Appendix to Credit Booms Gone Bust: Replication of Schularick and Taylor (AER 2012)

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Appendix: the Bayesian Panel Probit Model

Following Koop, Poirier, and Tobias (2007, pp. 210-11), write the panel probit model as

$$z_{it} = w_{it} * \alpha_i + x_{it} * \beta + e_{it}$$
$$e_{it} \sim N(0, 1)$$
$$y_{it} = \mathbf{1}(z_{it} > 0)$$

Here, i indexes the 14 countries in the data set. Note that this is an unbalanced panel; the number of time observations T_i varies from 72 for Switzerland to 108 in Canada and Norway.

The matrix w_{it} includes variables whose coefficients vary by country, in the baseline case only a constant. The country-specific intercepts are assumed to be Normally distributed around a common mean, analogous to a frequentist random-effects model: $\alpha_i \sim N(\alpha, \sigma_a^2)$.

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The matrix x_{it} contains the k variables with coefficients that are common across all countries: the five lagged values of real credit growth, and up to five lags of the crisis dummy in the dynamic panel models.

The prior distribution of the parameters is given by

$$\begin{aligned} \alpha &\sim N(\mu_\alpha, V_\alpha) \\ \beta &\sim N(\mu_\beta, V_\beta) \\ \sigma_a^2 &\sim IG(a, b), \end{aligned}$$

where V_α and V_β are covariance matrices and IG denotes the inverted Gamma distribution. I set the values of the prior parameters to correspond to a fairly diffuse prior: $\mu_\alpha = 0,\ V_\alpha = 100,\ \mu_\beta = \mathbf{0}_k,\ V_\beta = 100 * \mathrm{I}_k,\ a = 3,$ and $b = 1$. The results in the paper were essentially unchanged by setting the scale factors in V_α and V_β to 10 or 1000.

Koop, Poirier, and Tobias (2007) show that inference in this model can be carried out via a Gibbs sampling algorithm using data augmentation, with the following steps:

1. Given the current values of the parameters $\alpha, \alpha_i, \beta, \sigma_\alpha^2$ and the data y, draw the latent variable z_{it} from a truncated Normal distribution with mean $\alpha_i + x_{it}\beta$ and variance 1. That is, each Normal draw is restricted to be non-positive when $y_{it} = 0$, and positive for $y_{it} = 1$.

2. Draw the country-specific intercepts α_i:

$$\begin{aligned} \alpha_i | \alpha, \sigma_\alpha^2, \beta, z, y &\sim N(D_{\alpha_i} d_{\alpha_i}, D_{\alpha_i}), \text{ where} \\ D_{\alpha_i} &= 1/(T_i + \sigma_\alpha^{-2}) \text{ and} \\ d_{\alpha_i} &= \sum_{t=1}^{T_i} (z_{it} - x_{it}\beta) + \sigma_\alpha^{-2}\alpha \end{aligned}$$

3. Draw the vector of common slope parameters:

$$\begin{aligned} \beta | \alpha, \alpha_i, \sigma_\alpha^2, z, y &\sim N(D_\beta d_\beta, D_\beta), \text{ where} \\ D_\beta &= \left(X'X + V_\beta^{-1}\right)^{-1} \\ d_\beta &= X'(z - \bar{\bar{\alpha}}) + V_\beta^{-1}\mu_\beta, \end{aligned}$$

with X and z the stacked versions of x_{it} and z_{it}. Also, $\bar{\bar{\alpha}} = [\alpha_1 \iota'_{T_1}, \ldots, \alpha_n \iota'_{T_n}]'$, with ι_{T_i} a $T_i \times 1$ vector of ones.

4. Draw the common mean of the intercepts:

$$\begin{aligned}\alpha|\beta,\alpha_i,z,y &\sim N(D_\alpha d_\alpha, D_\alpha)\\ D_\alpha &= (n/\sigma_\alpha^2 + V_\alpha^{-1})^{-1}\\ d_\alpha &= \sum_{i=1}^{n} \alpha_i/\sigma_\alpha^2 + V_\alpha^{-1}\mu_\alpha\end{aligned}$$

5. Draw the variance of the intercepts:

$$\sigma_\alpha^2|\alpha,\alpha_i,\beta,z,y \sim IG\left(n/2 + a, \left[1/b + 0.5\sum_{i=1}^{n}(\alpha_i - \alpha)^2\right]^{-1}\right)$$

The results in the paper are based on iterating through steps 1-5 a total of 6,000 times, discarding the initial 1,000 draws.

As mentioned in the paper, table 1 below presents results from models with zero to five lags of the dependent variable. The first four columns are identical to table 3 in the paper.

Table 1: Bayesian panel probit estimates[a]

	Dependent variable: crisisST					
Constant[b]	-2.143	-2.1412	-2.1172	-2.1044	-2.1089	-2.1114
	[-2.60, -1.70]	[-2.58, -1.71]	[-2.56, -1.69]	[-2.56, -1.66]	[-2.57, -1.66]	[-2.56, -1.67]
$crisisST_{t-1}$		-5.7531	-5.7758	-3.7892	-2.4999	-4.9384
		[-11.82, -1.16]	[-11.07, -1.09]	[-8.93, -0.49]	[-5.56, -0.48]	[-13.22, 0.59]
$crisisST_{t-2}$			-4.8169	-9.4255	-8.9641	-3.3071
			[-14.40, -0.50]	[-17.13, -0.62]	[-17.16, -1.54]	[-7.98, -0.42]
$crisisST_{t-3}$				-0.3993	-0.4114	-0.4357
				[-1.36, 0.35]	[-1.45, 0.36]	[-1.42, 0.35]
$crisisST_{t-4}$					-0.1307	-0.1658
					[-1.01, 0.59]	[-0.95, 0.52]
$crisisST_{t-5}$						-0.0034
						[-0.77, 0.63]
$\Delta \ln(credit)_{t-1}$	0.022	-0.1353	-0.3221	-0.2905	-0.2787	-0.2829
	[-1.66, 1.80]	[-1.92, 1.65]	[-2.03, 1.45]	[-2.14, 1.62]	[-2.17, 1.60]	[-2.03, 1.40]
$\Delta \ln(credit)_{t-2}$	3.271	3.3967	3.3978	3.2438	3.3090	3.2681
	[1.35, 5.29]	[1.53, 5.33]	[1.40, 5.41]	[1.22, 5.21]	[1.34, 5.23]	[1.38, 5.20]
$\Delta \ln(credit)_{t-3}$	0.703	0.8859	0.9629	0.9333	0.8368	0.8633
	[-1.18, 2.61]	[-0.98, 2.81]	[-0.97, 2.88]	[-1.08, 2.92]	[-1.10, 2.87]	[-1.08, 2.79]
$\Delta \ln(credit)_{t-4}$	0.011	-0.0895	0.1074	0.1614	0.0587	0.0522
	[-1.89, 1.87]	[-1.99, 1.89]	[-1.83, 2.04]	[-1.82, 2.11]	[-2.05, 2.08]	-2.07, 2.10
$\Delta \ln(credit)_{t-5}$	1.039	1.1216	0.9443	0.9713	1.1335	1.1685
	[-0.64, 2.72]	[-0.51, 2.76]	[-0.68, 2.72]	[-0.67, 2.62]	[-0.59, 2.92]	[-0.53, 2.95]
Sum of lags	5.046	5.1794	5.0901	5.0193	5.0594	5.0693
of credit growth	[2.15, 8.13]	[2.35, 8.14]	[2.24, 8.00]	[2.16, 7.98]	[2.02, 8.14]	[2.11, 8.28]
Avg. marg. effect[c]	0.0410	0.0388	0.0332	0.0309	0.0403	0.0539
	[.01, 0.07]	[0.01, 0.08]	[0.01, 0.08]	[0.01, 0.08]	[0.01, 0.10]	[0.01, 0.13]
AUROC	0.673	0.6911	0.7024	0.7033	0.7012	0.7005
	[0.63, 0.70]	[0.65, 0.72]	[0.66, 0.73]	[0.66, 0.73]	[0.66, 0.73]	[0.66, 0.73]
Log-likelihood[d]	-205.65	-202.81	-200.87	-200.57	-200.59	-200.62
DIC[e]	445.33	439.96	436.11	437.53	440.30	441.58

Notes:

[a] Table entries are the posterior means based on 5,000 Gibbs sampling draws after a burn-in of 1,000 draws. 95% highest posterior density intervals are in square brackets.

[b] All models include country-specific intercepts; the 'constant' is their posterior mean across countries.

[c] Increase in crisis probability associated with five-year credit growth that is one standard deviation above its sample mean, averaged across countries.

[d] The log-likelihood is evaluated at the posterior means of the parameters.

[e] Deviance Information Criterion. See Spiegelhalter et al. (2002)