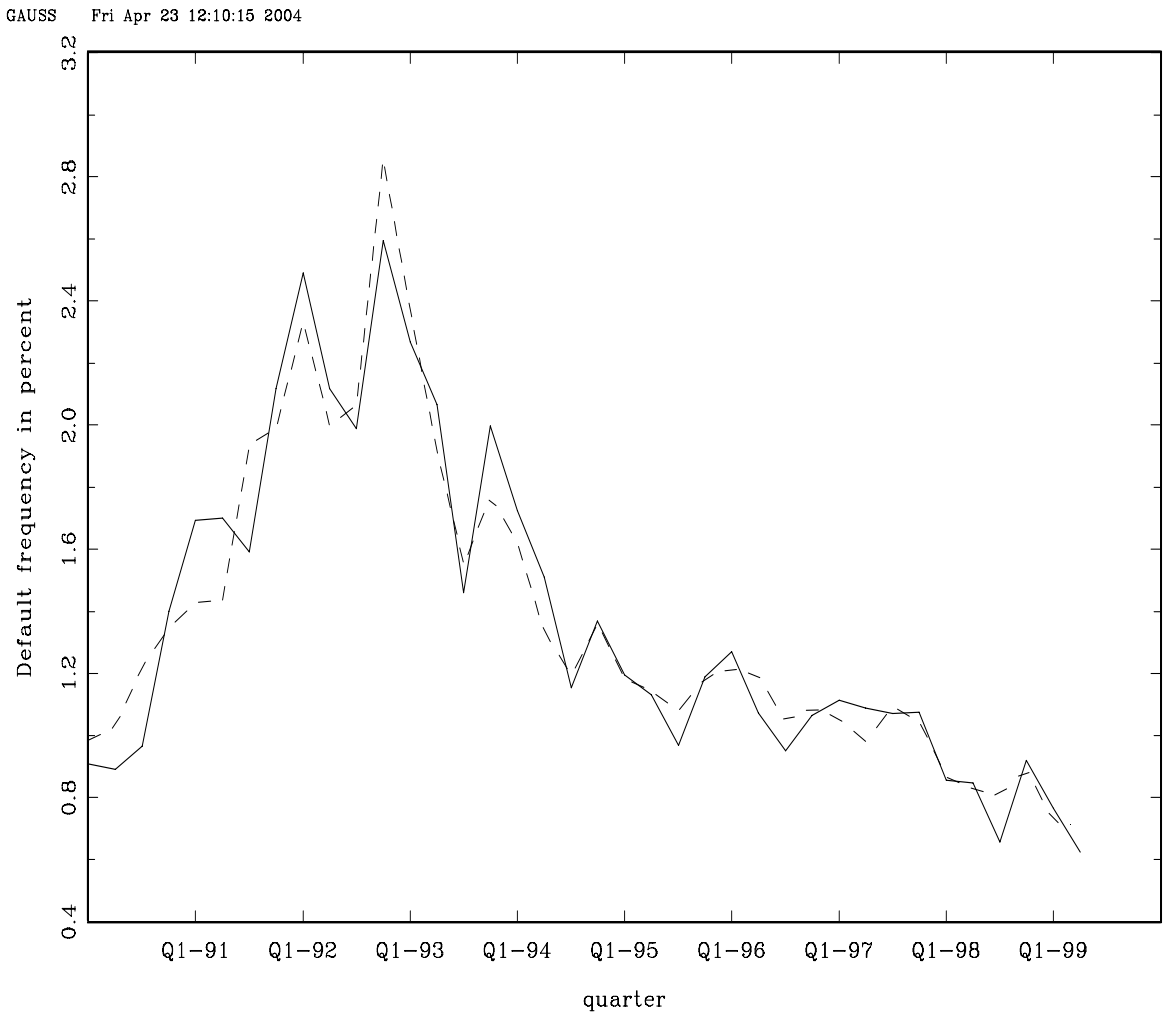
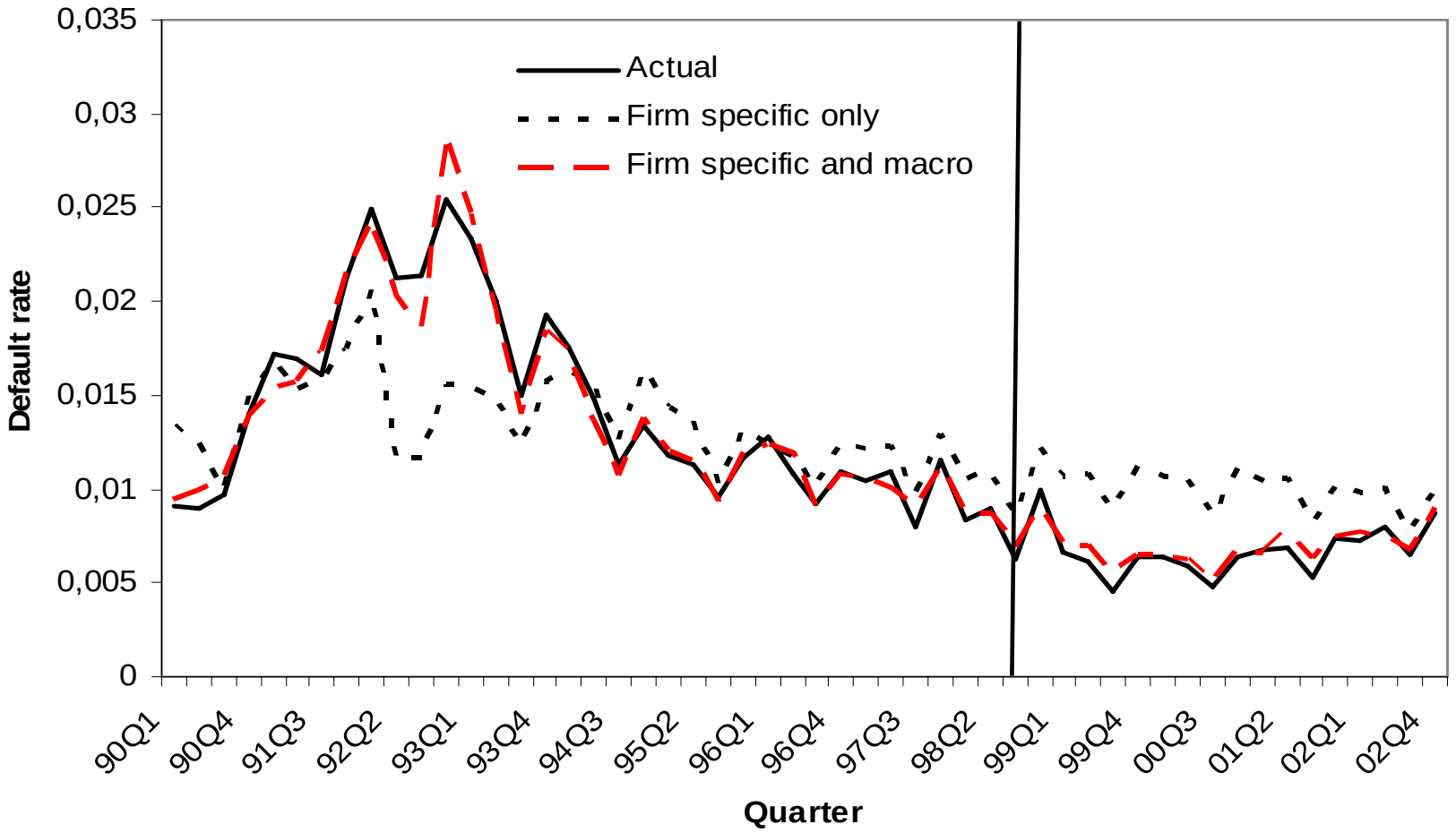


Figure: Actual and projected default rates at the aggregate level: Both idiosyncratic and aggregate information included

Actual (solid line) and predicted average default rates. Predicted default rates conditional on payment remarks and firm-specific variables only (dotted black line), or on payment remarks, firm-specific ánd macro variables (dashed red line). [Note: vertical line for start of forecast period should be at 2000Q1]



OLS estimations on average time-series data

- Produce very misleading estimates for accounting data

$$
\begin{aligned}
df_t \;=\; & \underset{(0.06)}{-0.23} \;\; \underset{(0.13)}{-0.23} \left(\frac{\mathsf{EBITDA}}{\mathsf{TA}}\right)_t + \underset{(0.06)}{0.30} \left(\frac{\mathsf{TL}}{\mathsf{TA}}\right)_t + \underset{(0.03)}{0.09} \left(\frac{\mathsf{LA}}{\mathsf{TL}}\right)_t \; ... \\
& \underset{(0.21)}{-0.94} \left(\frac{\mathsf{I}}{\mathsf{TS}}\right)_t + \underset{(0.08)}{0.19} \left(\frac{\mathsf{TL}}{\mathsf{TS}}\right)_t - \underset{(0.12)}{0.02} \left(\frac{\mathsf{IP}}{\mathsf{IP{+}EBITDA}}\right)_t \; ... \\
& \underset{(0.03)}{-0.05} y_{d,t} - \underset{(0.03)}{0.05} \pi_{d,t} + \underset{(0.03)}{0.12} R_{d,t} + \underset{(0.009)}{0.002} q_t + \hat{u}_{df,t}, \qquad (0.1)
\end{aligned}
$$

$R^2 = 0.93,\ \mathsf{DW} = 2.10,\ \mathsf{Sample:}\ 1990Q1 - 1999Q4\ (T = 40)$

Table 4: Out-of-sample fit

- Out-of-sample period: $2000Q1 - 2002Q4$, 12 quarters $\Rightarrow \approx 2,614,248$ obs.
- Time-series dimension: 5 models compared
  - (1) Conventional model: only firm-specific variables $\alpha^j, X_{i,t}$ (Table 2)
  - (2) Model with firm-specific and macro variables: $\alpha^j, X_{i,t}$ and β^j, Z_t (Table 3)
  - (3) Model with firm-specific and macro variables with *economy-wide coefficients*: $\alpha, X_{i,t}$ and β, Z_t
  - (4) Random walk time-series model
  - (5) Four quarter moving average time-series model
- Measure of fit
  - One-quarter ahead forecast errors on average default rate, summarized through RMSE: absolute and relative to model (2)

- Time-series dimension: Findings
  - Industry models *with* macro variables *added* outperform models with only firm-specific variables
  - Industry models with macro variables are slightly better than employing "economy-wide" model with macro to forecast industry average default rates (excl. Retail)
    - when excluding, efficiency of industry models relative to economy-wide increases
  - Industry models with macro variables generally outperform time series models (most industries, and industry aggregate; also economy-wide model)

Table 4: Out-of-Sample Root Mean Square Error (RMSE) for predicted average default frequencies for various models.

Model	***RMSE***											
Absolute RMSE for Model j [a]	**Agriculture**	**Manu-facturing**	**Construction**	**Retail**	**Hotel & Restaurant**	**Transport**	**Bank, Finance & Insurance**	**Real-Estate**	**Consulting & Rental**	**Not Classified**	**Industry aggregate**	**Economy Wide**
Only firm-specific variables	0,1973	0,3039	0,4239	0,4509	0,7457	0,2641	0,2070	0,7079	0,2504	0,2680	0,3427	0,3350
Firm-specific and macro	0,0711	0,0849	0,0842	0,1215	0,3210	0,0697	0,1013	0,2459	0,1176	0,2381	0,0660	0,0478
Economy wide coefficients	0,2830	0,0904	0,1612	0,0540	0,3454	0,0789	0,2124	0,3490	0,1728	0,7155	0,0478	0,0478
Time series random walk	0,1082	0,1179	0,1023	0,1180	0,2338	0,1119	0,1400	0,0737	0,1133	0,3576	0,1262	0,1262
4 quarter moving average	0,0854	0,1208	0,0772	0,0797	0,1570	0,0782	0,1137	0,0761	0,0869	1,5321	0,0893	0,0893
RMSE model j / RMSE Tabel 3 model [a]												
Only firm-specific variables	2,7752	3,5783	5,0368	3,7114	2,3231	3,7896	2,0435	2,8789	2,1291	1,1257	5,1901	7,0059
Economy wide coefficients	3,9806	1,0646	1,9155	0,4444	1,0759	1,1316	2,0963	1,4191	1,4687	3,0055	0,7243	1,0000
Time series random walk	1,5219	1,3885	1,2152	0,9712	0,7283	1,6053	1,3817	0,2998	0,9636	1,5019	1,9121	2,6399
4 quarter moving average	1,2007	1,4230	0,9173	0,6562	0,4891	1,1217	1,1225	0,3096	0,7385	6,4354	1,3522	1,8668

Notes: The RMSEs are computed as one-step-ahead forecasts of the predicted average default frequencies for the period 2000*Q*1-2002*Q4*. No model is estimated on data after 1999*Q*4. Industry aggregate RMSEs are computed by summing the default probabilities implied by each industry model quarterly. [a] Note that the macro variables in these forecasting models are lagged one quarter, so that all models are based on the same information set.

Table 4: Out-of-Sample Root Mean Square Error (RMSE) for predicted average default frequencies for various models.

Model	***RMSE***	
Absolute RMSE for Model j [a]	**Industry aggregate**	**Economy Wide**
Only firm-specific variables	0,3427	0,3350
Firm-specific and macro	0,0660	0,0478
Economy wide coefficients	0,0478	0,0478
Time series random walk	0,1262	0,1262
4 quarter moving average	0,0893	0,0893
RMSE model j / RMSE Tabel 3 model [a]		
Only firm-specific variables	5,1901	7,0059
Economy wide coefficients	0,7243	1,0000
Time series random walk	1,9121	2,6399
4 quarter moving average	1,3522	1,8668

- Cross section dimension, experiment 1:
  - Verify if models are able to pick out the potential defaults
    - Sort the firms by their estimated default probability,
    - Table 5: defaulting firms are typically classified to be more risky than non-defaulting firms
    - About 75 % of the defaulting firms are in the first decile, about 4 % of the defaults in deciles 5-10
    - Pseudo R2's have not deteriorated compared to in-of-sample values

Table 5: Out-of-sample Pseudo R-squares and decile tests at the industry level

Industry specific coefficients

	Agriculture	Manufacturing	Construction	Retail	Hotel & Restaurant	Transport	Bank. Finance & Insurance	Real-Estate	Consulting & Rental	Not Classified	All industries
Pseudo R²	0.40	0.34	0.51	0.38	0.41	0.44	0.43	0.58	0.41	0.46	-
Decile											
1	0.74	0.71	0.85	0.72	0.76	0.82	0.79	0.75	0.78	0.78	0.79
2	0.11	0.13	0.06	0.10	0.09	0.07	0.03	0.06	0.08	0.08	0.08
3	0.08	0.05	0.03	0.06	0.03	0.05	0.05	0.03	0.05	0.10	0.04
4	0.02	0.05	0.02	0.05	0.02	0.02	0.05	0.04	0.03	0.01	0.03
5	0.02	0.02	0.01	0.03	0.03	0.01	0.04	0.04	0.02	0.01	0.02
6 - 10	0.02	0.04	0.03	0.05	0.07	0.03	0.05	0.08	0.04	0.03	0.04
Sum	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

Economy-wide coefficients

	Agriculture	Manufacturing	Construction	Retail	Hotel & Restaurant	Transport	Bank. Finance & Insurance	Real-Estate	Consulting & Rental	Not Classified	All industries
Pseudo R²	0.46	0.35	0.51	0.37	0.35	0.45	0.45	0.47	0.44	0.43	0.42
Decile											
1	0.75	0.69	0.86	0.71	0.76	0.81	0.76	0.72	0.78	0.78	0.76
2	0.11	0.12	0.05	0.09	0.09	0.08	0.04	0.05	0.08	0.04	0.09
3	0.06	0.07	0.03	0.06	0.02	0.04	0.06	0.06	0.05	0.11	0.06
4	0.03	0.05	0.02	0.05	0.04	0.02	0.04	0.04	0.03	0.03	0.03
5	0.03	0.03	0.01	0.03	0.02	0.01	0.03	0.02	0.02	0.01	0.02
6 – 10	0.02	0.04	0.03	0.05	0.06	0.03	0.08	0.10	0.04	0.02	0.04
Sum	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

Notes: The out-of-sample period is 2000*Q*1-2002*Q*4, and the total number of firms in the panel for this period are 2,614,248. The parameters used are the ones estimated in Table 3. The decile test numbers in the table are obtained by sorting the estimated default probabilities, in descending order. and computing the default frequencies in the different deciles of the sorted data. Industry aggregate numbers are obtained by generating the estimated default probabilities with the industry specific parameters, adding the observations to a single dataset. and then apply the procedure outlined above to compute the default frequencies for the various deciles.

Industry specific coefficients

	Construction	Bank. Finance & Insurance	Real-Estate	All industries
Pseudo R^2	0.51	0.43	0.58	-
Decile				
1	0.85	0.79	0.75	0.79
2	0.06	0.03	0.06	0.08
3	0.03	0.05	0.03	0.04
4	0.02	0.05	0.04	0.03
5	0.01	0.04	0.04	0.02
6 - 10	0.03	0.05	0.08	0.04
Sum	**1.00**	**1.00**	**1.00**	**1.00**

Economy-wide coefficients

	Construction	Bank. Finance & Insurance	Real-Estate	All industries
Pseudo R^2	0.51	0.45	0.47	0.42
Decile				
1	0.86	0.76	0.72	0.76
2	0.05	0.04	0.05	0.09
3	0.03	0.06	0.06	0.06
4	0.02	0.04	0.04	0.03
5	0.01	0.03	0.02	0.02
6 – 10	0.03	0.08	0.10	0.04
Sum	**1.00**	**1.00**	**1.00**	**1.00**

- Cross section dimension, experiment 2:
  - Verify if distribution of estimated average PDs equals that of actual default frequencies
    - Sort firms by estimated PD, then calculate actual default frequency per percentile
  - Figure reports results for both industry models and economy-wide ("aggregate") model
    - Not enough observations for industry analysis: use all obs.
    - Most observations close to 45-degree line from origo (as desired)
  - When testing H_0: $\beta_0 = 0$ and $\beta_1 = 1$ in regression $Y_i = \beta_0 + \beta_1 \hat{Y}_i + \varepsilon_i$, where Y_i =actual default frequency and $\hat{Y}_i$ =estimated average default probability in percentile i, respectively we
    - firmly reject H_0 when $\hat{Y}_i$ is generated using a model with firm-specific variables
    - cannot reject H_0 when $\hat{Y}_i$ is generated using a model with firm-specific *and* macro variables
  - Adding macro improves fit by practically eliminating underestimation of PD

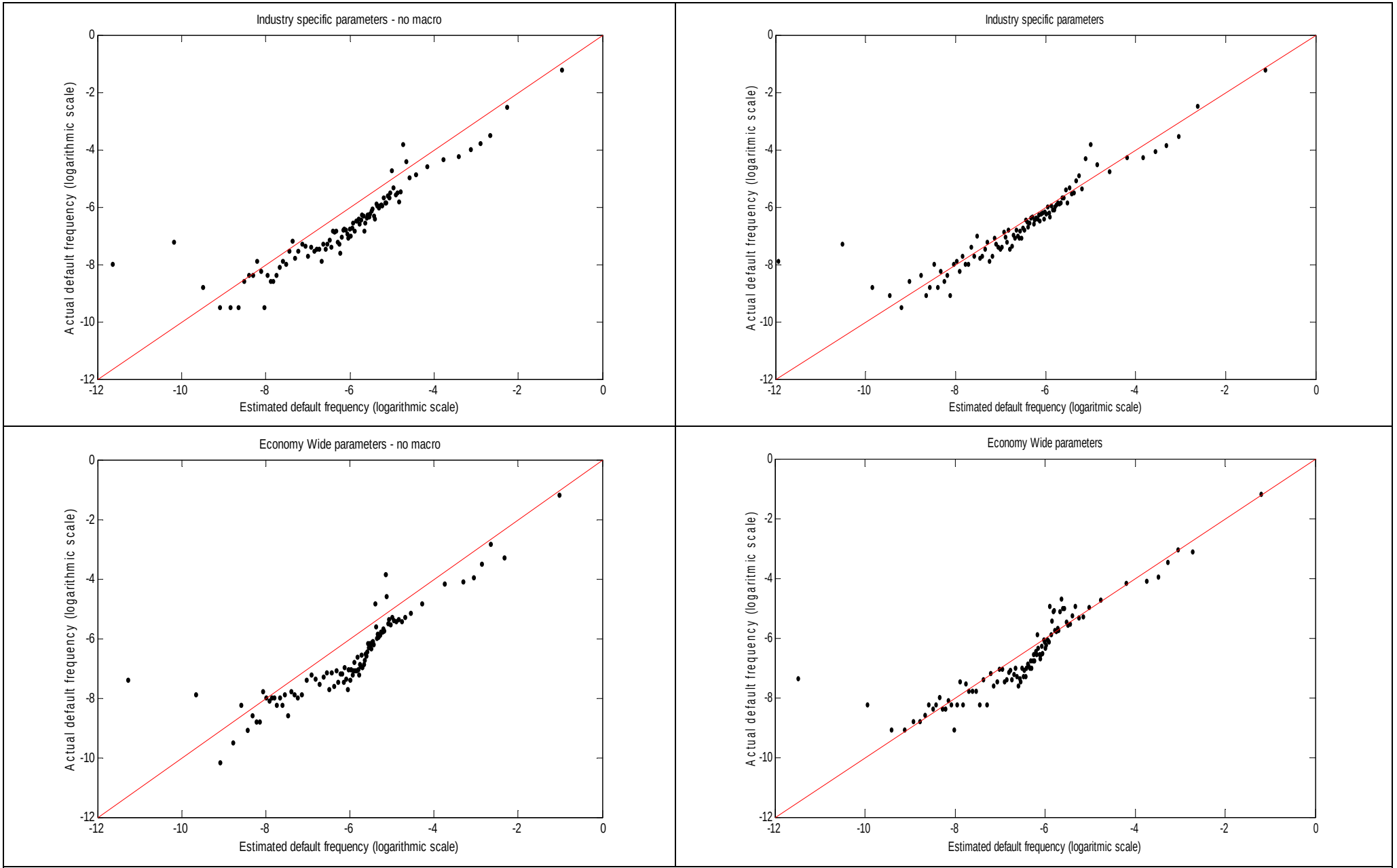
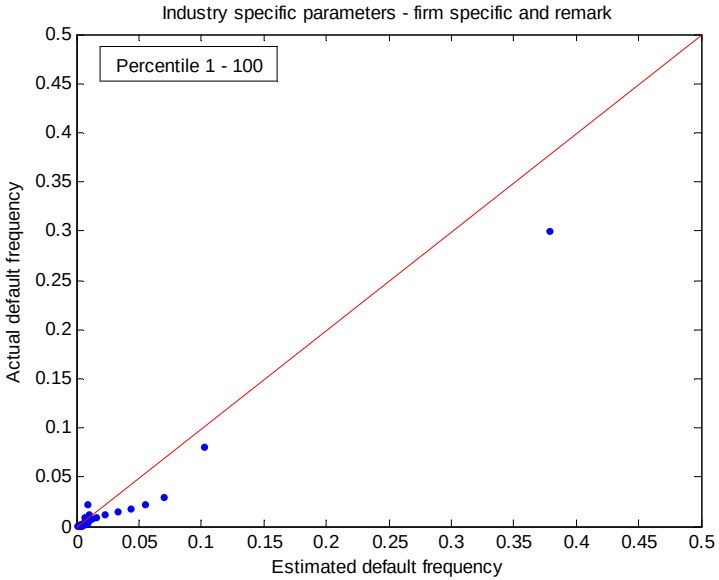


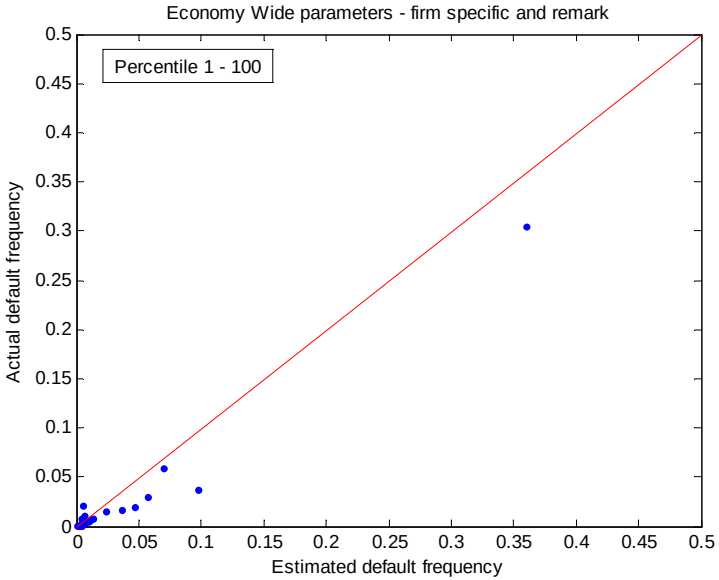
Figure XX: Sorted estimated default percentiles versus actual default frequencies for both economy-wide and industry-specific parameters. Left panel: Only firm-specific variables included (Table 2 models); Right panel: Macrovariables included (Table 3 models).

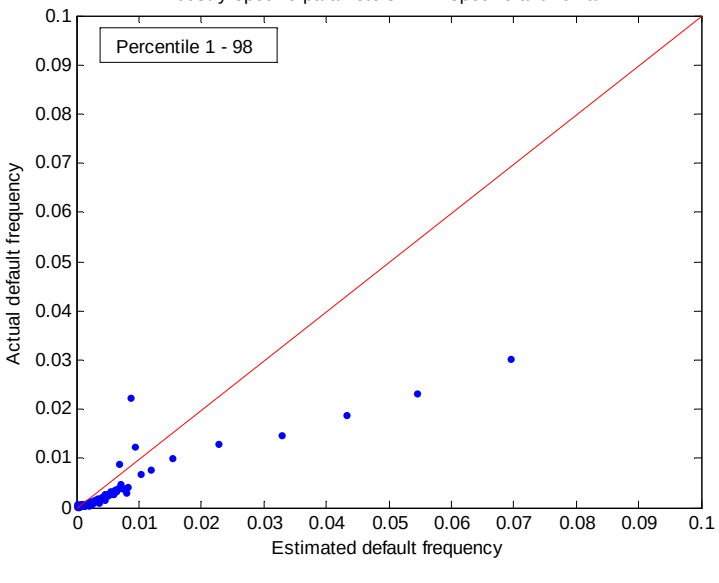
Concluding remarks

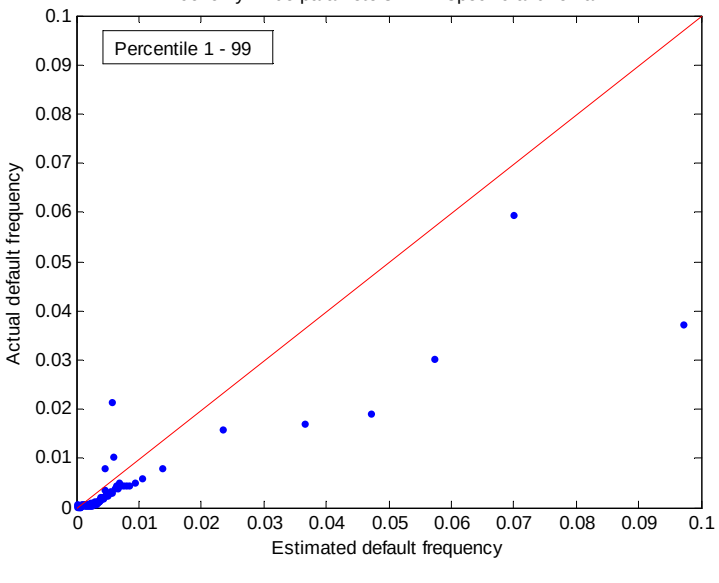
- Default-risk model with macro replicates data including peaks in beginning of the 1990s
  - Firm-specific variables do good job ranking firms; payment remarks in particular
  - But firm-specific variables cannot fully account for absolute level of default risk
  - Macroeconomic variables drivers of absolute levels of default risk at firm level, even in period of Swedish banking crisis
    - Hence banking-crisis can be "explained" by model (relations do not collapse)!
  - Estimation of default risk model using aggregate (i.e. average) data is not informative
  - Financial ratios are surprisingly non-cyclical; Possible causes:
    - Reporting frequency of defaulting/defaulted firms
    - Smoothing incentives for non-defaulting firms

- Effects of aggregate fluctuations on default probability
  - Very similar across industries
  - Slightly more pronounced in some industries in a plausible way (Construction, Real Estate, Banking Finance & Insurance), but differences not substantial
- Out-of-sample performance of industry models and economy-wide model:
  - Time-series dimension: both perform very well, beat all competitors
    - Industry models with macro variables outperform economy-wide model for 9/10 industries
    - Economy-wide slightly better when considering average over all industries
  - Cross-section dimension: both have as good fit as Shumway (2001)
    - Models tie in terms of R^2 and decile test
- Is there a role for separate models for industries?
  - No general gain, but likely dependent on the data



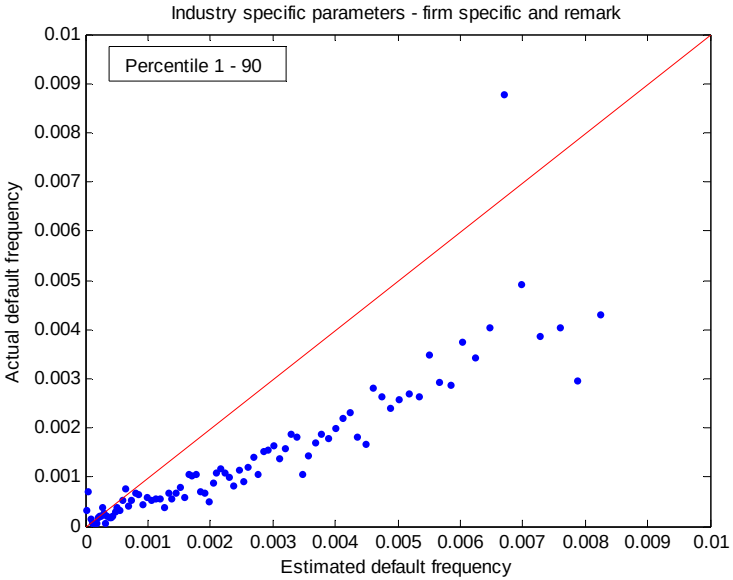






Industry specific parameters - firm specific and remark

Economy Wide parameters - firm specific and remark


Industry specific parameters - firm specific and remark
Percentile 1 - 90
Actual default frequency
Estimated default frequency
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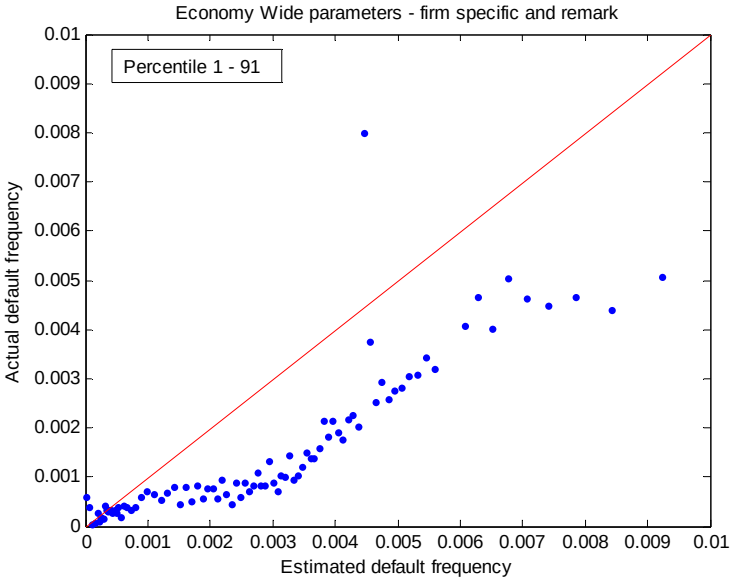
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.01


Economy Wide parameters - firm specific and remark
Percentile 1 - 91
Actual default frequency
Estimated default frequency
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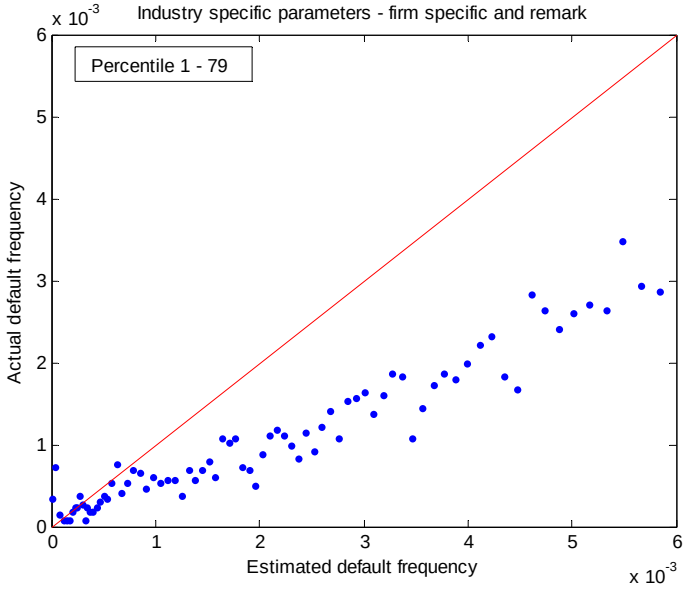
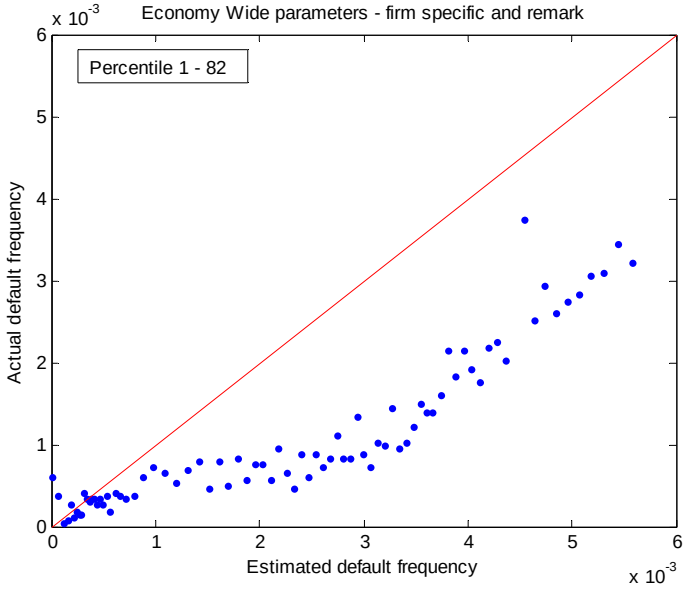
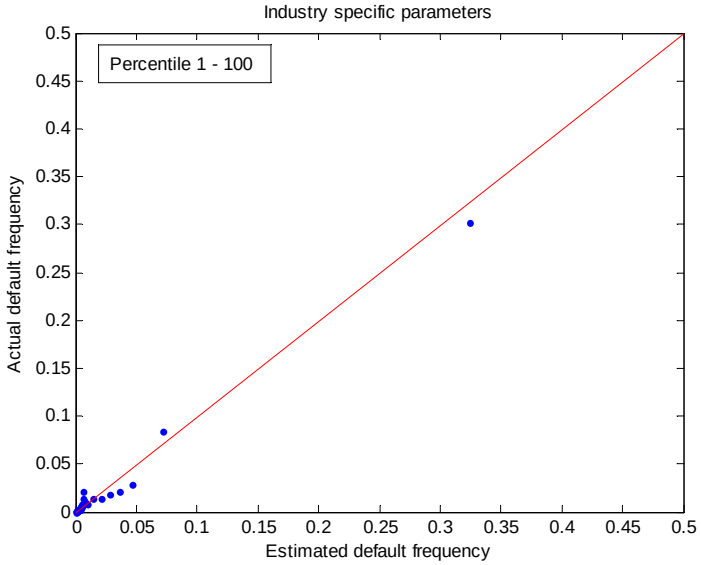
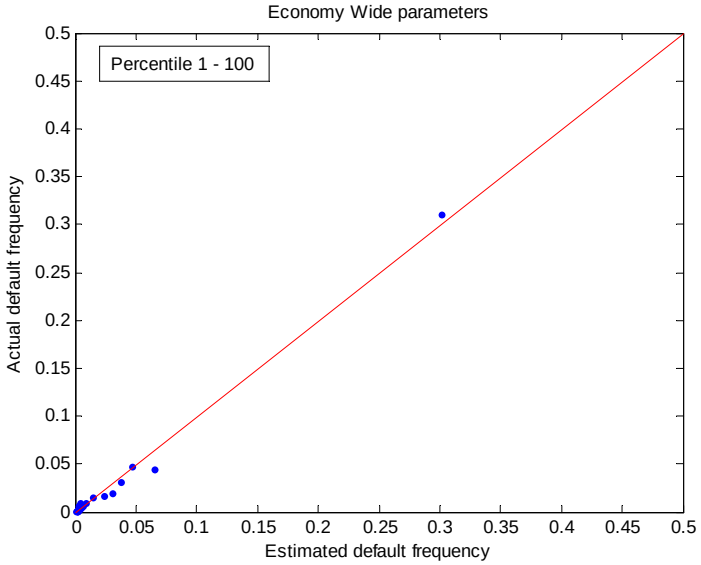
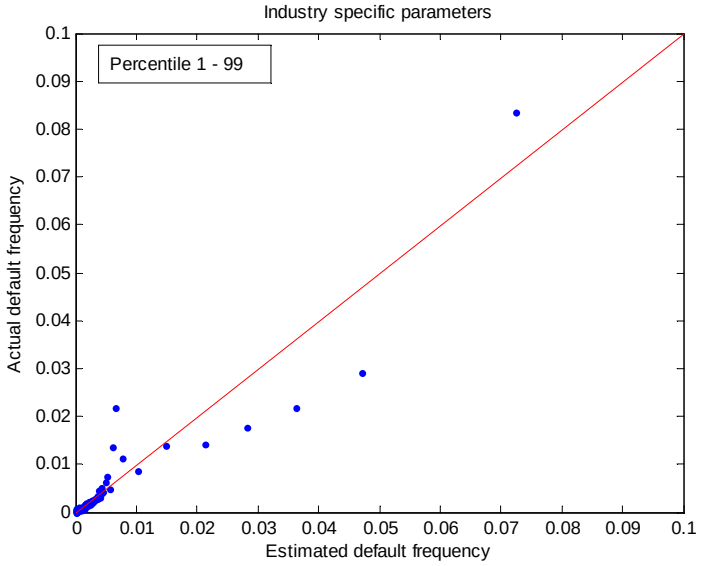
0.004
0.005
0.006
0.007
0.008
0.009
0.01

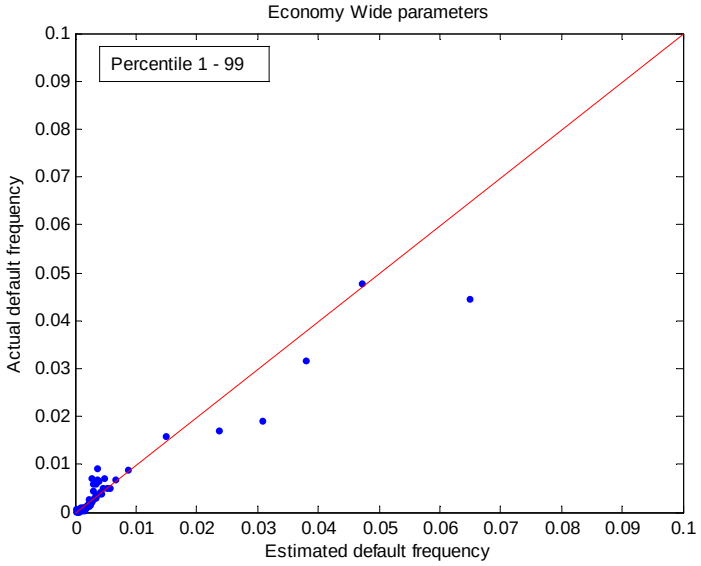

x 10^-3
Industry specific parameters - firm specific and remark
Percentile 1 - 79
Actual default frequency
Estimated default frequency
x 10^-3
0
1
2
3
4
5
6


x 10^-3
Economy Wide parameters - firm specific and remark
Percentile 1 - 82
Actual default frequency
Estimated default frequency
x 10^-3
0
1
2
3
4
5
6



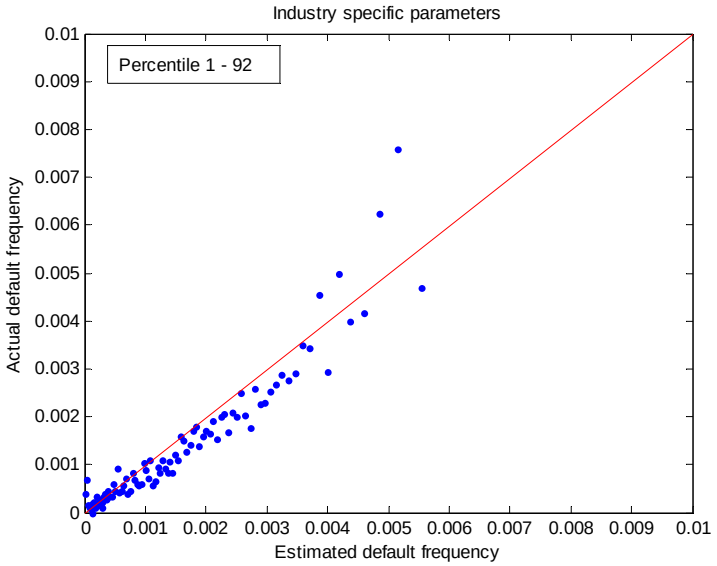






Industry specific parameters

Economy Wide parameters


Industry specific parameters
Percentile 1 - 92
Actual default frequency
Estimated default frequency
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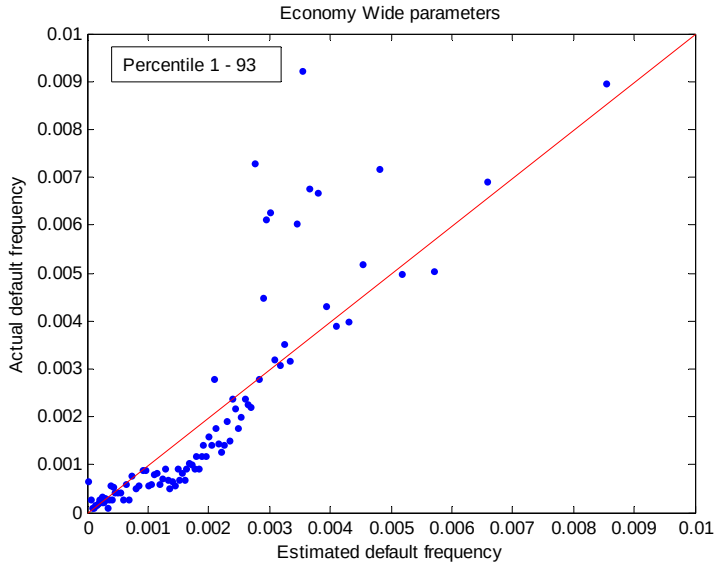
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.01


Economy Wide parameters
Percentile 1 - 93
Actual default frequency
Estimated default frequency
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0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.01