ONLINE APPENDIX

Household Debt Revaluation and the Real Economy: Evidence from a Foreign Currency Debt Crisis

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This is the Online Appendix for "Household Debt Revaluation and the Real Economy: Evidence from a Foreign Currency Debt Crisis" by Emil Verner and Győző Gyöngyösi.

- Appendix A contains additional tables and figures.
- Appendix B contains details on the data sources.
- Appendix C provides details on theories of the consumption response to a household debt revaluation.
- Appendix D lays out a model of the aggregate economic response to a household debt revaluation in an open economy.
- Appendix E presents a framework to bound the degree of unobserved selection in the loan-level analysis on financial spillovers.

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A Appendix Tables and Figures

Table A.1 Additional Survey Evidence on Characteristics of LC and FC Borrowers

	FC Mean/s.d.	LC Mean/s.d.	Non-borr. Mean/s.d.	FC-LC Difference b/t	Borr.-non-borr. Difference b/t
Primary	0.18	0.33	0.31	-0.15	-0.06
	(0.38)	(0.47)	(0.46)	(-4.41)	(-2.76)
Vocational	0.32	0.35	0.30	-0.03	0.03
	(0.47)	(0.48)	(0.46)	(-0.77)	(1.27)
High school	0.34	0.21	0.28	0.13	0.00
	(0.48)	(0.41)	(0.45)	(3.86)	(0.03)
College	0.16	0.11	0.11	0.05	0.03
	(0.37)	(0.32)	(0.31)	(1.87)	(1.86)
HH income in	2778.53	2703.11	2228.05	75.43	515.34
2009 (1000 HUF)	(1365.64)	(1377.13)	(1191.66)	(0.70)	(7.84)
Employed	0.60	0.51	0.36	0.08	0.19
	(0.49)	(0.50)	(0.48)	(2.15)	(7.64)
Retired/student	0.30	0.37	0.53	-0.07	-0.23
	(0.46)	(0.48)	(0.50)	(-1.89)	(-8.42)
Age	41.43	44.59	53.34	-3.16	-10.44
	(13.38)	(15.32)	(18.49)	(-2.85)	(-12.89)
HH size	3.40	3.41	2.62	-0.01	0.78
	(1.35)	(1.60)	(1.48)	(-0.05)	(10.07)
Observations	365	331	1137	696	1833

Notes: This table is similar to Table 2, but uses data from a separate individual-level survey with information on loan currency denomination. In particular, this table presents average individual-level characteristics of local currency borrowers (LC), foreign currency borrowers (FC), and non-borrowers from the February 2010 wave of the Tarki Household Monitor, a household survey. Foreign currency borrowers are individuals who report having positive loan payments in foreign currency. Local currency borrowers are individuals who report having positive loan payments, but zero foreign currency loan payments. Non-borrowers are individuals who report having no loan payments. This table shows that, compared to LC borrowers, FC borrowers have similar or higher education, income, and employment rates, and that FC borrowers are slightly younger.

Table A.2 Initial Banking Density and Household Foreign Currency Debt

	(1) DTI 08	(2) LC DTI 08	(3) FC DTI 08	(4) HH FC debt share, s_{z08}^{FC}
Log branch density in 1995	-0.040	0.059	-0.099	-0.11
	(0.082)	(0.037)	(0.062)	(0.035)
Baseline Controls	Yes	Yes	Yes	Yes
Credit Quality Controls	Yes	Yes	Yes	Yes
Export Exposure Controls	Yes	Yes	Yes	Yes
Industry Employment Shares	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes
R^2	0.33	0.35	0.25	0.35
Observations	2538	2538	2538	2538

Notes: This table presents regressions of various measures of households' debt portfolios in September 2008 on the log retail banking density in 1995. Banking density is defined as the number of bank branches per capita. Settlements with a higher initial banking density (of domestic banks) have lower overall debt-to-income in 2008 (column 1), higher debt-to-income in local currency (column 2), lower debt-to-income in foreign currency (column 3), and therefore a lower share of debt in foreign currency (column 4). Observations are weighted by 2007 population. Standard errors are clustered at the subregion level (175 units).

Table A.3 Correlates of Alternative Measures of Household FC Debt Exposure

Panel A: Household debt revaluation to income, $\Delta \tilde{d}_z^{Inc}$

Right-hand-side variable	Coefficient	S.E.	R^2	N
Debt to disposable income, 2008:9	15.336	1.352	0.640	2538
Log disposable income per capita, 2007	2.134	1.004	0.021	2538
Log population, 2007	0.074	0.124	0.002	2538
Share of population age 18-59, 2007	15.061	6.248	0.008	2538
Vocational education share	-1.440	4.633	0.000	2538
High school share	12.315	5.078	0.037	2538
College share	4.299	4.211	0.007	2538
Unemployment rate, 2007	-21.628	6.415	0.057	2538
Household default rate, 2008:9	-26.188	9.963	0.005	2538
Firm default rate, 2008:Q3	0.987	1.431	0.000	2538
House price growth, 2003-07	1.541	1.696	0.003	2538
House price growth, 2005-07	0.136	1.883	0.000	2538
LTV	-22.151	6.060	0.025	2538
Change in LTV, 2004-05 to 2007-08	-1.338	3.271	0.000	2538
Export sales share, 2007	-2.297	1.174	0.018	2538
Export sales per capita, 2007	-45.821	29.142	0.012	2538
Log sales-employment ratio, 2007	-0.421	0.339	0.005	2538
Corporate FC indebtedness, 2008, $s_{z08}^{FC,Firm}$	-0.588	1.158	0.001	2538
Manufacturing employment share, 2007	-1.338	1.328	0.006	2538
Construction employment share, 2007	9.304	2.777	0.026	2538
Agriculture employment share, 2007	-4.355	1.170	0.020	2538

Notes: The table presents regressions of alternative measures of household foreign currency debt exposure on various settlement level characteristics:

$$[\text{HH FC Debt Exposure}]_z = \alpha + \beta x_z + u_z.$$

In Panel A, the measure of exposure is the household debt revaluation to income, from 2008 to 2010, defined in equation (4). In Panel B, the measure of exposure is the mortgage FC debt share in September 2008. Observations are weighted by 2007 population. Standard errors are clustered at the subregion level.

Table A.3 Correlates of Alternative Measures of Household FC Debt Exposure (cont.)

Panel B: Mortgage FC debt share, September 2008

Right-hand-side variable	Coefficient	S.E.	R^2	N
Debt to disposable income, 2008:9	-0.043	0.019	0.009	2538
Log disposable income per capita, 2007	0.014	0.021	0.002	2538
Log population, 2007	0.005	0.001	0.013	2538
Share of population age 18-59, 2007	-0.239	0.170	0.004	2538
Vocational education share	-0.034	0.136	0.000	2538
High school share	0.064	0.090	0.002	2538
College share	-0.013	0.097	0.000	2538
Unemployment rate, 2007	0.010	0.142	0.000	2538
Household default rate, 2008:9	-0.218	0.321	0.001	2538
Firm default rate, 2008:Q3	0.070	0.043	0.002	2538
House price growth, 2003-07	0.081	0.042	0.017	2538
House price growth, 2005-07	-0.034	0.046	0.002	2538
LTV	0.139	0.145	0.002	2538
Change in LTV, 2004-05 to 2007-08	0.011	0.088	0.000	2538
Export sales share, 2007	-0.006	0.030	0.000	2538
Export sales per capita, 2007	0.148	0.609	0.000	2538
Log sales-employment ratio, 2007	0.018	0.011	0.016	2538
Corporate FC indebtedness, 2008, $s_{z08}^{FC,Firm}$	0.048	0.032	0.013	2538
Manufacturing employment share, 2007	-0.015	0.034	0.001	2538
Construction employment share, 2007	-0.058	0.053	0.002	2538
Agriculture employment share, 2007	-0.063	0.034	0.008	2538

Table A.4 Robustness: Impact of Including Individual Sets of Controls on the Baseline Results

Panel A: Default Rate	(1) No Controls	(2) Education	(3) HH Lev. and Inc.	(4) Demogr.	(5) Industry and Export	(6) Public Emp.	(7) Credit Quality	(8) Region FE
HH FC debt share, $s_{z08}^{FC} \times$ Post	9.30	6.49	7.33	8.61	8.55	8.82	7.08	8.82
	(1.02)	(0.80)	(0.76)	(0.92)	(0.92)	(0.93)	(0.66)	(0.79)
R^2	0.84	0.86	0.85	0.85	0.84	0.85	0.86	0.85
Observations	71064	71064	71064	71064	71064	71064	71064	71064
Panel B: Log New Auto Reg.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HH FC debt share, $s_{z08}^{FC} \times$ Post	-109.1	-49.4	-73.3	-99.2	-87.1	-103.8	-65.7	-111.0
	(16.6)	(13.3)	(14.0)	(15.1)	(13.7)	(15.9)	(13.2)	(11.9)
R^2	0.82	0.83	0.83	0.83	0.83	0.82	0.83	0.83
Observations	17766	17766	17766	17766	17766	17766	17766	17766
Panel C: Unemployment rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HH FC debt share, $s_{z08}^{FC} \times$ Post	2.42	1.36	1.78	2.60	2.11	2.56	1.71	2.78
	(0.75)	(0.77)	(0.76)	(0.69)	(0.75)	(0.75)	(0.72)	(0.56)
R^2	0.61	0.62	0.61	0.61	0.61	0.61	0.61	0.63
Observations	17766	17766	17766	17766	17766	17766	17766	17766

Notes: This table examines the impact of adding various sets of controls separately on the baseline results. All controls are interacted with the Post_t indicator variable. Column 1 presents the estimates of (1) without controls. Column 2 includes the education share controls (vocational share, high school share, and college share). Column 3 controls for household debt-to-income in 2008 and log disposable income per capita in 2007. Column 4 controls for log population, the share age 18-59, and the share over 60. Column 5 controls for one-digit NACE industry employment shares, export sales per capita in 2007, and the export sales share in 2007. Column 6 controls for the public employment program that was expanded significantly in 2012. Column 7 includes all the "Credit quality controls" (settlement-level household default rate in 2008Q3, LTV, change in LTV from 2004-05 to 2007-08, house price growth from 2004 to 2007, and the settlement-level firm default rate in 2008). Column 8 controls for region fixed effects (7 units). Standard errors are clustered at the subregion level (175 units).

Table A.5 Robustness: Household Debt Revaluation Shock in the Cross Section from 2008 to 2010

Panel A: ΔDefault$_z$	(1)	(2)	(3)	(4)
HH debt revaluation, $\Delta\tilde{d}_z$	0.26	0.17		
	(0.031)	(0.024)		
HH debt to inc. revaluation, $\Delta\tilde{d}_z^{Inc}$			0.051	0.11
			(0.014)	(0.019)
R^2	0.078	0.28	0.011	0.28
Observations	2538	2538	2538	2538
Panel B: ΔLog New Auto Reg.$_z$	(1)	(2)	(3)	(4)
HH debt revaluation, $\Delta\tilde{d}_z$	-4.22	-1.65		
	(0.76)	(0.46)		
HH debt to inc. revaluation, $\Delta\tilde{d}_z^{Inc}$			-0.69	-1.33
			(0.39)	(0.38)
R^2	0.044	0.36	0.0043	0.36
Observations	2538	2538	2538	2538
Panel C: ΔUnemp. rate$_z$	(1)	(2)	(3)	(4)
HH debt revaluation, $\Delta\tilde{d}_z$	0.093	0.060		
	(0.026)	(0.024)		
HH debt to inc. revaluation, $\Delta\tilde{d}_z^{Inc}$			0.024	0.037
			(0.012)	(0.013)
R^2	0.022	0.18	0.0055	0.18
Observations	2538	2538	2538	2538
Baseline Controls		Yes		Yes
Credit Quality Controls		Yes		Yes
Export Exposure Controls		Yes		Yes
Industry Employment Shares		Yes		Yes
Region FE (7 units)		Yes		Yes

Notes: This table shows that the main settlement level results are robust to using the household debt revaluation shock measures defined in equations (3) and (4). The regressions are estimated using cross-sectional differences from 2008 to 2010. Observations are weighted by 2007 population. Standard errors are clustered at the subregion level (175 units).

Table A.6 Oster (2019) Bounds for Robustness to Proportional Selection on Unobservables

Panel A: No controls to all controls

	No controls		All controls		R^2_{max}		Bounding values	
Specification	$\dot{\beta}$	$\dot{R}^2$	$\tilde{\beta}$	$\tilde{R}^2$	$\Pi = 1.3$	$\Pi = 2$	$\beta^*_{\Pi=1.3}$	$\beta^*_{\Pi=2}$
Default	9.30	0.06	5.73	0.25	0.32	0.49	4.29	0.95
Auto registration	-109.06	0.03	-53.14	0.18	0.24	0.37	-33.12	13.60
Unemployment	2.42	0.01	1.65	0.13	0.17	0.26	1.39	0.80

Panel B: Education controls to all controls

	Educ. controls		All controls		R^2_{max}		Bounding values	
Specification	$\dot{\beta}$	$\dot{R}^2$	$\tilde{\beta}$	$\tilde{R}^2$	$\Pi = 1.3$	$\Pi = 2$	$\beta^*_{\Pi=1.3}$	$\beta^*_{\Pi=2}$
Default	6.49	0.16	5.73	0.25	0.32	0.49	5.11	3.65
Auto registration	-49.40	0.12	-53.14	0.18	0.24	0.37	-56.50	-64.33
Unemployment	1.36	0.04	1.65	0.13	0.17	0.26	1.77	2.05

Notes: This table constructs bounding values for the baseline estimates following the procedure outlined by Oster (2019), building on Altonji, Elder and Taber (2005). The procedure assumes that selection on unobservables is proportional to selection on observables. The bounding value, β^* is constructed as $\beta^* = \tilde{\beta} - \frac{(\dot{\beta}-\tilde{\beta})(R^2_{max}-\tilde{R}^2)}{\tilde{R}^2-\dot{R}^2}$, where $\dot{\beta}$ and $\dot{R}^2$ are the point estimate and R-squared for the regression without controls and $\tilde{\beta}$ and $\tilde{R}^2$ are the same values from the regression with controls. The calculations assume that the degree of proportionality between selection on unobservables and selection on observables is one ($\delta = 1$). The procedure requires making an assumption about the maximum possible R^2. We follow the calibration in Oster (2019) and use $R^2 = \min(1, \Pi \cdot \tilde{R}^2)$ with $\Pi = 1.3$ as our benchmark R^2_{max}, and we also show robustness to the more conservative value of $\Pi = 2$. The R-squared is the R-squared using variation within settlement and within time fixed effects. Panel A presents the bounding value when moving from the specification with no controls (column 1 in Tables 4 and 5) to the specification with all controls (column 3 in Table 4 and 5). Panel B presents the bounding values when moving from the specification with education controls (Table A.4 column 2) to all controls.

Table A.7 Robustness: Alternative Hypotheses and Other Measures of Exposure

Panel A: Default rate

	Alternative Hypotheses							Other Measures of Exposure		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	IV: Mort. FC share	IV: 03-05 FC share	OLS	OLS	OLS	OLS	OLS	OLS
HH FC debt share, $s_{z08}^{FC} \times POST_t$	5.44	5.53	5.04	4.92	4.02	5.54	5.44			
	(0.69)	(0.70)	(0.90)	(1.14)	(0.78)	(0.69)	(0.64)			
Fraction of loans in FC, $f_{z08}^{FC} \times$ Post								6.13		
								(0.76)		
FC loans per adult (std.) × Post									0.90	
									(0.10)	
LC loans per adult (std.) × Post										-0.33
										(0.14)
Unemployment rate $\hat{\beta}_z \times$ Post	0.15									
	(0.062)									
Unemployment rate, 2007 × Post		-0.10								
		(0.025)								
Home equity share in FC debt × Post		2.49								
		(0.73)								
DTI Increase, 2004-2008 × Post					0.069					
					(0.013)					
New HH lending, 2008-2011 × Post						2.17				
						(1.57)				
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Credit Quality Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Export Exposure Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Employment Shares	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Region FE (20 units)							Yes			
IV 1st Stage F-statistic			1824.8	449.5						
R^2	0.58	0.59	0.58	0.58	0.59	0.58	0.59	0.58	0.58	0.58
Observations	70616	71036	71064	71036	70896	71064	71064	71064	71064	71064

Notes: This table shows that the effect of household foreign currency debt exposure on local unemployment is robust to a variety of specification and robustness checks. Panels A, B, and C present the results for the settlement default rate (quarterly), log new auto registrations (annual), and unemployment rate (annual). Controls are as defined in Table 4 and are interacted with Post_t. Observations are weighted by 2007 population. Standard errors are clustered at the subregion level (175 units).

Table A.7 Robustness: Alternative Hypotheses and Other Measures of Exposure (cont.)

Panel B: Log New Auto Registrations

	Alternative Hypotheses							Other Measures of Exposure		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	IV: Mort. FC share	IV: 03-05 FC share	OLS	OLS	OLS	OLS	OLS	OLS
HH FC debt share, $s_{z08}^{FC} \times POST_t$	-55.0	-47.5	-46.8	-43.5	-51.0	-54.2	-35.8			
	(9.17)	(9.00)	(10.4)	(16.5)	(10.4)	(9.12)	(8.27)			
Fraction of loans in FC, $f_{z08}^{FC} \times$ Post								-74.2		
								(10.9)		
FC loans per adult (std.) $\times$ Post									-17.6	
									(1.98)	
LC loans per adult (std.) $\times$ Post										1.80
										(1.54)
Unemployment rate $\hat{\beta}_z \times$ Post	-2.22									
	(0.97)									
Unemployment rate, 2007 $\times$ Post		-1.59								
		(0.51)								
Home equity share in FC debt $\times$ Post		-31.7								
		(7.82)								
DTI Increase, 2004-2008 $\times$ Post					-0.24					
					(0.23)					
New HH lending, 2008-2011 $\times$ Post						53.0				
						(28.5)				
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Credit Quality Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Export Exposure Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Employment Shares	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Region FE (20 units)							Yes			
IV 1st Stage F-statistic			1822.0	449.1						
R^2	0.77	0.77	0.77	0.77	0.77	0.77	0.78	0.77	0.77	0.77
Observations	17654	17759	17766	17759	17724	17766	17766	17766	17766	17766

Table A.7 Robustness: Alternative Hypotheses and Other Measures of Exposure (cont.)

Panel C: Unemployment Rate

	Alternative Hypotheses							Other Measures of Exposure		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	OLS	IV: Mort. FC share	IV: 03-05 FC share	OLS	OLS	OLS	OLS	OLS	OLS
HH FC debt share, $s_{z08}^{FC} \times POST_t$	1.54	2.18	1.49	1.86	1.39	1.58	1.47			
	(0.51)	(0.48)	(0.58)	(0.76)	(0.58)	(0.52)	(0.49)			
Fraction of loans in FC, $f_{z08}^{FC} \times$ Post								2.04		
								(0.54)		
FC loans per adult (std.) × Post									0.29	
									(0.079)	
LC loans per adult (std.) × Post										-0.10
										(0.074)
Unemployment rate $\hat{\beta}_z$ × Post	0.25									
	(0.047)									
Unemployment rate, 2007 × Post		-0.22								
		(0.023)								
Home equity share in FC debt × Post		0.84								
		(0.40)								
DTI Increase, 2004-2008 × Post					0.011					
					(0.0086)					
New HH lending, 2008-2011 × Post						-1.64				
						(0.86)				
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Credit Quality Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Export Exposure Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Employment Shares	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Region FE (20 units)							Yes			
IV 1st stage F-statistics			1822.0	449.1						
R^2	0.63	0.65	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
Observations	17654	17759	17766	17759	17724	17766	17766	17766	17766	17766

Table A.8 Covariate Balance on the Propensity-Score Matched Sample

	Treat. Mean	Control Mean	Treat.-Control Diff.	t-stat. for Diff.	Norm. Diff.
Debt to disposable income, 2008:9	0.63	0.61	0.02	0.92	0.05
Log disposable income per capita, 2007	13.47	13.49	-0.02	0.25	-0.05
Log population, 2007	8.77	8.76	0.01	0.01	0.00
Share of population age 18-59, 2007	0.61	0.61	0.00	0.97	0.08
Share of population older than 60, 2007	0.22	0.21	0.00	1.00	0.07
Vocational education share	0.23	0.22	0.01	0.46	0.10
High school share	0.24	0.24	0.00	0.06	0.01
College share	0.10	0.11	-0.01	0.52	-0.14
Unemployment rate, 2007	8.27	7.21	1.06	1.20	0.16
Default rate, 2008:9	1.11	1.13	-0.02	0.14	-0.01
Firm default rate, 2008:Q3	6.34	5.54	0.80	1.67	0.08
LTV	0.62	0.61	0.00	0.98	0.08
Change in LTV, 2004-05 to 2007-08	0.06	0.06	0.00	0.16	0.02
House price growth, 2003-07	31.10	26.58	4.51	1.64	0.19
House price growth, 2005-07	16.14	15.25	0.89	0.36	0.04

Notes: This table presents the covariate balance for the propensity-score matched sample. Treatment and Control settlements are defined as those in the top and bottom quartiles of the household FC debt share in September 2008. For each variable X, the normalized difference is defined following Imbens and Wooldridge (2009) as $\frac{\overline{X}_T - \overline{X}_C}{\sqrt{S_T^2 + S_C^2}}$, where $\overline{X}_T$ and $\overline{X}_C$ are the treatment and control sample means, and S_T^2 and S_C^2 are the variances of X in the treatment and control samples.

Table A.9 Robustness: Propensity Score Matching Based on Top and Bottom Quartile of Household FC Debt Exposure

	OLS		PS-Matched Sample			
Panel A: Default	(1)	(2)	(3)	(4)	(5)	(6)
Treatment × Post	1.89	1.09	1.18	1.11		
	(0.22)	(0.19)	(0.29)	(0.20)		
HH FC debt share, s_{z08}^{FC} × Post					6.30	4.94
					(1.11)	(0.82)
R^2	0.44	0.84	0.41	0.81	0.41	0.81
Observations	48440	48440	29148	29148	29148	29148
Panel B: New Auto Reg.	(1)	(2)	(3)	(4)	(5)	(6)
Treatment × Post	-23.8	-10.4	-18.6	-10.1		
	(3.74)	(2.58)	(6.05)	(2.58)		
HH FC debt share, s_{z08}^{FC} × Post					-77.5	-45.8
					(23.7)	(10.5)
R^2	0.71	0.83	0.69	0.82	0.69	0.82
Observations	12110	12110	7287	7287	7287	7287
Panel C: Unemployment Rate	(1)	(2)	(3)	(4)	(5)	(6)
Treatment × Post	0.44	0.35	0.38	0.27		
	(0.18)	(0.14)	(0.16)	(0.12)		
HH FC debt share, s_{z08}^{FC} × Post					1.66	1.23
					(0.63)	(0.46)
R^2	0.55	0.62	0.52	0.59	0.52	0.59
Observations	12110	12110	7287	7287	7287	7287
Settlement and Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Controls		Yes		Yes		Yes
Region FE (7 units)		Yes		Yes		Yes
Credit Quality controls		Yes		Yes		Yes
Export Exposure Controls		Yes		Yes		Yes
Industry Employment Shares		Yes		Yes		Yes

Notes: This table examines the robustness of the main settlement level results when matching settlements in the top and bottom quartile of exposure using propensity score matching. Treatment in an indicator variable that equals one for settlements in the top quartile of exposure based on s_{z08}^{FC} and zero for settlements in the bottom quartile of exposure. Columns 1 and 2 report OLS regressions as in equation (1) Treatment as the measure of exposure. Column 3-6 estimate the regressions on the propensity-score matched sample. The sample is matched using our full set of controls. Columns 5 and 6 use the continuous measure of treatment, s_{z08}^{FC}, on the matched sample. Standard errors are clustered at the subregion level (175 units).

Table A.10 Robustness: Weighting and Subsamples

Panel A: Default rate	(1) Full sample	(2) 50% Smallest Settlements	(3) 50% Largest Settlements	(4) Largest Cities	(5) 175 Subregions	(6) 175 Subregions
HH FC debt share, $s_{z08}^{FC} \times$ Post	3.95	3.20	5.70	3.77	10.2	5.72
	(0.80)	(0.86)	(1.02)	(1.40)	(1.82)	(1.44)
R^2	0.47	0.39	0.60	0.65	0.51	0.69
Observations	71064	35532	35532	8568	4900	4900
Panel B: New auto reg.	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, $s_{z08}^{FC} \times$ Post	-24.8	-13.7	-63.3	-96.1	-152.3	-102.8
	(6.33)	(7.09)	(10.7)	(22.1)	(29.9)	(27.5)
R^2	0.60	0.48	0.72	0.82	0.80	0.87
Observations	17766	8883	8883	2142	1225	1225
Panel C: Unemployment rate	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, $s_{z08}^{FC} \times$ Post	1.10	0.84	1.65	2.46	1.92	2.38
	(0.42)	(0.46)	(0.59)	(1.15)	(0.98)	(1.03)
R^2	0.38	0.30	0.54	0.64	0.65	0.73
Observations	17766	8883	8883	2142	1225	1225
Weights	Equal	Equal	Equal	Equal	Pop.	Pop.
Settlement FE	Yes	Yes	Yes	Yes		
Subregion FE					Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes	Yes	Yes
Credit Quality Controls	Yes	Yes	Yes	Yes	Yes	Yes
Export Exposure Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Employment Shares	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This tables examines the robustness of the main settlement-level results to weighting schemes, subsamples, and the level of aggregation. In columns 5 and 6, the data are aggregated to the level of 175 subregions. Controls are as in Table 4 column 3, and all controls are interacted with the Post_t indicator. Standard errors are clustered at the subregion level (175 units).

Table A.11 Robustness: Firm Employment Regressions Controlling for Lagged Employment Growth and Weighting by Log Employment

Panel A: Lagged Employment Growth Control				
	All Firms	Non-Exporters	Exporters	Non-Tradable
	(1)	(2)	(3)	(4)
HH FC debt share, $s_{z08}^{FC} \times$ Post	-8.05	-8.77	-1.48	-10.9
	(2.74)	(3.03)	(6.76)	(5.00)
Lagged growth rate $\times$ Post	0.35	0.34	0.45	0.35
	(0.0064)	(0.0082)	(0.016)	(0.012)
Firm and Year FE	Yes	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes	Yes
Settlement Controls	Yes	Yes	Yes	Yes
Region (7 units) FE	Yes	Yes	Yes	Yes
2-Digit Industry FE	Yes	Yes	Yes	Yes
R^2	0.094	0.10	0.098	0.11
Observations	463869	373352	90517	117327
Panel B: Log Employment Weights				
	All Firms	Non-Exporters	Exporters	Non-Tradable
	(1)	(2)	(3)	(4)
HH FC debt share, $s_{z08}^{FC} \times$ Post	-8.86	-10.5	-2.52	-10.1
	(3.45)	(3.90)	(7.54)	(6.14)
Firm and Year FE	Yes	Yes	Yes	Yes
Firm-level Controls	Yes	Yes	Yes	Yes
Settlement Controls	Yes	Yes	Yes	Yes
Region (7 units) FE	Yes	Yes	Yes	Yes
2-Digit Industry FE	Yes	Yes	Yes	Yes
R^2	0.065	0.075	0.059	0.075
Observations	463869	373352	90517	117327

Notes: This table shows that the firm employment growth estimates in Table 6 are robust to controlling for firm-level lagged employment growth (Panel A) and to weighting observations by 2007 log firm employment (Panel B). Lagged employment growth is computed from 2006 to 2007. Panel B weights by log employment instead of the level of employment because the firm size distribution is highly skewed, so the mean and variance of the level weights are not necessarily finite. Standard errors are clustered at the subregion level (175 units).

Table A.12 Household Debt Revaluation to Income and Firm Employment

	All Firms	Non-Exporters	Exporters	Non-Tradable
	(1)	(2)	(3)	(4)
HH debt to inc. revaluation × Post	-0.18	-0.23	0.16	-0.20
	(0.071)	(0.081)	(0.21)	(0.13)
Firm and Year FE	Yes	Yes	Yes	Yes
Firm-level controls	Yes	Yes	Yes	Yes
Settlement controls	Yes	Yes	Yes	Yes
Region (7 units) FE	Yes	Yes	Yes	Yes
2-Digit Industry FE	Yes	Yes	Yes	Yes
R^2	0.066	0.073	0.057	0.076
Observations	463869	373352	90517	117327

Notes: This table is similar to Table 6, but uses the household debt revaluation relative to income from 2008 to 2010 defined in equation (4) as the measure of the household foreign currency debt shock. The dependent variable is log firm employment. Standard errors are clustered at the subregion level (175 units).

Table A.13 Household Debt Revaluation and Firm Employment: Controlling for Bank Credit Supply Shocks

	(1)	(2)	(3)	(4)
HH FC debt share, $s_{z08}^{FC} \times$ Post	-8.52	-6.81	-10.1	-9.77
	(3.81)	(3.76)	(3.34)	(3.35)
Firm and Year FE	Yes	Yes	Yes	Yes
Bank FE		Yes		Yes
Firm-level Controls			Yes	Yes
Settlement Controls			Yes	Yes
Region (7 units) FE			Yes	Yes
2-Digit Industry FE			Yes	Yes
R^2	0.92	0.92	0.92	0.92
Number of Firms	66267	66267	66267	66267
Observations	775533	775533	775533	775533

Notes: This table addresses the potential concern that the firm-level effect of household debt revaluation is spuriously driven by a differential contraction in bank lending to firms. The table presents regressions at the firm-year-bank relationship level to control for unobserved time-varying bank lending shocks. The specification is

$$\ln(E_{ibt}) = \alpha_i + \gamma_t + \delta_{bank,Post} + \beta(s_{z08}^{FC}\text{Post}_t) + (X_i\text{Post}_t)\Gamma^F + (X_z\text{Post}_t)\Gamma^S + \epsilon_{ibt}.$$

The dependent variable is log firm employment. $\delta_{bank,Post}$ is a bank by Post_t fixed effect that absorbs time-varying bank-relationship-specific shocks. We obtain information on firm-bank relationships from a register of firms' bank account numbers and assume that a firm-bank pair have a lending relationship if the firm has an account with a given bank between 2006 and 2008. Steven Ongena, Ibolya Schindele and Dzsamila Vonnák (2017) demonstrate a strong bank lending channel of monetary policy for these firm-bank pairs. Controls are as defined in Table 6, and all controls are interacted with Post_t. To recover the firm-level estimates, observations are re-weighted by the inverse of a firm's total number of relationships. A firm is assumed to have a banking relationship if it has a relationship in 2006, 2007, or 2008. We also include a separate fixed effect interacted with Post_t for firms without a banking relationship. One-tenths of firms have no banking relationship, 48 percent of firms have exactly one banking relationship, and the remaining 42 percent of firms have two or more relationship. Standard errors are dually clustered on bank identifier and subregion (175 units).

Table A.14 Labor Market Adjustment: Wages and Migration

	Log Payroll Per Worker		Log Nominal Wages		In-Migration Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, $s_{z08}^{FC} \times$ Post	-3.07	-4.13	7.18	7.27	0.0055	0.0063
	(3.40)	(3.64)	(4.63)	(5.64)	(0.0032)	(0.0027)
Unit of Obs.	Firm	Firm	Settl.	Settl.	Settl.	Settl.
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes				
Settlement FE			Yes	Yes	Yes	Yes
Firm Controls		Yes				
2-Digit Industry FE		Yes				
Settlement Controls		Yes		Yes		Yes
Region (7 units) FE		Yes		Yes		Yes
R^2	0.027	0.033	0.63	0.64	0.0013	0.074
Observations	461682	461682	8321	8321	17488	17488

Notes: This table presents estimates of the effect of household FC debt exposure on wages and the in-migration rate. There is limited evidence of a gradual downward adjustment in wages following the debt revaluation shock, and no evidence of an increase in out-migration. Payroll per worker in columns 1 and 2 is total payroll expenses divided by the number of employees in the firm-level census data (NAV). Nominal wages in columns 3 and 4 refers to the settlement average of residualized hourly wages multiplied by 100, estimated from the worker-level Structure of Earnings Survey. Details on the residual wages from the Structure of Earnings Survey are provided in Appendix B.2. The advantage of the payroll per worker measure is that it covers the universe of firms in NAV, whereas the Structure of Earnings Survey only contains a sample of workers. The advantage of the nominal wage growth estimates from the Structure of Earnings Survey is that we can compute wages residualized with worker-level characteristics. Note that while the nominal sample size in columns 3 and 4 is only 794 settlements, this sample represents 87.8 percent of the overall 2007 population. The in-migration rate in columns 5 and 6 is the settlement in-migration to population ratio. Observations in columns 3-6 are weighted by 2007 population. Standard errors are clustered at the subregion level (175 units).

Table A.15 Household Debt Revaluation and Housing Markets

	Log Median House Prices		Log Hedonic House Prices		New Housing Units Per 1000 Inhabitants	
	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, $s_{z08}^{FC} \times \mathbf{1}_{2009-10}$	-34.0	5.97	-13.1	-5.32	3.15	0.30
	(6.25)	(6.70)	(9.51)	(8.14)	(0.99)	(0.94)
HH FC debt share, $s_{z08}^{FC} \times \mathbf{1}_{2011-12}$	-51.2	-7.09	-31.6	-18.9	7.31	3.82
	(9.15)	(7.80)	(10.8)	(9.13)	(0.98)	(0.85)
Baseline Controls		Yes		Yes		Yes
Credit Quality Controls		Yes		Yes		Yes
Export Exposure Controls		Yes		Yes		Yes
Industry Employment Shares		Yes		Yes		Yes
Region FE (7 units)		Yes		Yes		Yes
R^2	0.39	0.49	0.13	0.23	0.24	0.29
Observations	17766	17766	12690	12690	17760	17760

Notes: This table explores the connection between household foreign currency exposure and housing markets. The dependent variable in columns 1 and 2 is the log median house price index. Columns 3 and 4 use the hedonic house price index (Figure 7 shows the estimates over time for both indices). House price indexes are measured at the subregion level. The dependent variable in columns 5 and 6 is the number of new housing units relative per 1000 inhabitants. Variables $\mathbf{1}_{2009-10}$ and $\mathbf{1}_{2011-12}$ equal one in year 2009-10 and 2011-12, respectively, and zero otherwise. Observations are weighted by 2007 population. Standard errors are clustered at the subregion level (175 units).

Table A.16 Loan-Level Default by Borrower Leverage and Loan Maturity

	LC and FC Housing Loans		
	(1)	(2)	(3)
$FC_i \times$ Post	4.03	2.01	8.40
	(0.21)	(0.22)	(1.25)
$FC_i \times \text{HighLev}_b \times$ Post		3.82	
		(0.16)	
$FC_i \times \text{Maturity}_i \times$ Post			-0.22
			(0.052)
Loan and Time FE	Yes	Yes	Yes
Loan Controls	Yes	Yes	Yes
Borrower Controls	Yes	Yes	Yes
Settlement Controls	Yes	Yes	Yes
R^2	0.037	0.038	0.041
Number of Loans	664659	664659	664659
Observations	20960622	20960622	20960154

Notes: This table presents loan-level estimates of equation (7) and examines whether foreign currency borrowers with higher leverage and shorter maturity loans are more likely to default. The dependent variable is an indicator for whether a loan is in default in quarter t. FC_i is an indicator that equals one for loans in foreign currency. HighLev_b is an indicator variable that equals one when a borrower's debt in 2008 relative to settlement income per capita is above the median. Maturity_i is loan i's maturity in years. Loan controls refer to loan type fixed effect (mortgage or HE). Borrower controls are the total number of mortgage and HE loans, log total borrower debt in 2008Q3, and five-year age bin fixed effects. Settlement controls refers to all the controls in Table 4, column 3. All controls are interacted with the Post indicator. Standard errors are clustered at the subregion level (175 units).

Table A.17 Determinants of Firm Foreign Currency Financing

Right-hand-side variable	Coefficient	S.E.	R^2	N
Log employment, 2007	0.032	0.001	0.019	66267
Log sales per worker, 2007	0.020	0.001	0.006	66267
Employment growth, 2004-07	0.024	0.002	0.002	61448
Export sales share, 2007	0.146	0.011	0.009	66267
Exporter	0.071	0.007	0.010	66267
Manufacturing	0.045	0.003	0.004	66267

Notes: This table presents firm-level univariate regressions of a firm's foreign currency debt share on various firm characteristics:

$$(\text{Firm FC debt share})_{i08} = \alpha + \beta x_i + u_i.$$

Standard errors are clustered at the subregion level (175 units).

Table A.18 Household and Firm FC Debt Exposure by Firm Size

	All Firms	Small (3 to 9)	Medium (10 to 50)	Large ($\geq$ 51)
	(1)	(2)	(3)	(4)
HH FC debt share, s_{z08}^{FC}	0.041	0.056	0.0093	-0.0050
	(0.034)	(0.030)	(0.054)	(0.11)
R^2	0.000090	0.00019	0.0000041	0.00000092
Observations	66267	47015	15443	3809

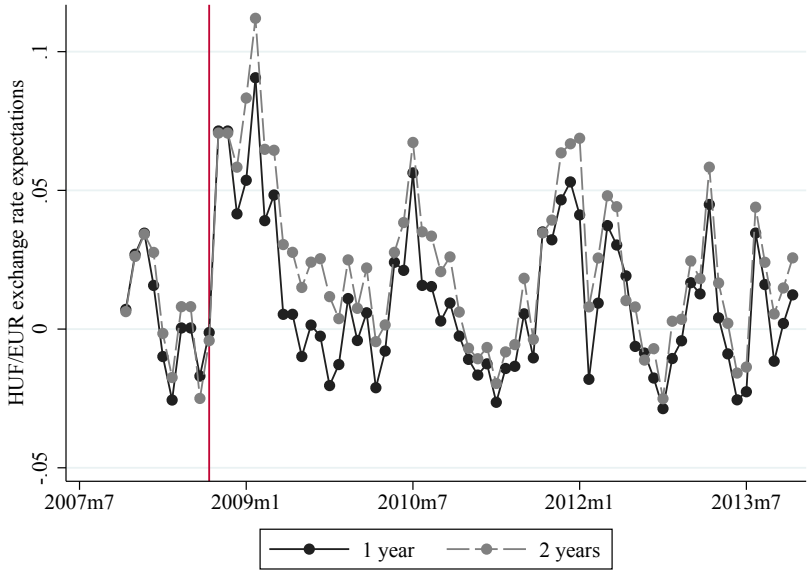
Notes: This table reports the correlation between firm foreign currency debt share against the local settlement household FC debt share. Standard errors are clustered at the subregion level (175 units).

Table A.19 Firm FC Debt and Firm-Level Outcomes: Exploiting Variation across Swiss Franc and Euro Exposure

	Log Invest.	Invest./ Capital	Log Sales	Log Real Val. Added	Log Empl.
	(1)	(2)	(3)	(4)	(5)
Firm CHF share × Post	-36.9	-12.8	1.88	2.00	1.18
	(2.95)	(1.58)	(1.34)	(1.28)	(0.72)
Firm EUR share × Post	11.2	-3.03	11.4	12.8	4.59
	(4.95)	(1.14)	(2.97)	(3.23)	(1.91)
HH FC debt share, s_{z08}^{FC} × Post	-31.4	3.25	-14.7	-18.6	-7.57
	(16.9)	(4.13)	(7.37)	(7.66)	(2.82)
Exporter × Post	17.4	3.88	3.42	4.21	0.14
	(1.40)	(0.50)	(0.97)	(0.74)	(0.44)
Firm and Year FE	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes
Settlement Controls	Yes	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes	Yes
2-Digit Industry FE	Yes	Yes	Yes	Yes	Yes
R^2	0.052	0.047	0.036	0.063	0.023
Number of Firms	66263	66267	66267	66259	66267
Observations	418239	463869	463869	461860	463869

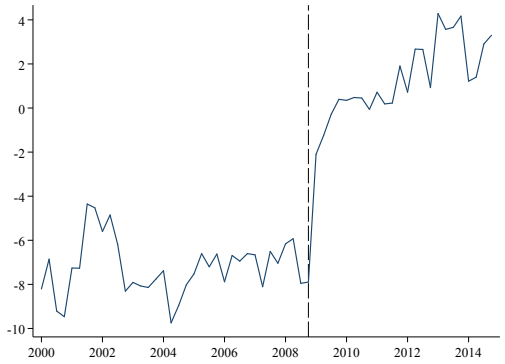
Notes: This table is similar to Table 8, but it separates the firm FC debt share in 2008 into two components: the Swiss franc (CHF) share and the euro (EUR) share. The forint depreciated substantially more against the Swiss franc (44 percent from 2008 to 2010) than the euro (15 percent), so firms with a greater proportion of Swiss franc debt experienced a larger debt shock. Both shares are measured in 2008. We include the small fraction of dollar debt as part of the CHF share. The table shows that relative to firms with debt in euro, firms with debt in Swiss franc see stronger declines in investment, and weaker sales, output, and employment growth around the depreciation. Nevertheless, in contrast to the effect of household FC debt exposure, firms with Swiss franc debt do not perform worse in the crisis compared to firms without FC debt for all outcomes except investment. The dependent variables are log investment (column 1), the investment-to-lagged assets ratio (columns 2), log firm sales (column 3), log firm real value added (column 4), and log firm employment (columns 5). The firm FC debt share is measured in 2008. Settlement controls refer to the "Baseline controls" and "Credit quality controls." All controls are interacted with Post_t. Standard errors are clustered at the subregion level (175 units).

Figure A.1 Consensus Forecasts of the HUF-EUR Exchange Rate

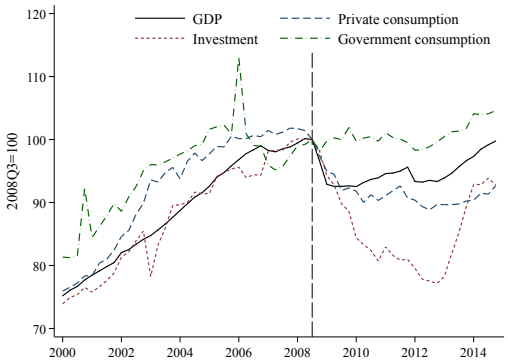


Notes: The figure plots the expected depreciation of the Hungarian forint (HUF) relative to the euro (EUR) from Consensus Forecasts, a survey of professional forecasters (CF, 2016). Exchange rate expectations are reported at the one and two year horizons. The vertical line represents September 2008.

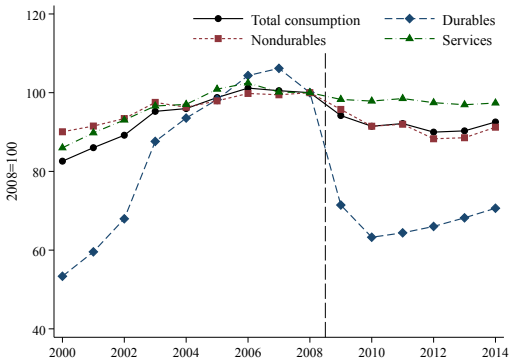
Figure A.2 Macroeconomic Context



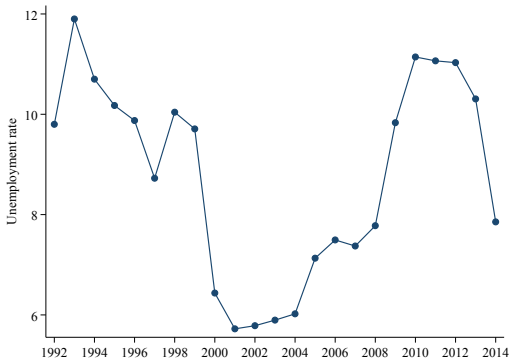
(a) Current Account to GDP ratio (%)



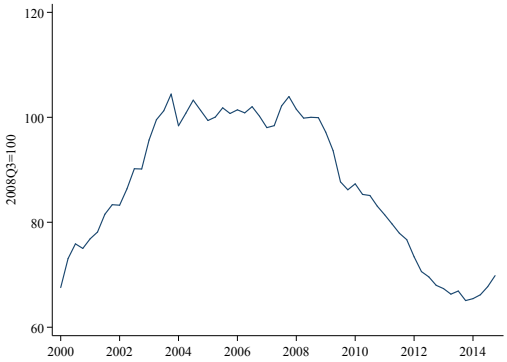
(b) Components of GDP



(c) Consumption



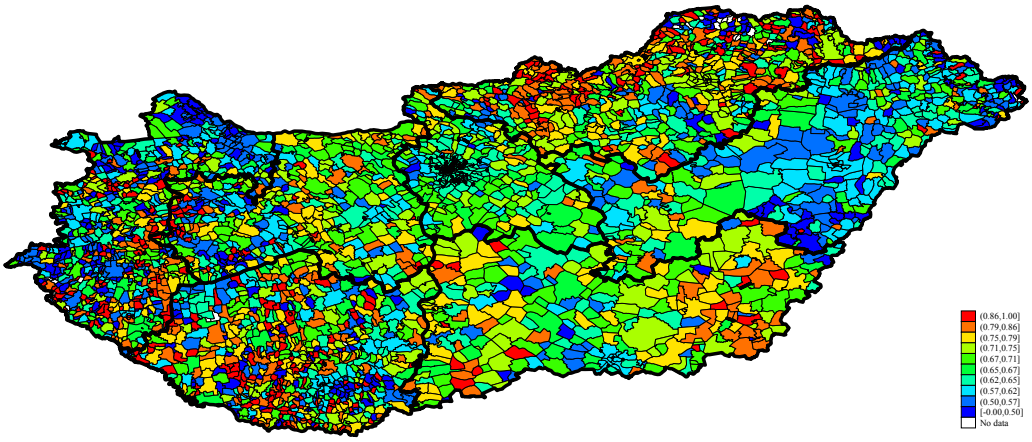
(d) Unemployment Rate



(e) Real House Price Index

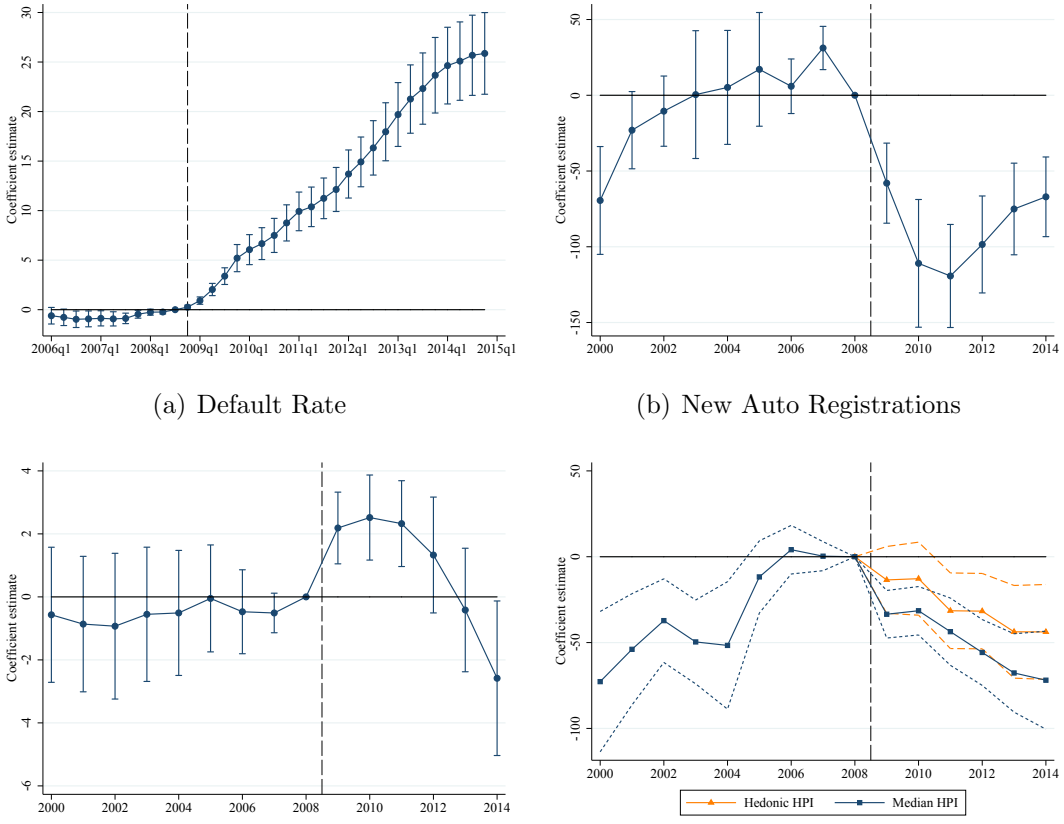
Notes: This figure presents the evolution of key macroeconomic aggregates up to and after the October 2008 forint depreciation. The current account to GDP, components of GDP, and consumption measures are from OECD (2016). The unemployment rate is from the IMF IFS (2016). The real house price index is the MNB nominal house price index MNB (2017) deflated by the CPI from the OECD (2016).

Figure A.3 Geographic Distribution of Household FC Debt Exposure



Notes: This figure presents a map of the September 2008 household FC debt share across settlements in Hungary. Thick black lines represent the borders of 7 major regions. The map shows that there is variation both within and across major regions in the FC debt share.

Figure A.4 Estimates over Time without Controls



(a) Default Rate

(b) New Auto Registrations

(c) Unemployment Rate

(d) House Prices

Notes: This figure presents estimates of $\{\beta_k\}$ from equation (2) for various outcomes without control variables. Observations are weighted by 2007 population. Error bars represent 95 percent confidence intervals computed from standard errors clustered at the subregion level.

Figure A.5 Placebo Test: 1998 Russian Financial Crisis

Notes: This figure uses the second half of the 1990s as a placebo sample. Figure A.2 shows that unemployment in Hungary rose around the 1998 Russian Financial Crisis, and then subsequently recovered. This figure presents estimates of the following specification for the period 1995-2001, where 1997 is the omitted year,

$$u_{zt} = \alpha_z + \gamma_t + \sum_{k \neq 1997} \beta_k \{ s_{z08}^{FC} \cdot \mathbf{1}_{k=t} \} + \epsilon_{zt}.$$

For the late 1990s placebo sample the coefficients $\{\hat{\beta}_y\}$ are precisely estimated and not significantly different from zero. Observations are weighted by 2007 population. Error bars represent 95 percent confidence intervals computed from standard errors clustered at the subregion level.

B Data Appendix

B.1 Household Credit Registry and Other Credit Market Data

The Hungarian Household Credit Registry records information on all loans granted to households starting in April 2012. This allows us to observe loan information for all loans that are outstanding in April 2012 or later and loan repayment in all months thereafter. In order to construct a measure of households' balance sheet exposure to the depreciation, we reconstitute the credit registry back to January 2000 using information on the origination date, originated amount, loan type, currency, and variable interest rate. We have interest rates at the bank-product level, where product includes loan type (mortgage, home equity loan, auto loan, etc.), maturity, and currency.[1]

With this information we use an annuity formula to impute the monthly payment and remaining balance for each loan in the credit registry. Specifically, for each loan i in currency c of type k originated at time t_0 with maturity m and remaining periods $n = t_0+m-t+1$, we denote the imputed values of the monthly payment and remaining loan balance as $\tilde{P}_{it}$ and $\tilde{D}_{it}$. These are computed as

$$\tilde{P}_{it} = \tilde{D}_{it}\left(\frac{1-R_{ckmbt}^{-n}}{R_{ckmbt}-1}\right)^{-1}$$
$$\tilde{D}_{it} = \tilde{D}_{i,t-1}\cdot R_{ckmb,t-1} - P_{i,t-1}, \quad D_{it_0} = \tilde{D}_{it_0} \text{ given as originated amount,}$$

where R_{ckmbt} is the average monthly gross interest rate charged by bank b for that specific loan product (currency, loan type, maturity at issuance) in period t. This formula thus computes the sequence of payments and loan balances that we would observe in the absence of default, assuming that loan i pays the average variable rate charged by bank b for that loan product. We do not believe that the assumption that loans remain current is severe drawback for this methodology because default rates were very low before the 2008 crisis (see Figure B.3).[2]

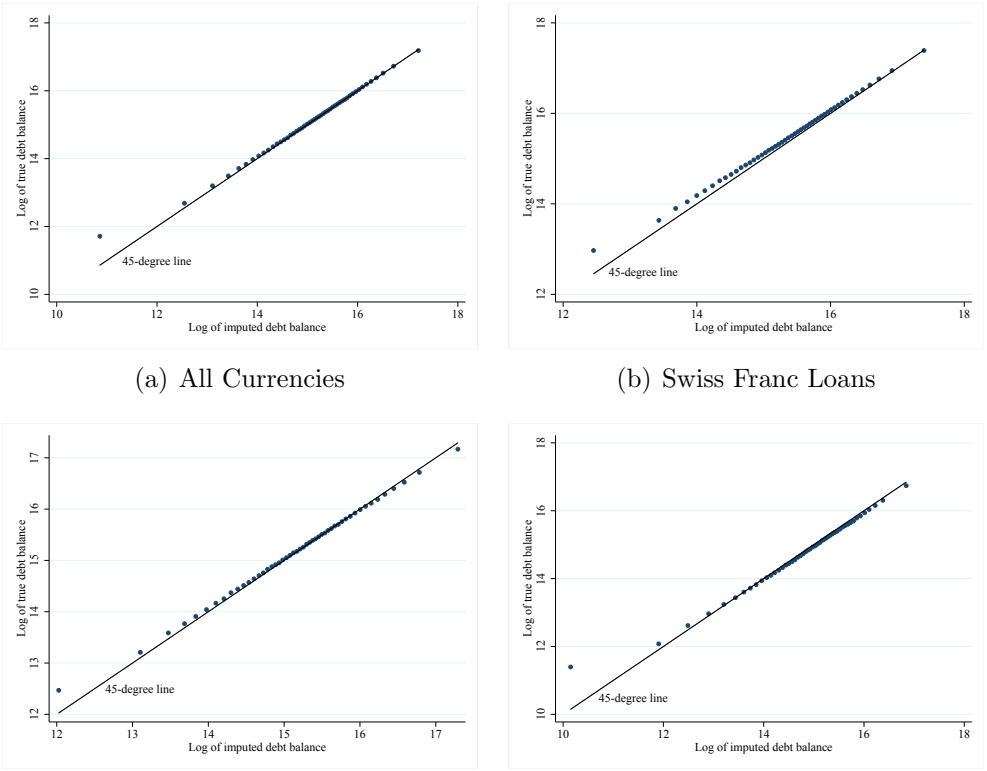
B.1.1 Accuracy of the Imputation within the Credit Registry

As a first test of the accuracy of the annuity model, Figure B.1 plots binned bivariate means of the imputed and actual loan balances in December 2012. Panel (a) plots the binned means for all mortgage and home equity loans in our sample, and panels (b)-(d) presents subsamples by currency. On average our imputation performs well: most bins lie on or very close to the 45-degree line. The imputed balances slightly underestimate the true balances, which may be explained partly by loans falling into

[1]Note that the credit registry does not report interest rates at the loan level. Instead, we draw on interest rate information from a separate database maintained by the National Bank of Hungary, which reports the average monthly interest rate across different loan products charged by banks operating in Hungary.

[2]Statistics from the National Bank of Hungary show that the fraction of non-performing loans was below 1 percent for both local currency loans and foreign currency housing loans in 2008Q3.

Figure B.1 Validation of Imputation Procedure: Binned Bivariate Means of Imputed and Actual Loan Balance in 2012



(a) All Currencies

(b) Swiss Franc Loans

(c) Euro Loans

(d) Forint Loans

Notes: This figure plots binned bivariate means (binscatter) of imputed and actual loan balances in 2012:12 using 50 quantiles. The imputed loan balance is modeled using an annuity formula using loan-level information on the originated amount, time of origination, and bank-by-product specific interest rate to construct monthly interest payments, amortization, and remaining loan balance. The figure shows that on average the imputed values line on or near the 45-degree line and are thus close to the true values.

arrears during the crisis. Note that since default rates increased substantially in the crisis, our approximation is likely to be more accurate in earlier years, closer to the time of origination and before the sharp uptick in defaults.

To provide a sense of the goodness of fit, Table B.1 reports regressions of the true loan balance on the imputed balance in 2012:12. The table shows that the R^2 for the regression of the true balance on the imputed balance in 83 percent for all loans, and lies between 80-96 percent for various subsets of loans. The coefficient on the slope is naturally biased downward from unity because of classical measurement error in $\tilde{D}_{it}$, and similarly the coefficient on the constant is biased upward since the average loan balance is positive.

Table B.1 Regressions of True Loan Balance in 2012:12 on Imputed Balance

	Dependent variable: true balance in 2012:12, $\ln(D_{it})$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Imputed balance, $\ln(\tilde{D}_{it})$	0.873	0.890	0.840	0.871	0.916	0.835	0.930
	(0.00039)	(0.00048)	(0.00067)	(0.00053)	(0.0010)	(0.00060)	(0.0020)
Constant	1.942	1.672	2.471	2.088	1.290	2.411	1.259
	(0.0059)	(0.0072)	(0.010)	(0.0082)	(0.016)	(0.0089)	(0.030)
Sample	All	Mortgage	Home equity	CHF	EUR	HUF	JPY
R^2	0.833	0.849	0.802	0.866	0.915	0.793	0.947
Observations	1002891	618714	384177	414899	74106	501142	12735

Notes: This table presents regressions of the log true loan balance in 2012:12 on the log imputed loan balance in 2012:12. Standard errors are reported in parentheses.

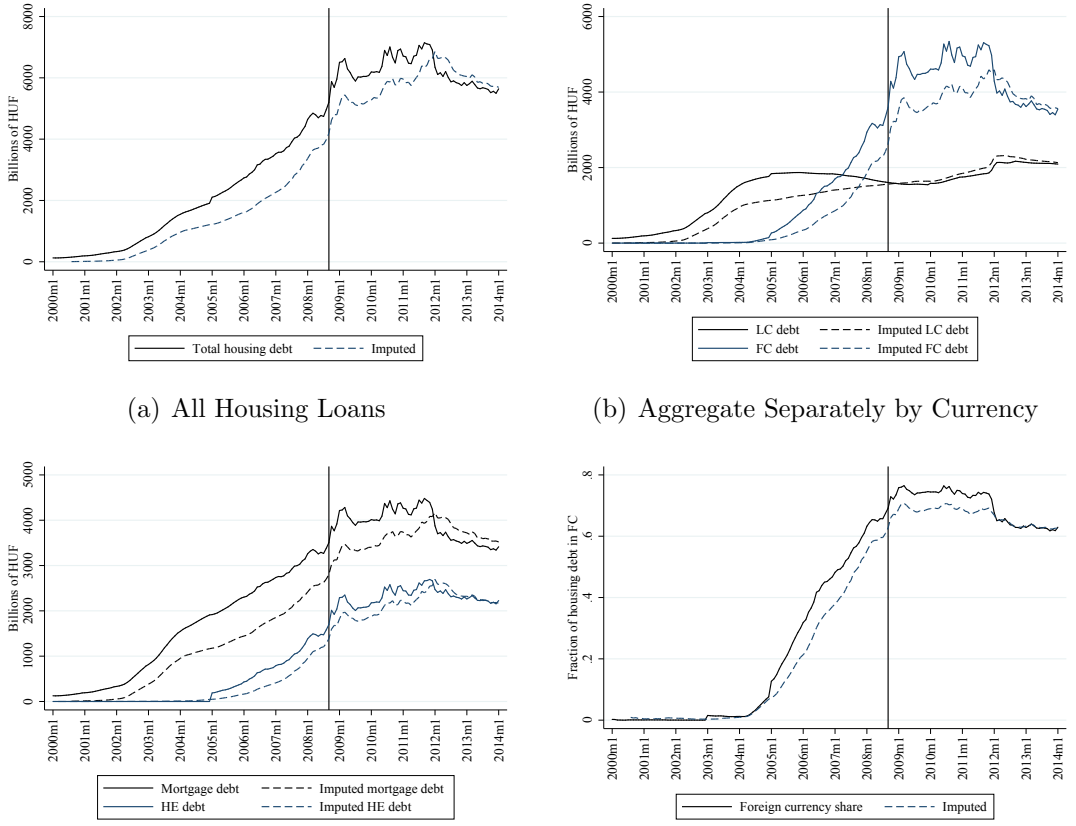
B.1.2 Missing Loans and Comparison with Aggregate Financial Accounts

A concern arising from the fact that the credit registry starts in early 2012 is that some loans that were outstanding in late 2008 may not exist in early 2012, leading us to mis-measure a region's exposure to the depreciation. To provide an impression of the credit registry's coverage of outstanding balances over time, Figure B.2 presents a comparison of the aggregate outstanding housing debt in the Household Credit Registry reconstituted back to 2000 and the "true" aggregate from the flow of funds (Financial Accounts), reported by the National Bank of Hungary. The Financial Accounts are constructed from bank balance sheet data and measure all outstanding debt by loan type and currency.

Figure B.2 reveals that the imputed aggregate matches the time series behavior of the true aggregate closely, although, as expected, our measure shows a lower level of outstanding credit. In particular, we account for 80.5 percent of total outstanding housing debt and 73.0 percent of foreign currency housing debt in September 2008 (panels (a) and (b)). Panel (b) shows that we match the aggregate level of local currency debt almost perfectly by September 2008. The shortfall in our imputed series thus comes from missing FC debt. As a result, panel (d) shows that in September 2008 the aggregate share of foreign currency debt is 62.7 percent in the imputed series compared to 69.1 percent in the Financial Accounts.

There are three potential reasons for this shortfall in FC loans: the 2011 Early Repayment Program for FC loans, short maturities and repayment, and other forms of prepayment and refinancing. It turns out the 2011 Early Repayment Program explains most of the shortfall.

Figure B.2 Comparison of Imputed Aggregate Debt and Financial Accounts



(a) All Housing Loans

(b) Aggregate Separately by Currency

(c) Aggregate Separately by Loan Type

(d) Foreign Currency Share of Housing Debt

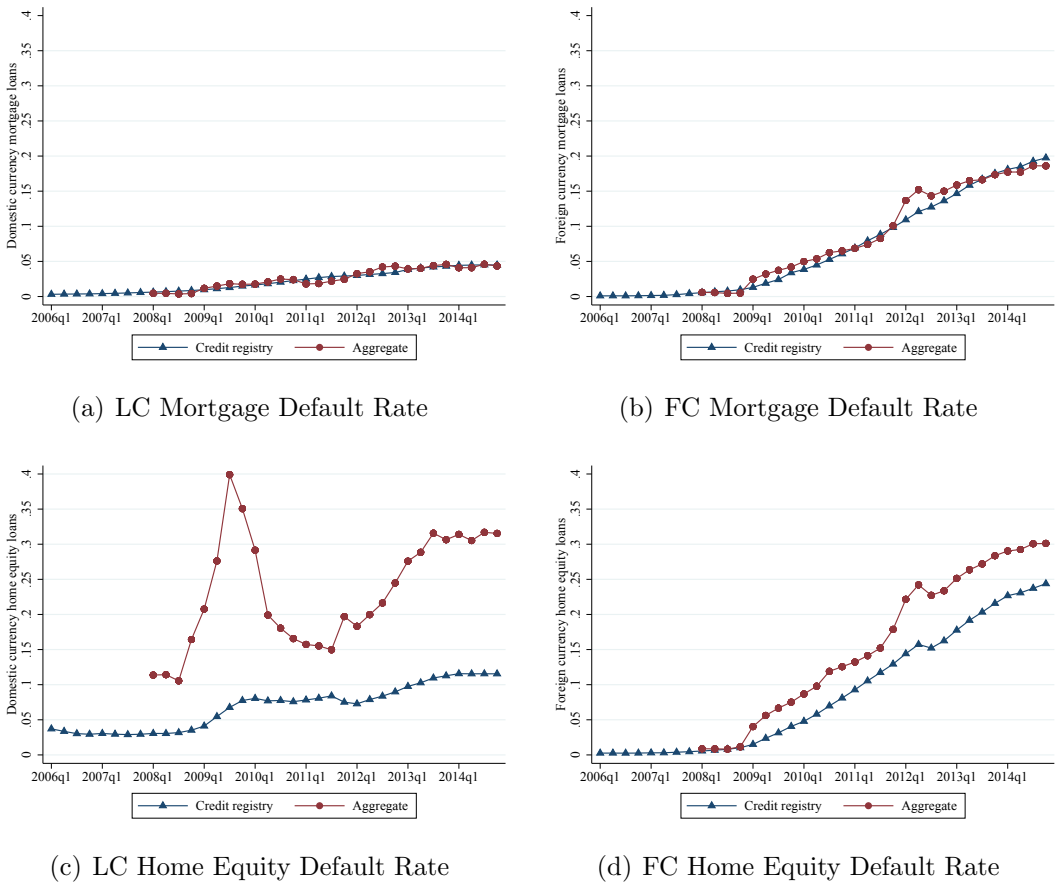
Notes: This figure compares outstanding housing credit aggregates from Financial Accounts data published by MNB (the "true" credit aggregate) and credit aggregates computed from the Household Credit Registry using the imputation procedure described in the text. The vertical line represents the month for which our exposure variable is computed (September 2008). Panel (a) compares the national aggregate for all mortgage and home equity loans, while panels (b) and (c) present sub-aggregates by currency and loan type. The figures show that our imputation procedure captures a substantial (over 80 percent) fraction of outstanding balances in 2008:9. However, prepayments from the 2011 Early Repayment Program means that we fail to account for about 23 percent of outstanding FC debt (measured as of 2011:10, immediately before the program). Panel (d) shows that the aggregate foreign currency share in the imputed data is similar but lower than the true aggregate share (62.7 percent compared to a true value of 69.1 percent in 2008:9).

B.1.3 Comparison of Defaults from the Credit Registry and MNB Aggregate Statistics

The household default registry records information on all default spells starting in 2010, and it contains the *last* default spell before 2010 for each loan. For example, if a loan originated in January 2006 enters into default in January 2007, is cured in June 2007,

and enters into default again in June 2008, then we observe the default spell from June 2008, but not the spell from January to June 2007. Default is recorded when cumulative payments exceeding on month's full-time minimum wage are at least 90 days in arrears. Since the default registry contains information on default spells prior to 2010, we extend the default indicator back to 2006. Given that we only observe the last default, the credit registry potentially underestimates defaults prior to 2010.

Figure B.3 Aggregate Default Rates from the Credit Registry and MNB Financial Stability Statistics



(a) LC Mortgage Default Rate

(b) FC Mortgage Default Rate

(c) LC Home Equity Default Rate

(d) FC Home Equity Default Rate

Notes: This figure compares household default rates from the Household Credit Registry with MNB's aggregate non-performing loan rates from the Financial Stability Statistics ("Aggregate"). The Financial Stability Statistics measure is based on information reported directly from bank balance sheets to MNB and does not rely on the Household Credit Registry. This measure is available from 2008 onward.

Figure B.3 compares the aggregate default rate by currency and loan type from the credit registry with aggregate non-performing loan rates from MNB's Financial Stability Statistics. The non-performing loan rates from the Financial Stability Statistics are reported to MNB by all banks operating in Hungary and is not based on information in

the credit registry. Non-performing loans are defined as loans that are at least 90 days in arrears. The aggregate non-performing loan rates from MNB are available starting in 2008, so we cannot cross-validate the credit registry default measure prior to 2008.

The figure shows that aggregate default rates estimated from the credit registry track the aggregate non-performing loan rates reported directly by banks across loan types and currencies. The exception is LC home equity loans in panel (c). However, local currency home equity loans are a small segment of the market. For example, local currency home equity loans are only 2.0 percent of total home equity debt and 0.6 percent of total housing debt in September 2008. Therefore, overall the credit registry captures the increase in credit risk as reported from bank balance sheets. Note that this also suggests that missing loans do not substantially distort average credit quality captured by the credit registry.

B.1.4 Early Repayment Program of 2011

The primary reason for the FC housing debt shortfall in the Household Credit Registry relative to the financial accounts is that 21.3 percent of outstanding FC debt (15.9 percent of total debt) was prepaid in late 2011 through an Early Repayment Program (ERP). The ERP allowed borrowers to repay FC loans in full at a discount on market exchange rates of approximately 25 percent, with the majority of losses imposed on lenders.[3] The program explains the sharp fall in aggregate FC debt in late 2011 along with a rise in LC debt as some borrowers refinanced into LC loans (Figure B.2).

Because the 2011 ERP required that borrowers repay the FC loan in full, it disproportionately benefited borrowers with higher income or liquid wealth, as well as more creditworthy borrowers who could finance the repayment with a new LC loan.[4] If these determinants of participation in the program are correlated with shocks to the local economy and to FC exposure, our estimates will be biased unless we appropriately account for this selection. For example, high income regions where borrowers are more likely to participate in the ERP may also be less exposed to business cycle shocks, leading us to overestimate the effect the foreign currency debt shock. We address this potential selection in several ways.

First, in the main analysis we control for settlement disposable income per capita, as income is expected to be a key determinant of participation in the 2011 ERP. As we describe in section III, the estimates are reasonably similar when controlling for income (see Table A.4), which indicates that any systematic mis-measurement of s_{z08}^{FC} induces at most a modest bias in the estimates.

In addition, we take three different approaches to *explicitly correct* our measure of FC exposure for loans that are not in the credit registry because of the 2011 ERP. We

[3]The discount varied by currency denomination and ranged from 20-36 percent.

[4]The program did not facilitate refinancing into loans in domestic currency, and banks actively avoided granting loans that would allow borrowers to participate in the ERP. In 2013 the Hungarian Competition Authority fined 11 major financial institutions for colluding to limit the full prepayment of foreign currency loans.

refer to these as ERP Adjustments #1, #2, and #3. The first two approaches draw on additional loan-level information, while the third approach presents simulations under assumptions about participation in the ERP across settlements.

ERP Adjustment #1 (Three-banks dataset). The first approach draws on a separate loan level dataset for three of the largest banks in Hungary. The data includes all loans originated starting in 2004 (and thus virtually all FC loans to households), so it covers almost all loans that were prepaid through the 2011 Early Repayment Program for these three banks. These three banks have a combined market share of 24 percent of total consumer lending, and this database captures 34.4 percent of the debt that prepaid through the ERP.

We use this dataset to construct a settlement-level estimate of the amount of debt that was prepaid through the 2011 ERP for every other bank in the sample. Let x_z^{3b} be the fraction of the three banks' housing debt that is repaid in settlement z, $\overline{x}^{3b}$ be the overall fraction that is repaid for the three banks, and $\overline{x}_b$ be the overall fraction of debt that is repaid for any other bank b. With these three observable objects, the aim is to recover the fraction of bank b's debt that is repaid in z, x_{bz}, for the remaining banks. We assume that this variable can be approximated as follows

$$x_{bz} = x_z^{3b} \left(\frac{\overline{x}_b}{\overline{x}^{3b}} \right). \tag{B.1}$$

That is we scale the average ERP propensity for the three banks in z with aggregate ERP propensity of bank b relative to the three banks. Thus, a bank that has a higher aggregate fraction of its debt repaid in the ERP relative to the three banks is also assumed to have a higher propensity in a given settlement.

With x_{bz} the bank-settlement prepaid amount is reconstructed as $\hat{D}_{bz}^{prepaid} = \frac{x_{bz}}{1-x_{bz}} D_{bz}^{FC}$. With the imputed prepayment $\hat{D}_{zb}^{prepaid}$ we calculate the implied debt level in September 2008 assuming a representative Swiss franc loan for each bank-settlement that was originated in March 2007, in the middle of the FC credit boom.[5] Summing over all banks in z gives us a measure of the September 2008 loan balance for ERP participants in settlement z, $\hat{D}_{z08}^{prepaid}$. We then simply adjust the foreign currency share of total housing debt for this term:

$$\tilde{s}_{z08}^{FC} = \frac{\sum_c \mathcal{E}_{08}^c D_{z08}^{*c} + \mathcal{E}_{08}^{chf} \hat{D}_{z08}^{prepaid}}{D_{z08} + \sum_{c \in C} \mathcal{E}_{08}^c D_{z08}^{*c} + \mathcal{E}_{08}^{chf} \hat{D}_{z08}^{prepaid}}. \tag{B.2}$$

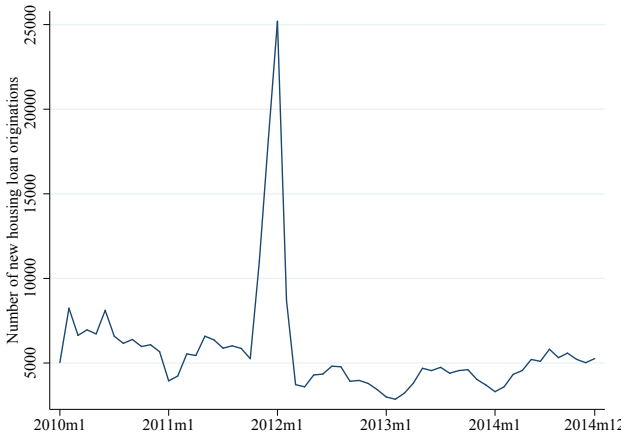
ERP Adjustment #2 (LC Refinancing). The second method draws on information contained in the volume of LC debt origination in a settlement around the time

[5] We choose March 2007 based on the average month of origination for prepaid loans issued by the three banks for which we have complete data. Two-thirds of prepaid loans are mortgages and one-third are HE loans, so we use a weighted average of the bank-product interest rate for the representative loan.

of the 2011 Early Repayment Program. Refinancing into LC loans accounts for 33.0 percent of the participation in the 2011 ERP (approximately HUF 349.4 bn),[6] so the volume of refinancing provides an alternative indication of how intensively households participated in the program in a given area.

To construct a measure of ERP prepayment based on refinancing, we assume that all LC loans originated in the fourth quarter of 2011 were FC loans originated before September 2008 that were refinanced in the ERP. Figure B.4 shows that there is a spike in originations in 2011Q4 during ERP window. The volume of new issuance in surrounding months is low, so it is reasonable assume that all loans originated in this period were refinancing loans to take advantage of the ERP. We scale up the refinanced debt in each settlement so that it accounts for the entire 2011 ERP. This assumes that debt that was repaid is proportional to the amount that was refinanced. Note that method #2 explicitly targets aggregate, unlike ERP Adjustment #1. With an estimate of the prepaid debt in settlement z we model the loan balance in September 2008 using a representative Swiss franc loan and assuming a monthly interest rate equal to the average interest rate set by the eight major banks in Hungary. The foreign currency share variable is then adjusted as in method #1.

Figure B.4 Number of New Housing Loan Originations



Notes: This figure shows the number of new housing loan originations per month. The figure illustrates the sharp spike in new originations around the ERP window, reflecting an increase in local currency loan issuance used to prepay foreign currency loans through the ERP.

Performance of ERP Adjustments #1 and #2. Table B.2 compares the aggregate prepayment through the ERP with the prepayment implied by methods #1 and

[6]To arrive at this number we assume that all new LC loans originated in 2011:11-2012:2 minus the average of the originated amount in 2011:10 and 2012:3 are used in the ERP. We scale originated value up by 38.05 percent to reflect the 27.5 percent discount on the market exchange rate.

Table B.2 Aggregate Prepayment in 2011 Early Repayment Program

Prepaid debt in 2011 ERP (bn HUF)	1,135
Imputed prepayment #1	1,058
Imputed prepayment (targets aggregate) #2	1,135

Table B.3 Correlation of ERP Participation across ERP Adjustment Methods

	ERP Adj. #1	ERP Adj. #2	Bank 1 $x_z^{Bank,1}$	Bank 2 $x_z^{Bank,2}$	Bank 3 $x_z^{Bank,3}$
ERP Adj. # 1	1.00				
ERP Adj. # 2	0.05	1.00			
Bank 1, $x_z^{Bank,1}$	0.35	0.25	1.00		
Bank 2, $x_z^{Bank,2}$	0.23	0.37	0.19	1.00	
Bank 3, $x_z^{Bank,3}$	0.26	0.33	0.16	0.20	1.00
Observations	2538				

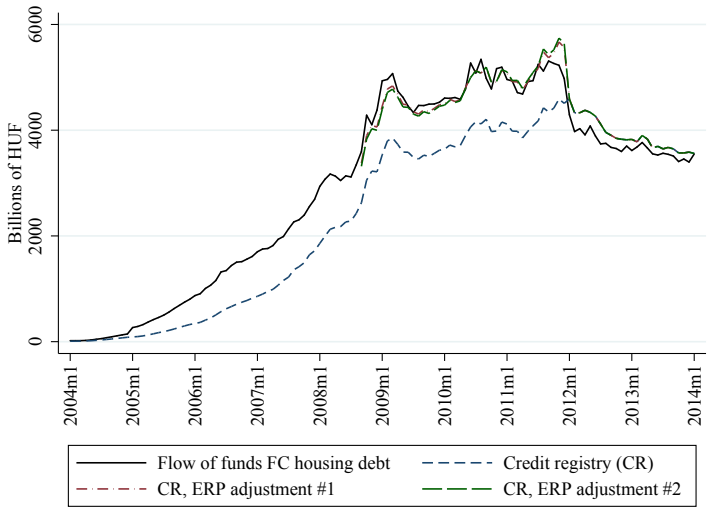
Notes: This table presents the correlation matrix for various estimates of participation in the 2011 Early Repayment Program. ERP Adj. #1 refers to the share of foreign currency debt that is prepaid in a settlement according to the estimate from the Three-banks dataset. ERP Adj. #2 is defined similarly, but where prepaid debt is estimated using the volume of local currency refinancing. Variables $x_z^{Bank,j}$, for $j = 1, 2, 3$, are defined as the share of foreign currency debt prepaid in settlement z for a bank j, where bank j is one of the three anonymous banks in the Three-banks dataset.

#2. Method #1 matches the aggregate level closely, with HUF 1,058bn compared the target of HUF 1,135bn, or 3.7bn euros. Recall that method #2 mechanically matches the aggregate.

Figure B.5 shows the impact of the ERP adjustment on aggregate FC debt. With the imputation we account for 95 percent of total debt in September 2008 (with method #1), and the imputed aggregate for all methods tracks the level of outstanding FC debt closely. This implies that four-fifths of the FC debt shortfall in the Household Credit Registry is explained by the ERP.

Table B.3 presents a correlation matrix of various estimates of ERP participation propensity at the settlement level. The share of debt prepaid according ERP Adjustments #1 and #2 are positively correlated, but the correlation is low at only 0.05. The share of debt prepaid at the bank level for the banks in the Three-banks dataset is more strongly positively correlated across settlements. This implies that, for example, in local areas where customers of bank 1 had a higher repayment propensity, customers of bank 2 and 3 also had higher propensity to participate in the ERP. This supports

Figure B.5 Early Repayment Program Adjustment and Aggregate FC Debt



Notes: This figure compares aggregate FC housing debt in the flow of funds (Financial Accounts) against aggregate FC housing debt in the credit registry when we adjust the credit registry using ERP adjustments #1 and #2. The figure illustrates that the ERP adjustments account for most of the missing debt in the credit registry.

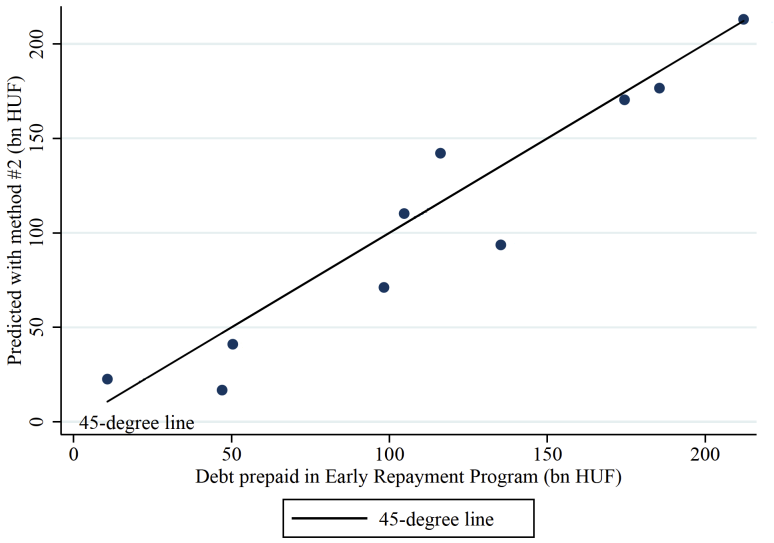
the assumption behind ERP Adjustment #1, namely that repayment propensities are higher for other banks in a settlement with high ERP propensity for the three banks.

We also obtained data on the total prepayment for each bank in our sample, and Figure B.6 plots the predicted prepayment for method #1 against the true value for the eight major banks in Hungary, (i.e. $\hat{D}_b^{prepaid} = \sum_z \hat{D}_{zb}^{prepaid}$ and $D_b^{prepaid}$). Our simple non-parametric in method #1 yields an R^2 of 90.1 percent.

Figure B.7 compares the original and ERP-adjusted foreign currency debt shares, s^{FC} and $\tilde{s}^{FC}$. As expected, the adjustment raises the FC share in all settlements, and more so in settlements with a lower original share. The correlation between the original and the two adjusted measures is high (0.873 and 0.961 for ERP Adjustments #1 and #2, respectively).

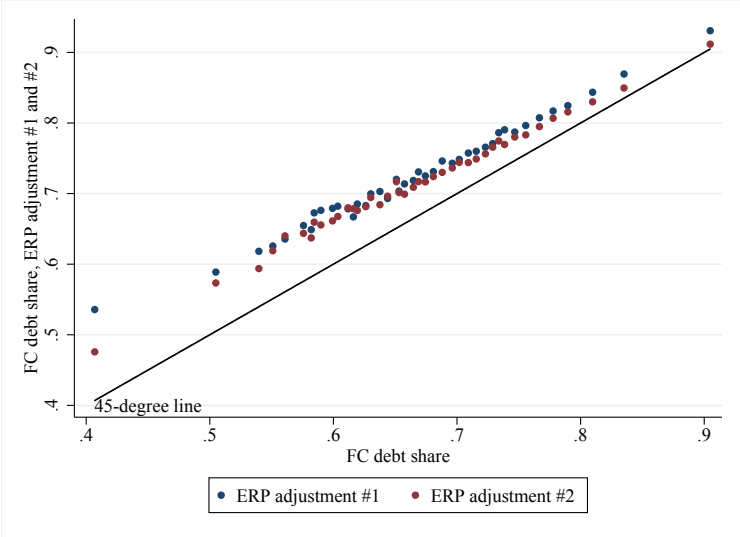
Effect of Controlling for the Early Repayment Program on the Main Results. Table B.4 presents robustness tests for the main results using the two adjusted foreign currency exposure variables. The point estimates are reasonably similar to the baseline estimates. The estimates for the adjusted variables tend to be slightly lower (especially for Adjustment #2). While the standard errors increase, the main results retain their statistical significance.

Figure B.6 Method #1 Predicted and Actual 2011 Early Repayment Program Debt Reduction by Bank



Notes: This figure plots the amount of debt prepaid through the 2011 Early Repayment Program for the 8 major banks, the savings cooperatives, and the rest of the banks against the predicted amount using ERP Adjustment #1.

Figure B.7 Original and ERP Adjusted FC Debt Shares



Notes: This figure plots binned bivariate means (binscatter) of the foreign currency debt share adjusted for the Early Repayment Program against the original FC share (s_{z08}^{FC}).

Table B.4 Robustness of Main Results to Missing Data Adjustments

Panel A: Default

	ERP Adj. #1 (3-Banks)		ERP Adj. #2 (Refinance)	
	(1)	(2)	(3)	(4)
HH FC debt share × Post	8.25	6.13	7.93	4.23
	(1.17)	(0.75)	(1.09)	(0.75)
Full Settlement Controls		Yes		Yes
R^2	0.84	0.87	0.84	0.87
Observations	71064	71064	71064	71064

Panel B: New Auto Registrations

	ERP Adj. #1 (3-Banks)		ERP Adj. #2 (Refinance)	
	(1)	(2)	(3)	(4)
HH FC debt share × Post	-72.1	-45.7	-83.3	-32.2
	(18.2)	(8.83)	(14.8)	(8.33)
Full Settlement Controls		Yes		Yes
R^2	0.81	0.83	0.81	0.83
Observations	17766	17766	17766	17766

Panel C: Unemployment

	ERP Adj. #1 (3-Banks)		ERP Adj. #2 (Refinance)	
	(1)	(2)	(3)	(4)
HH FC debt share × Post	1.53	1.33	1.90	1.17
	(0.87)	(0.51)	(0.81)	(0.51)
Full Settlement Controls		Yes		Yes
R^2	0.60	0.65	0.60	0.65
Observations	17766	17766	17766	17766

Notes: The table presents estimate of the baseline results in section III of the paper with the adjusted household foreign currency debt share measures.

ERP Adjustment #3 (Simulation approach). The third approach to assess the robustness of the main results to accounting for debt missing due to the Early Repayment Program is to allocate debt across settlements based on a simple formula. Specifically, we assume that the amount of debt prepaid in settlement z is given by

$$D_z^{prepaid,\epsilon_x} = C(x_z)^{\epsilon_x} Pop_{z,07}, \tag{B.3}$$

where x_z is settlement characteristic that captures ability to prepay, such as disposable income per capita or the college share, ϵ_x is the elasticity of prepayment with respect to x_z, $Pop_{z,07}$ is settlement population in 2007, and C is a constant that we adjust so that the sum of the allocated prepaid debt sums to the aggregate amount prepaid through the ERP. Note that an elasticity $\epsilon_x = 0$ implies that prepaid debt is allocated proportionally to settlement population. After allocating debt according to (B.3), we adjust the foreign currency debt share as in ERP Adjustment method #1.

What is a reasonable value for the elasticity ϵ_x? A useful starting point is the elasticity of estimated ERP prepayment from methods #1 and #2. Table B.5 presents estimates of these elasticities. These estimates imply an elasticity of about 0.4 to 1.9 with respect to disposable income per capita and 0.1 to 1.1 with respect to education. We will consider a full range of elasticities from -5 to 5, and will focus on elasticities between 0 and 2 as our preferred values.

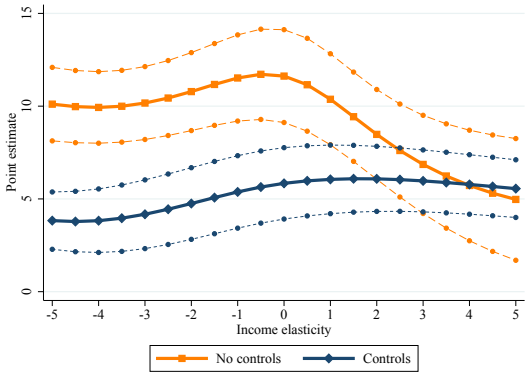
Figure B.8 presents the results of reestimating the key regressions in Tables 4 and 5 using the the adjusted household FC debt share. We present estimates with and without our full set of controls. Panels (a)-(c) present the estimates where x_z equals disposable income per capita, and panels (d)-(f) present the estimates where x_z is the college share. Each point is the estimate when the household FC debt share, $s^{FC}_{z,08}$ is adjusted according to allocation rule (B.3) with a given elasticity.

For negative elasticities, the estimates are generally not highly sensitive to the ERP adjustment. For positive elasticities the estimates decline in magnitude as the elasticity rise. The auto registration estimate is the most sensitive to the adjustment, and the unemployment estimate the least sensitive. For reasonable income elasticities of around 0 to 2, the estimates are within the ranges reported in the baseline results in Tables 4 and 5. For example, the unemployment estimates are around 2 in panel (c) and slightly below 2 in panel (f), values not too different from the baseline estimate of 1.65 in Table 5. The estimates with controls are generally also more robust to the adjustment, since the control variables capture part of any selection bias attributed to missing data (based on this parametric allocation rule).

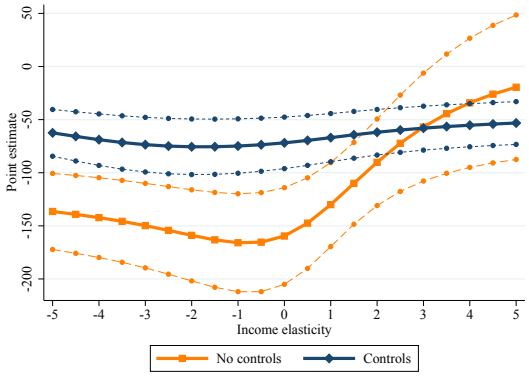
B.1.5 Short Maturities and Repayment

Another potential source of measurement error is that loans may have short maturities or come due before April 2012, but be outstanding around the depreciation. We do not believe this is a serious concern from the perspective of our study for the following reasons. First, our study focuses on housing-related obligations (mortgage and home equity loans). These are long-dated, with a median maturity at origination of 20 years for mortgages and 15 years for home equity loans. Aggregate credit series from MNB reveal that the fraction of housing loans with maturity shorter than 5 years in September 2008 is 1.69 percent, and the average of this fraction from January 2000 to September 2008 is 2.41 percent. Second, any short-term loan that would be fully repaid in this 3.5 year period would likely have a low remaining balance in the run-up to the crisis and not represent a significant exposure to the depreciation. Third, since

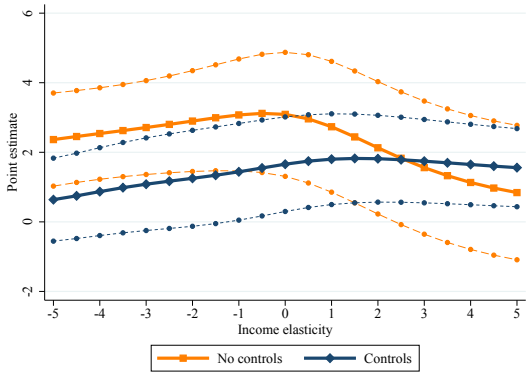
Figure B.8 Impact of ERP Adjustment #3 on Baseline Model Estimates



(a) Household Default Rate, x_z = Disp. Income



(b) New Auto Registrations, x_z = Disp. Income



(c) Unemployment Rate, x_z = Disp. Income

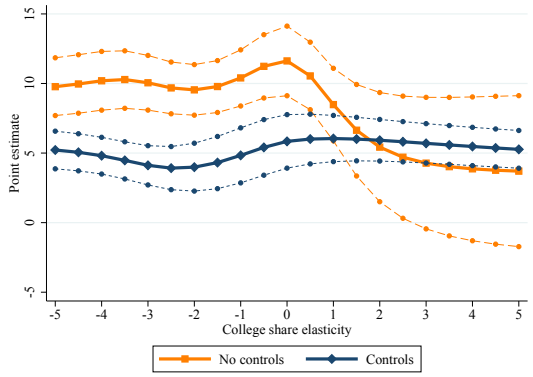
Notes: This figure illustrates how our main regression results are affected by adjusting the household FC debt share for debt prepaid through the ERP using the allocation rule in equation (B.3). Specifically, each point is a point estimate of β from

$$Y_{zt} = \alpha_z + \gamma_t + \beta(s_{z,08}^{FC,\epsilon} Post_t) + X_z Post_t \Gamma + \epsilon_{zt}.$$

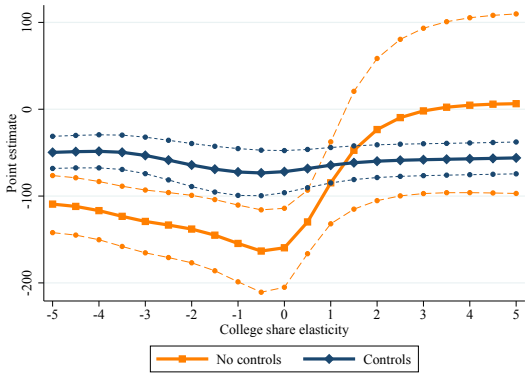
The x-axis varies the elasticity ϵ_x, which affects the allocation of prepaid debt and thus $s_{z,08}^{FC,\epsilon_x}$. Dashed lines represent 95 percent confidence intervals. The "No controls" estimate correspond to column 1 in Table 4, and the "Controls" estimate corresponds to our full set of controls in column 3 of Table 4.

mortgage lending took off from a very low initial level in 2000, the number of housing loans that would be expected to be retired between 2008:9 and 2012:3 is a small fraction of the aggregate. And finally, we are able to match the aggregates series quite closely by accounting for the 2011 Early Repayment Program.

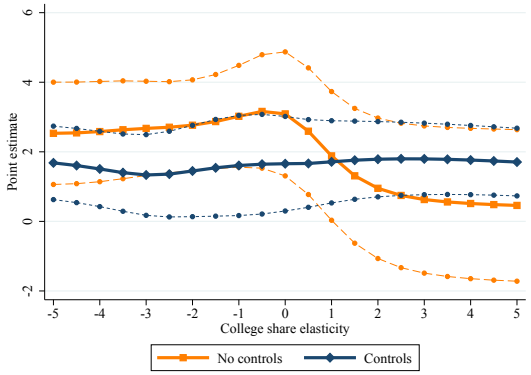
Figure B.8 Impact of ERP Adjustment #3 on Baseline Model Estimates (cont.)



(d) Household Default Rate, x_z = College Share



(e) New Auto Registrations, x_z = College Share



(f) Unemployment Rate, x_z = College Share

B.1.6 Settlement Loan-to-Value Estimates

The Household Credit Registry does not report loan-to-value ratios at the loan level. However, individual banks do report the volume of yearly originations across loan-to-value bins by loan currency denomination to the National Bank of Hungary. Using this information, we compute the origination volume weighted average LTV by currency, bank, and year of origination, LTV_{cbt}. We then construct a settlement-level LTV prior to the depreciation as the loan volume weighted average of LTV_{cbt} from 2004 through 2008. We also construct the change in the settlement-level average LTV between 2004-05 and 2007-08 to capture changes in LTV at origination over the credit expansion. This measure allows us to control for LTV differences across settlements that are driven by variation across bank-currency-year of origination dimensions. However, it does not capture variation within these dimensions across settlements. For example, it would not capture variation in LTVs that would arise if a specific bank had different lending

policies for foreign currency loans across regional bank branches.

Table B.5 Elasticity of Imputed ERP Debt Prepayment with Respect to Income and Education

Panel A: Income Elasticity				
	ERP Adj. #1 (Three-Banks)		ERP Adj. #2 (Refinance)	
	(1) Log ERP per Capita	(2) Log ERP	(3) Log ERP per Capita	(4) Log ERP
Log disp. inc. per cap.	0.41	0.68	1.95	1.89
	(0.069)	(0.072)	(0.076)	(0.079)
Log population		0.76		1.06
		(0.017)		(0.015)
R^2	0.015	0.50	0.30	0.75
Observations	2535	2535	2050	2050
Panel B: College Share Elasticity				
	ERP Adj. #1 (Three-Banks)		ERP Adj. #2 (Refinance)	
	(1) Log ERP per Capita	(2) Log ERP	(3) Log ERP per Capita	(4) Log ERP
Log college share	0.10	0.35	1.03	1.06
	(0.035)	(0.040)	(0.039)	(0.043)
Log population		0.73		0.97
		(0.019)		(0.015)
R^2	0.0037	0.50	0.32	0.75
Observations	2529	2529	2050	2050

Notes: This table presents regressions of the log of estimated debt prepaid through the ERP on disposable income measures (panel A) and the college share (panel B).

B.2 Wage Estimates from the Structure of Earnings Survey

The Structure of Earnings Survey (SES) is conducted annually by the National Employment Service and samples 6 percent of Hungarian employees, recording information on their income in May. Firms with 5-20 employees are randomly sampled from the census of enterprises and report information on all employees. All large firms with at least 20 employees are required to report information on a 10 percent random sample of employees based on employee date of birth. See Harasztosi and Lindner (2019) for a detailed description of the SES.

We estimate composition adjusted wages at the settlement level in the following manner. In each year, we run the following regression separately for men and women

$$\ln(W_{it}) = \alpha_t + X_{it}\Gamma_t + \nu_{it},$$

where W_{it} is worker i's nominal hourly wage (total wage compensation divided by total hours) and X_{it} is a vector of five-year age dummies (with 41-45 as the omitted category) and education dummies (with high school as the omitted category). We then exponentiate the residual plus the constant to obtain the composition adjusted wage, $\tilde{W}_{it} = e^{\hat{\nu}_{it}+\hat{\alpha}_t}$ and compute the average of $\tilde{W}_{it}$ in each settlement. This procedure yields estimated wage series for about one-third of the settlements in our sample that cover 87.8 percent of the population. With reported hours we also compute the average monthly hours in a settlement, conditional on employment.

C Consumption Response to Debt Revaluation

C.1 Permanent Income Consumer

A permanent income consumer of the form first studied by Hall (1978) has a consumption function

$$c_t = -rd_t + \frac{r}{1+r}\sum_{j=0}^{\infty}\frac{E_t[y_{t+j}]}{(1+r)^j}.$$

In this model, the d_t represents one period debt, y_t is income in period t, and E_t is the expectation conditional on information available in t. The consumer is assumed to have quadratic utility and a discount rate equal to the interest rate r. An unanticipated, zero probability debt revaluation shock Δd_t, thus leads to a decline in consumption of $r\Delta d_t$.

C.2 Hand-to-Mouth Consumer

A hand-to-mouth (HtM) consumer simply consumes her per period resources. Therefore, the consumption response to a debt revaluation is simply the change in per period debt service. As a result, the maturity of the debt exposed to revaluation affects the magnitude of the consumption response.

Consider an annuity loan of amount d, interest rate r, maturity m, and per period debt service of P. The value of the debt can then be written as a finite geometric series

$$d = \sum_{j=1}^{m}\frac{P}{(1+r)^j} = \frac{P}{1+r}\sum_{j=0}^{m-1}\frac{1}{(1+r)^j},$$

which has the solution

$$d = P\frac{1-(1+r)^{-m}}{r}.$$

The per period debt payment is then

$$P = d\frac{r}{1-(1+r)^{-m}}.$$

As maturity goes to infinity, $m \to \infty$, the per period debt payment converges to $P = rD$. Therefore, with infinite maturity debt, the PI and HtM consumer have the same MPC out of an increase in debt of r. With debt due in one period, the payment is $P = (1+r)D$. The ratio between the payment on finite maturity debt and the payment on a perpetual debt is

$$\frac{P_m}{P_\infty} = \frac{1}{1-(1+r)^{-m}} \tag{C.1}$$

With an interest rate of 5 percent and a remaining maturity of 18 years, the average for housing loans prior to the 2008 forint depreciation, the payment is 1.7 times larger with finite maturity debt relative to infinite maturity debt. A HtM consumer would therefore have a 1.7 times stronger consumption response to an increase in monthly payments compared to the PI consumer. With an interest rate of 4 (7) percent this ratio is 1.97 (1.42).

D Debt Revaluation in an Open Economy Model

D.1 Model Set-Up

This appendix presents a simple small open economy model that illustrates the contrasting expansionary and contractionary effects of an unanticipated household debt revaluation present in a broad class of neoclassical and New Keynesian models. We model a region as an island small open economy in a continuum of economies $i \in [0, 1]$ following Galí and Monacelli (2005). To provide simple analytical results, we employ the recent continuous time formulation of Farhi and Werning (2017). We focus on an unanticipated exchange rate shock at time $t = 0$, which generates perfect foresight response from the initial steady state.

Households. Household preferences are given by

$$\int_0^\infty e^{-\rho t}\left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi}\right] dt,$$

where consumption is an aggregate of home and foreign goods

$$C_t = \left[(1-\alpha)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}.$$

Home goods are an aggregate of a continuum of varieties with elasticity of substitution ϵ

$$C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}}.$$

The parameter α indexes the degree of home bias in consumption. The foreign good is an aggregate of goods from each country with elasticity of substitution γ. In turn, the consumption good produced by country i is an aggregate of varieties produced within i:

$$C_{F,t} = \left(\int_0^1 C_{i,t}^{\frac{\gamma-1}{\gamma}} di\right)^{\frac{\gamma}{\gamma-1}}, \qquad C_{i,t} = \left(\int_0^1 C_{i,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right)^{\frac{\epsilon}{\epsilon-1}}.$$

Below we simplify and focus on the case where $\sigma = \eta = \gamma = 1$ (known as the Cole-Obstfeld case), but we keep the notation general for now.

We follow Farhi and Werning (2017) and assume incomplete markets.[7] Specifically, to be consistent with our empirical setting, the household has access to risk-free debt denominated in domestic and foreign currency. The budget constraint is

$$\mathcal{E}_t \dot{D}_t^* + \dot{D}_t = \mathcal{E}_t i_t^* D_t^* + i_t D_t + P_t C_t - W_t N_t - T_t - \Pi_t, \quad t \geq 0,$$

[7] Galí and Monacelli (2005) focus on the symmetric complete markets case, which simplifies the analysis by removing net foreign assets as a state variable.

where D_t and D_t^* are debt denominated in domestic and effective foreign currency, and i_t and i_t^* are the home and foreign nominal interest rate.[8] In the initial steady state we have $\mathcal{E} = 1$ and $i = i^* = \rho$.

Household optimality implies the following first order conditions for logged variables:

$$\begin{aligned} \sigma c_t + \varphi n_t &= w_t - p_t \\ \dot{c}_t &= \sigma^{-1}(i_t - \pi_t - \rho) \\ \dot{c}_t &= \sigma^{-1}(i_t^* - \pi_t - \rho + \dot{e}). \end{aligned}$$

Firms. The production function of the firm producing variety j in the home country is $Y_t(j) = A_H N_t(j)$. Real marginal cost in terms of domestic prices is given by $MC_t = \frac{1+\tau}{A_H}\frac{W_t}{P_{H,t}}$, where τ is a employment subsidy that is set to offset the monopoly distortion. Log real marginal cost is thus

$$mc_t = -\nu + w_t - p_{H,t} - a_H, \quad \nu \equiv -\ln(1+\tau). \tag{D.1}$$

Firms set prices in producer currency in a staggered fashion and can reset prices with arrival rate ρ_δ.

Terms of Trade and Real Exchange Rate. It is useful to define and relate the terms of trade to the various price indexes in the economy. The consumer price index in the home country is $P_t = \left[(1-\alpha)P_{H,t}^{1-\eta} + \alpha P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}$, where the home producer price index is the standard Dixit-Stiglitz aggregate over varieties j: $P_{H,t} = \left(\int_0^1 P_{H,t}(j)^{1-\epsilon}dj\right)^{\frac{1}{1-\epsilon}}$. Define the effective terms of trade as the price of foreign goods relative to the price of home goods, $S_t = \frac{P_{F,t}}{P_{H,t}}$, and the effective real exchange rate as $\mathcal{Q}_t = \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{P_{F,t}}{P_t}$, given producer currency pricing.

Home CPI can be log-linearized as

$$p_t = (1-\alpha)p_{H,t} + \alpha p_{F,t} = p_{H,t} + \alpha s_t \Rightarrow \pi_t = \pi_{H,t} + \alpha \dot{s}_t. \tag{D.2}$$

This allows us to relate the log terms of trade to the log real exchange rate

$$q_t = (1-\alpha)s_t.$$

Consumption Risk Sharing and Wealth Effects. We assume all foreign countries are symmetric. The Euler equation for the home country and country i imply an international risk sharing condition:

$$C_t = \Theta^i C_t^i \mathcal{Q}_{i,t}^{\frac{1}{\sigma}}.$$

[8] There is a continuum of symmetric foreign countries. The foreign currency bond is denominated in the effective spot exchange rate $\mathcal{E} = \left(\int_0^1 \mathcal{E}_i^{1-\gamma}di\right)^{\frac{1}{1-\gamma}}$.

Taking logs and integrating over i gives us

$$c_t = \theta + c_t^* + \frac{1}{\sigma} q_t,$$

where $\theta = \theta^i = \int_0^1 \theta^i di$ and $c_t^* \equiv \int_0^1 c_t^i di$. θ is a term that depends on net foreign debt, and a debt revaluation that increases the home country's net foreign debt lowers θ.

Goods Market Clearing. Using the standard CES demand functions, the market clearing condition for variety j is

$$\begin{aligned} Y_t(j) &= C_{H,t}(j) + \int_0^1 C_{H,t}^i(j) di \\ &= (1-\alpha) \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\epsilon} \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + \alpha \int_0^1 \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\epsilon} \left(\frac{P_{H,t}}{\mathcal{E}_{i,t} P_{F,t}^i} \right)^{-\gamma} \left(\frac{P_{F,t}^i}{P_t^i} \right)^{-\eta} C_t^i di \end{aligned}$$

Inserting this into the domestic output aggregator $Y_t = \left(\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$, we have

$$\begin{aligned} Y_t &= (1-\alpha) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t + \alpha \int_0^1 \left(\frac{P_{H,t}}{\mathcal{E}_{i,t} P_{F,t}^i} \right)^{-\gamma} \left(\frac{P_{F,t}^i}{P_t^i} \right)^{-\eta} C_t^i di \\ &= \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} \left[(1-\alpha) C_t + \alpha C_t \int_0^1 \left(\frac{P_{F,t}^i \mathcal{E}_{i,t}}{P_{H,t}} \right)^{\gamma-\eta} Q_{i,t}^{\eta - \frac{1}{\sigma}} \Theta_i^{-1} di \right]. \end{aligned}$$

Under the assumption that $\sigma = \gamma = \eta = 1$ the goods market clearing condition simplifies to

$$Y_t = C_t S_t^\alpha \left[(1-\alpha) + \alpha \Theta^{-1} \right], \tag{D.3}$$

which can be log-linearized as

$$y_t = c_t + \alpha s_t - \alpha \theta. \tag{D.4}$$

Using the risk sharing condition $c_t = \theta + c_t^* + q_t$ and the fact that $q_t = (1-\alpha) s_t$ yields

$$y_t = c_t^* + s_t + (1-\alpha)\theta. \tag{D.5}$$

An increase in θ increases demand for home output by $(1-\alpha)$, the share on home goods.

Net Exports. Define net exports in terms of domestic output as $nx_t = \left(\frac{1}{Y}\right) \left(Y_t - \frac{P_t}{P_{H,t}} C_t \right)$. Log-linearizing and using that $S^\alpha = P_t / P_{H,t}$ yields

$$nx_t = y_t - c_t - \alpha s_t = -\alpha \theta,$$

where the last equality uses (D.4) and hence the assumption of unitary elasticities of substitution. Therefore, when $\theta > 0$ ($\Theta > 1$) the home country can run trade deficits

of $\alpha\theta$ in each period. The assumption of unit elasticities simplifies the analysis because it implies that the trade balance is constant.

IS Equation. Differentiating the market clearing condition (D.4) with respect to time under the assumption of unitary elasticities, we have

$$\dot{y}_t = \dot{c}_t + \alpha \dot{s}_t$$

Substituting out consumption from the Euler equation, $\dot{c}_t = i_t - \pi_t - \rho$, implies

$$\dot{y}_t = i_t - \pi_t - \rho + \alpha \dot{s}.$$

Finally, using (D.2), the dynamic IS equation is

$$\dot{y}_t = i_t - \pi_{H,t} - \rho.$$

Marginal Cost, Output, and Phillips Curve. To a first order approximation, we can relate domestic output to domestic productivity and employment as

$$y_t = a_H + n_t.$$

Using this and other relations, we can rewrite real marginal cost in (D.1) as

$$\begin{aligned} mc_t &= -\nu + (w_t - p_t) + (p_t - p_{H,t}) - a_H && \text{(D.6)} \\ &= -\nu + (1+\varphi) y_t + \alpha\theta - (1+\varphi) a_H && \text{(D.7)} \end{aligned}$$

where we assume $\sigma = \gamma = \eta = 1$.

The natural level of output that obtains under flexible prices when $mc = -\mu = \ln\left(\frac{\epsilon}{\epsilon-1}\right)$, is thus

$$y_t^n = a_H + \frac{\nu - \mu}{1+\varphi} - \frac{\alpha\theta}{1+\varphi}. \tag{D.8}$$

The deviation from real marginal cost relative to the initial natural level (with $\theta = 0$) is

$$\tilde{mc}_t = (1+\varphi)\tilde{y}_t + \alpha\theta. \tag{D.9}$$

Calvo price setting implies that domestic inflation dynamics are given by the New-Keynesian Phillips curve

$$\dot{\pi}_{H,t} = \rho \pi_{H,} - \lambda \tilde{mc}_t, \quad \lambda = \rho_\delta(\rho + \rho_\delta) \tag{D.10}$$

which, using (D.9), can be rewritten as

$$\dot{\pi}_{H,t} = \rho \pi_{H,} - \kappa \tilde{y}_t - \lambda\alpha\theta, \quad \kappa = \lambda(1+\varphi). \tag{D.11}$$

Initial Flexible Price Steady State. In the initial steady state $\theta = 0$. Moreover, we assume $a_H = c^* = 0$. From (D.5) and (D.8), the natural level of output and terms of trade are simply $y^n = 0, s^n = 0$.

D.2 Consequences of a Household Debt Revaluation

We assume that in the initial steady state the nominal exchange rate equals one, $\mathcal{E} = 1$. The household is long in domestic currency assets and borrows in foreign currency, so debt in terms of output satisfies $\bar{D}^* + \bar{D} = 0$, $\bar{D}^* > 0$.[9] The economy is in the natural allocation with $\theta = 0$ and balanced trade.

At time zero there is Δe percent depreciation that raises debt to $\Delta e \bar{D}^* > 0$. This is the fundamental shock we study. The increase in debt implies that the economy must run trade surpluses. Under the assumption of unit elasticities of substitution, the trade balance is constant and equals $nx = -\alpha\theta$. The country budget constraint therefore implies that net foreign debt relative to initial output is $\Delta e \bar{D}^* = \int_0^\infty e^{-\int_0^t i_s ds} nx dt = \int_0^\infty e^{-\rho t} nx dt = \frac{nx}{\rho}$. As a result, the debt revaluation implies that the wedge in the risk sharing condition declines by

$$\theta = -\frac{\rho \Delta e D^*}{\alpha}.$$

This term has the intuitive property that the increase in debt is smoothed according to the rate at which the households can borrow ρ.

How does the exchange rate shock and associated debt revaluation affect output and prices? We can trace the effect by solving the following system:

$$\dot{\pi}_{H,t} = \rho \pi_{H,t} - \kappa y_t + \lambda \rho \Delta e D^* \tag{D.12}$$

$$\dot{y}_t = i_t - \pi_{H,t} - \rho \tag{D.13}$$

$$y_0 = -\frac{1-\alpha}{\alpha} \rho \Delta e D^* + \Delta e. \tag{D.14}$$

Equation (D.12) is the standard New-Keynesian Phillips curve, adjusted for the wealth effect of the debt revaluation. Equation (D.13) is the dynamic IS curve. Given that we think of the home economy as an independent region within a currency union, we assume that $i_t = \rho$, so that domestic monetary policy does not react to the shock. Equation (D.14) is the initial goods market clearing condition. The nominal exchange rate enters the initial condition, as it jumps by Δe, depreciating the terms of trade, but prices are sticky and hence evolve smoothly.[10]

Analytical Solution. We can write the system in (D.12)-(D.13) as $\dot{X}_t = AX_t + B_t$ and apply the transformation $Z_t = V^{-1} X_t$, where $V^{-1} A V = D$. Here V is the matrix of eigenvectors of A, and D is the diagonal matrix of eigenvalues of A:

$$A = \begin{bmatrix} \rho & -\kappa \\ -1 & 0 \end{bmatrix}, \quad D = \begin{bmatrix} \overline{\nu} & 0 \\ 0 & \nu \end{bmatrix}, \quad V = \begin{bmatrix} -\overline{\nu} & -\nu \\ 1 & 1 \end{bmatrix}, \quad \overline{\nu} = \frac{\rho + \sqrt{\rho^2 + 4\kappa}}{2}, \quad \nu = \frac{\rho - \sqrt{\rho^2 + 4\kappa}}{2}$$

[9] The assumption that $\bar{D}^* + \bar{D} = 0$ is without loss of generality, as we can always redefine the initial natural allocation as one with a different wedge in the consumption risk sharing condition.

[10] Empirically, the terms of trade moves significantly less than one for one with exchange rate shock. A weaker quantitative effect of the exchange rate channel through expenditure switching strengthens our identifying assumption, as it implies that the expenditure switching channel will also matter less for output in the cross-section of regions.

The system we want to solve is then $\dot{Z} = DZ + V^{-1}B$, or

$$\dot{z}_1 = \overline{\nu} z_1 + \frac{\lambda \rho \Delta e D^*}{\nu - \overline{\nu}} \tag{D.15}$$

$$\dot{z}_2 = \nu z_2 + \frac{\lambda \rho \Delta e D^*}{\overline{\nu} - \nu} \tag{D.16}$$

$$\tag{D.17}$$

The general solution is

$$z_{1t} = b_1 e^{\overline{\nu} t} - \frac{\lambda \rho \Delta e D^*}{\nu - \overline{\nu}} \frac{1}{\overline{\nu}} \tag{D.18}$$

$$z_{2t} = b_2 e^{\nu t} - \frac{\lambda \rho \Delta e D^*}{\overline{\nu} - \nu} \frac{1}{\nu}, \tag{D.19}$$

where b_1 and b_2 are constants. We set $b_1 = 0$ for the saddle path stable solution. Using $X_t = V Z_t$, we can obtain the solution in terms of the original variables

$$X_t = \begin{bmatrix} -\nu e^{\nu t} b_2 \\ b_2 e^{\nu t} - \frac{\lambda \rho \Delta e D^*}{\nu - \overline{\nu}} \left(\frac{1}{\overline{\nu}} - \frac{1}{\nu} \right) \end{bmatrix} \tag{D.20}$$

To obtain b_2, we use the initial condition (D.14)

$$b_2 = -\frac{1-\alpha}{\alpha} \rho \Delta e D^* + \Delta e + \frac{\lambda \rho \Delta e D^*}{\nu - \overline{\nu}} \left(\frac{1}{\overline{\nu}} - \frac{1}{\nu} \right)$$

The output response to the exchange rate shock is then:

$$\begin{aligned} y_t &= \left(-\frac{1-\alpha}{\alpha} e^{\nu t} - (1 - e^{\nu t}) \frac{\lambda}{\nu - \overline{\nu}} \left(\frac{1}{\overline{\nu}} - \frac{1}{\nu} \right) \right) \rho \Delta e D^* + \Delta e \cdot e^{\nu t} \\ y_t &= \left(-\frac{1-\alpha}{\alpha} e^{\nu t} + (1 - e^{\nu t}) \frac{1}{1+\varphi} \right) \rho \Delta e D^* + \Delta e \cdot e^{\nu t} \\ y_t &= \beta_t \Delta e D^* + \gamma_t \Delta e \end{aligned} \tag{D.21}$$

and the response of domestic inflation is

$$\pi_{H,t} = -\nu e^{\nu t} \left(-\frac{1-\alpha}{\alpha} \rho D^* \Delta e - \frac{\rho \Delta e D^*}{1+\varphi} + \Delta e \right).$$

The debt revaluation channel tends to lower inflation and depreciate the terms of trade, as demand falls and labor supply expands.

The first channel on the right-hand-side of (D.21) is the household debt revaluation channel. The debt-revaluation can have opposing expansionary supply and contractionary demand effects, captured by the different terms entering β_t. An increase in household debt lowers households' wealth and consumption, which leads households to

boost labor supply, raising output. With flexible prices, this labor supply effect dominates, and an increase in debt boosts output in the short run. At the same time, the increase in the households' real debt burden will depress consumption and therefore demand. With nominal rigidities, the demand channel dominates in the short run, and the rise in real debt burdens depresses output through a demand effect. Estimation of β_t, therefore, provides a test of flexible versus sticky price models.

The second channel on the right-hand-side of equation (D.21) is the standard expenditure switching channel. The depreciation lowers the relative price of home goods and thus increases the demand for home goods. The response in (D.21) highlights that if households have currency mismatch, the expansionary effect of exchange rate depreciation is dampened and may even be reversed, posing a dilemma for monetary policy in a currency crisis.

E Financial Spillovers and Unobserved Selection

This section presents a simple statistical model of individual-level default. The model illustrates how comparison of the coefficient on FC from equation (7) *with* and *without* controlling for s^{FC} provides information on the degree of local-level unobserved selection.[11]

E.1 Set-up

Consider a borrower i in local area z. Borrower-level FC debt exposure, FC_i, can equal zero or one. Assume borrower-level FC debt exposure is driven by three factors. The first factor is unobserved credit risk q_z at the local (settlement) level. The second factor is a random local-level foreign currency exposure shifter, r_z. The difference between q_z and r_z is that, unlike q_z, r_z does not independently affect the probability of default. The third factor is an individual level iid shock. Local-level FC debt exposure, excluding borrower i, is given by

$$s_{z,-i} = \frac{1}{N_i - 1} \sum_{j \in z, j \neq i} FC_j,$$

where N_i is the number of borrowers in a settlement. Finally, assume the probability of default is generated by the following model

$$Y_{iz} = \beta_{FC} FC_i + \beta_s s_{z,-i} + \beta_q q_z + \epsilon_{iz}, \tag{E.1}$$

where ϵ_{iz} is an iid shock. Thus, default is determined by individual FC exposure (FC_i), local FC exposure ($s^{FC}_{z,-i}$), and by unobserved credit risk (q_z) that is correlated with FC_i and $s_{z,-i}$. In this set-up, we abstract from individual-level selection based on the result that FC and LC borrowers are approximately similar at the individual level (see Section III.C).

E.2 Short and Intermediate Regressions

Consider first estimating the short regression, corresponding to column 1 in Table 7:

$$Y_{iz} = \beta_0 + \beta_{FC} FC_i + \epsilon_{iz} \tag{E.2}$$

which yields

$$\tilde{\beta}_{FC} = \frac{\widehat{\text{cov}}(Y, FC)}{\widehat{\text{var}}(FC)},$$

where we omit subscripts to lighten the notation, and all variables are demeaned. We use $\widehat{\text{var}}$ and $\widehat{\text{cov}}$ to refer to sample variances and covariances and var and cov to refer to their population values. Estimating the intermediate regression

$$Y_{iz} = \beta_0 + \beta_{FC} FC_i + \beta_s s_{z,-i} + \epsilon_{iz} \tag{E.3}$$

[11] We thank David Matsa for pointing us in this direction.

yields an estimate on FC of

$$\hat{\beta}_{FC} = \frac{\widehat{\text{var}}(s)\widehat{\text{cov}}(FC, Y) - \widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(s, Y)}{\widehat{\text{var}}(FC)\widehat{\text{var}}(s) - \widehat{\text{cov}}(FC, s)^2}.$$

Our object of interest is the difference between the short and intermediate regression coefficients:

$$\tilde{\beta}_{FC} - \hat{\beta}_{FC} = \frac{\widehat{\text{cov}}(Y, FC)}{\widehat{\text{var}}(FC)} - \frac{\widehat{\text{var}}(s)\widehat{\text{cov}}(FC, Y) - \widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(s, Y)}{\widehat{\text{var}}(FC)\widehat{\text{var}}(s) - \widehat{\text{cov}}(FC, s)^2}. \tag{E.4}$$

We will show that this object contains information on the importance of local-level unobserved selection driven by q.

E.3 Evaluation of $\tilde{\beta}_{FC} - \hat{\beta}_{FC}$

The common denominator of (E.4) can be written as

$$D = \widehat{\text{var}}(FC)\Big[\widehat{\text{var}}(FC)\widehat{\text{var}}(s) - \widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(FC, s)\Big]$$

The numerator then becomes:

$$\begin{aligned} N &= \widehat{\text{cov}}(Y, FC)\widehat{\text{var}}(FC)\widehat{\text{var}}(s) - \widehat{\text{cov}}(Y, FC)\widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(FC, s) \\ &\quad - \widehat{\text{var}}(FC)\widehat{\text{var}}(s)\widehat{\text{cov}}(FC, Y) + \widehat{\text{var}}(FC)\widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(Y, s) \\ N &= \widehat{\text{cov}}(FC, s)\Big[\widehat{\text{var}}(FC)\widehat{\text{cov}}(Y, s) - \widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(Y, FC)\Big]. \end{aligned}$$

Combining these yields

$$\tilde{\beta}_{FC} - \hat{\beta}_{FC} = \frac{\widehat{\text{cov}}(FC, s)}{\widehat{\text{var}}(FC)} \times \underbrace{\frac{\widehat{\text{var}}(FC)\widehat{\text{cov}}(Y, s) - \widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(Y, FC)}{\widehat{\text{var}}(FC)\widehat{\text{var}}(s) - \widehat{\text{cov}}(FC, s)\widehat{\text{cov}}(FC, s)}}_{\text{A}} \tag{E.5}$$

Now consider taking the number of borrowers in z and the number of local areas z to infinity, $N_i, N_z \to \infty$. Consider the term denoted by A. Using that

$$\begin{aligned} \widehat{\text{cov}}(Y, s) &\to_p \beta_{FC}\text{cov}(FC, s) + \beta_s\text{var}(s) + \beta_q\text{cov}(q, s) \\ \widehat{\text{cov}}(Y, FC) &\to_p \beta_{FC}\text{var}(FC) + \beta_s\text{cov}(s, FC) + \beta_q\text{cov}(q, FC), \end{aligned}$$

we have that

$$A \to_p \beta_s + \frac{\beta_q\Big(\text{var}(FC)\text{cov}(q, s) - \text{cov}(FC, s)\text{cov}(q, FC)\Big)}{\text{var}(FC)\text{var}(s) - \text{cov}(FC, s)\text{cov}(FC, s)}.$$

Substituting back into (E.5), we obtain

$$\tilde{\beta}_{FC} - \hat{\beta}_{FC} \to_p \frac{\text{cov}(FC, s)}{\text{var}(FC)} \times \left(\beta_s + \frac{\beta_q\Big(\text{var}(FC)\text{cov}(q, s) - \text{cov}(FC, s)\text{cov}(q, FC)\Big)}{\text{var}(FC)\text{var}(s) - \text{cov}(FC, s)\text{cov}(FC, s)}\right).$$

Using that $\text{cov}(q,s) = \text{cov}\left(q, (N_i-1)^{-1}\sum_{j\neq i} FC_j\right) = \text{cov}(q, FC)$, this simplifies to

$$\tilde{\beta}_{FC} - \hat{\beta}_{FC} \to_p \beta_s \frac{\text{cov}(FC,s)}{\text{var}(FC)} + \beta_q \frac{\text{cov}(FC,q)}{\text{var}(FC)} \left(\frac{\text{cov}(FC,s)\text{var}(FC) - \text{cov}(FC,s)\text{cov}(FC,s)}{\text{var}(FC)\text{var}(s) - \text{cov}(FC,s)\text{cov}(FC,s)} \right)$$

Focusing on the final term in parentheses, the law of total covariance implies

$$\begin{aligned} \text{cov}(FC,s) &= \text{E}[\text{cov}(FC_i, FC_j|s)] + \text{cov}(\text{E}(FC_i|s), \text{E}(FC_j|s)), \quad j \neq i \\ &= 0 + \text{cov}(s,s) \\ &= \text{var}(s). \end{aligned}$$

This implies that

$$\frac{\text{cov}(FC,s)\text{var}(FC) - \text{cov}(FC,s)\text{cov}(FC,s)}{\text{var}(FC)\text{var}(s) - \text{cov}(FC,s)\text{cov}(FC,s)} = 1$$

. Therefore,

$$\tilde{\beta}_{FC} - \hat{\beta}_{FC} \to_p \underbrace{\beta_s \frac{\text{cov}(FC,s)}{\text{var}(FC)}}_{(i)} + \underbrace{\beta_q \frac{\text{cov}(FC,q)}{\text{var}(FC)}}_{(ii)}. \tag{E.6}$$

E.4 Interpretation

Equation (E.6) is the key result of this exercise. It implies that the difference between the short and intermediate regressions estimates of β_{FC} captures the sum of: (i) the systematic relation between FC and s, times the effect of s on Y, and (ii) the relation between FC and the unobserved selection q, times the effect of q on Y.

The coefficient on FC_i would, therefore, be expected to decline for two reasons when controlling for s. The first is mechanical. FC will be correlated with s because individual foreign currency exposure is partly determined by local factors. The second is more concerning. If unobserved selection is an important driver of FC and the outcome Y, the coefficient will decline because controlling for s captures this unobserved selection. However, if the difference $\tilde{\beta}_{FC} - \hat{\beta}_{FC}$ is small, then it suggests that unobserved selection is not a major concern, i.e. that $\beta_q \frac{\text{cov}(FC,q)}{\text{var}(FC)}$ is relatively small. This also implies that the short regression provides an estimate that is approximately unbiased.

To provide a sense of the potential magnitude of term (ii) in (E.6), we can calculate the remaining terms under several assumptions. In our data, $\widehat{\text{var}}(FC) = 0.23$ and $\widehat{\text{cov}}(FC,s) = 0.005$. Assuming that $\beta_s = 3.99$ (as in Table 7), this implies that $\beta_q \text{cov}(FC,q) = -.011$. This exercise implies that omitted credit quality is not biasing the estimate of β_{FC} (and hence β_s) upward.

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