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

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October 2018

Abstract

We examine the real economic consequences of a sudden increase in household debt burdens by exploiting spatial variation in exposure to household foreign currency debt during Hungary's late-2008 currency crisis. The revaluation of debt burdens leads to higher default rates and a collapse in spending. These responses translate into a worse local recession and depressed house prices. A 10 point increase in debt-to-income raises the unemployment rate by 0.6 percentage points, driven by employment losses at non-exporting firms. Consistent with demand externalities of debt financing, regional foreign currency debt has negative spillovers on nearby borrowers without foreign currency debt.

[*]This research received financial support from the Alfred P. Sloan Foundation through the NBER Household Finance small grant program. We are extremely grateful to Atif Mian, Mark Aguiar, Adrien Matray, Motohiro Yogo, and Wei Xiong for valuable guidance and encouragement. For helpful comments we thank Adrien Auclert, Tamás Briglevics, Markus Brunnermeier, Will Dobbie, Sergio de Ferra (discussant), Bo Honoré, Oleg Itskhoki, Nobu Kiyotaki, Stefan Lewellen (discussant), Ben Moll, Dmitry Mukhin, Mikkel Plagborg-Møller, Federico Ravenna, Michala Riis-Vestergaard, Eyno Rots, Chris Sims, Amir Sufi, Gianluca Violante, Ben Young, and seminar participants at Berkeley Haas, Chicago Booth, Columbia Business School, CREi, DAEiNA, Danmarks Nationalbank, Dartmouth, Harvard, Imperial College, INSEAD, MIT Sloan, the National Bank of Hungary, NORMAC, NYU Conference on Household Finance, Princeton, SED, Stanford GSB, Tepper-LAEF Conference, and Wharton. We thank Ádám Szeidl for sharing CEU's establishment location dataset, Elisabeth Beckman and the Austrian Central Bank for sharing the Euro Survey data, and János Köllő for sharing T-Star data. Réka Zempléni provided excellent research assistance. The views in this paper are solely those of the authors and do not necessarily reflect the views of the National Bank of Hungary.

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How does elevated household debt affect the real economy in a crisis? A prominent view, going back to Irving Fisher's *debt-deflation* hypothesis, argues that household debt is a powerful contractionary mechanism. Debt forces leveraged households to cut back on consumption and leads to fire-sales that depress wealth. Recent models demonstrate that these contractionary effects may impose negative spillover effects on other households that are not internalized by borrowers when making financing decisions (e.g., Korinek and Simsek 2016, Farhi and Werning 2016). Since the Great Recession, concerns about elevated household debt have led many countries to implement macro-prudential policies to constrain household leverage.

Understanding the contractionary effects of household debt has important implications for theory and macro-prudential regulation. However, estimating the causal effect of debt on real outcomes and the role of spillovers presents several empirical challenges. First, increases in household debt are often part of a broader cycle in real activity and financial conditions. Although several studies find that expansions in household debt predict more severe recessions (e.g., Jordà, Schularick, and Taylor 2014), it is difficult to disentangle whether and why debt itself causes more severe recessions.[1] Second, estimating equilibrium effects and spillovers requires variation in household debt both across local economies and across individuals within an economy.

In this paper, we provide causal evidence on the real economic effects of a sudden increase in household debt burdens using a foreign currency debt crisis in Hungary as a natural experiment. We exploit individual and spatial variation in households' exposure to foreign currency debt during the sharp depreciation of the Hungarian forint starting in late-2008. Using this *household debt revaluation shock*, we provide two main results. First, the household debt revaluation causes a significantly worse local recession, driven by a decline in local demand. Second, the debt revaluation has negative spillovers on nearby households, including households without foreign currency debt.

Hungary provides an appealing setting to study the effects of higher debt for two reasons. First, in 2008, 69% of household debt was denominated in foreign currency.

[1]Country-level data show that credit expansions predict growth slowdowns, house price declines, bank credit contractions, equity market crashes, distressed corporate balance sheets, and over-optimistic expectations (Schularick and Taylor 2012, Baron and Xiong 2017, Krishnamurthy and Muir 2017, Mian, Sufi, and Verner 2017). Dynan (2012) analyzes whether household debt overhang constrained consumption in the U.S. during the Great Recession, but notes that debt is strongly correlated with regional housing booms and busts, which Mian and Sufi (2014a) show have strong effects on local consumption and employment.

Second, Hungary experienced a sharp and unexpected depreciation of over 30% in late 2008, driven by factors unrelated to the household sector. This combination led to a sudden increase in household debt to disposable income of over 10% in local currency terms. This sudden revaluation of household debt contracts allows us to estimate the effects of higher household debt, holding fixed other cyclical factors. Although we focus on Hungary, foreign currency lending to households was widespread throughout many countries in Europe during the 2000s. For example, Ranciere, Tornell, and Vamvakidis (2010) find that foreign currency lending led to an "unprecedented" level of currency mismatch in Eastern Europe prior to the 2008 crisis.

We use administrative household credit registry data from Hungary to construct a new dataset on household debt and default at the individual and regional level. We match these household credit data at the regional level with measures of household spending, unemployment, and house prices. Moreover, we combine these data with firm-level census and credit registry data that include information on employment, output, banking relationships, export revenues, and firm debt by currency. Our data, therefore, provide a complete picture of private foreign currency financing.

Our empirical approach exploits variation in exposure to foreign currency debt across individuals and regions. Variation is primarily driven by the timing of borrowing due to changes in the availability of government-subsidized local currency loans. Areas with a greater initial depth of domestic banks experienced more domestic currency lending at first. After the removal of the subsidy, foreign banks, which were the main foreign currency lenders, greatly expanded their branch network. This led to a catch up in indebtedness and higher foreign currency debt exposure in initially underserved regions. Individual-level survey data shows that foreign and local currency borrowers are broadly similar on observable dimensions. Furthermore, at the regional level household foreign currency debt exposure is uncorrelated with household leverage in 2008, local export intensity, or local firms' borrowing in foreign currency.

We first show that household debt revaluation leads to a strong increase in household defaults and a decline in consumption. Using data across 3,124 local areas (municipalities), we find that a one percentage point increase in debt-to-income leads to a 0.1 percentage point increase in default rates and a 1.4% decline in auto spending. The strong consumption response to debt revaluation implies that households are not hedged against their foreign currency debt positions.

Next, we investigate how the household debt revaluation affects local employment.

Standard models have differing implications for the effect of debt revaluation on real activity. In an open economy model with household currency mismatch and nominal rigidity, debt revaluation triggers a decline in consumption and employment. By contrast, in a model with flexible prices, debt revaluation lowers consumption, but increases employment, as households boost labor supply.

In the data, we find that regions with greater exposure to household foreign currency debt experience a significant and persistent rise in unemployment after the depreciation. Exploiting firm-level census data, we show that the rise in unemployment is driven by employment losses at non-exporting firms and firms in the non-tradable sector. By contrast, exporting firms are unaffected. The rise in unemployment is thus consistent with the importance of local household demand effects on real activity. In terms of magnitudes, we estimate that a 10 percentage point increase in household debt-to-income raises the local unemployment rate by 0.4 to 0.8 percentage points. The estimates imply that a $306k (2008 PPP) increase in debt destroys one local job.

Why does the household debt revaluation lead to persistently higher local unemployment? We find evidence of limited adjustment through wage declines, migration, or reallocation to exporting firms. In addition, regions with more exposure to household foreign currency debt experience a persistent relative decline in house prices after the depreciation. The amplification through house price declines is broadly consistent with recent models of pecuniary externalities from collateralized foreign currency borrowing (e.g., Mendoza 2010, Bianchi 2011, Korinek 2011).

The finding that debt revaluation causes a rise in unemployment and a decline in house prices is consistent with theories where debt has negative demand and fire-sale externalities (e.g., Farhi and Werning 2016). An implication of these theories is that borrowing in foreign currency has negative spillover effects on other households in the crisis, including households that did not borrow in foreign currency. We find direct evidence of such spillovers in loan-level data. A borrower living in regions where other households borrowed heavily in foreign currency is more likely to default, conditional on the borrower's own foreign currency debt position. The spillovers affect even borrowers with only domestic currency debt.

We take several steps to support our identifying assumption, namely that the debt revaluation shock is not correlated with unobserved shocks affecting local economic outcomes. The estimates are robust to controlling for pre-crisis household income, leverage, demographics, export exposure, industry composition, and credit quality.

Trends in all outcome variables are parallel in the years leading up to the forint depreciation in the fall of 2008, ruling out that the worse recession is driven by a reversal of a local boom. Moreover, we find no evidence that more exposed areas have higher historical cyclicality. Furthermore, using firm-level data, we show that the estimated impact of the household debt revaluation is robust to controlling for *firm* foreign currency debt exposure, relationship-specific bank lending shocks, and other firm-level observables. Firms with foreign currency debt do not differentially reduce employment around the depreciation, as these firms are more productive and more likely to be exporters.

This paper contributes to a growing literature on household leverage and business cycles. Recent studies emphasize that a combination of high household debt, deleveraging, and house price declines can trigger a recession in the presence of macroeconomic frictions (e.g., Mian, Rao, and Sufi 2013, Eggertsson and Krugman 2012, Guerrieri and Lorenzoni 2015). Our contribution is to trace the effect of a shock directly to household debt and study the impacts on spending, local firms, house prices, and real allocations. Our analysis is also connected to recent studies showing that borrowers who experience debt payment reductions have a lower probability of default and use additional funds to increase spending on durables (e.g., Di Maggio et al. 2017, Agarwal et al. 2016, Dobbie and Goldsmith-Pinkham 2015). Relative to most of these studies, we study a large shock to debt (over 6% of GDP), with variation across individuals and regions. This allows us to focus on local equilibrium effects and show that foreign currency financing has negative spillover effects.

Finally, this paper contributes to the international finance literature on foreign currency debt and currency crises. This literature has focused on *firm* and *bank* foreign currency indebtedness.[2] To our knowledge, our paper is the first to analyze the effects of *household* foreign currency exposure, despite the prevalence of household foreign currency debt throughout emerging Europe in the 2000s and in previous emerging market crises. In addition, whereas the previous literature has documented

[2]Eichengreen and Hausman (2005) provide an overview of foreign currency financing in emerging markets. A number of studies analyze the causes and consequences of firm foreign currency exposures in emerging market crises (e.g. Krugman 1999, Caballero and Krishnamurthy 2003, Aguiar 2005, Kim, Tesar, and Zhang 2015, Du and Schreger 2015). Cross-country studies find that the country-level FC debt exposure increases the probability and severity of a sudden stop crisis (e.g., Calvo, Izquierdo, and Mejia 2008), but the use of aggregate data makes it difficult to disentangle the role of household, firm, and bank balance sheet effects, as well as other country-level shocks and policy responses.

a foreign currency balance-sheet effect at the firm level, we show that foreign currency exposure has local aggregate effects. We thus provide empirical evidence on the classic Transfer Problem, which asks how the economy adjusts to an increase in external debt burdens (Keynes 1929).

The remainder of the paper is structured as follows. Section 1 discusses the background on the foreign currency debt crisis in Hungary. Section 2 describes the data. Section 3 discusses the theoretical framework and empirical methodology. Sections 4 through 6 present the results, and section 7 concludes.

1 The Hungarian Foreign Currency Debt Crisis

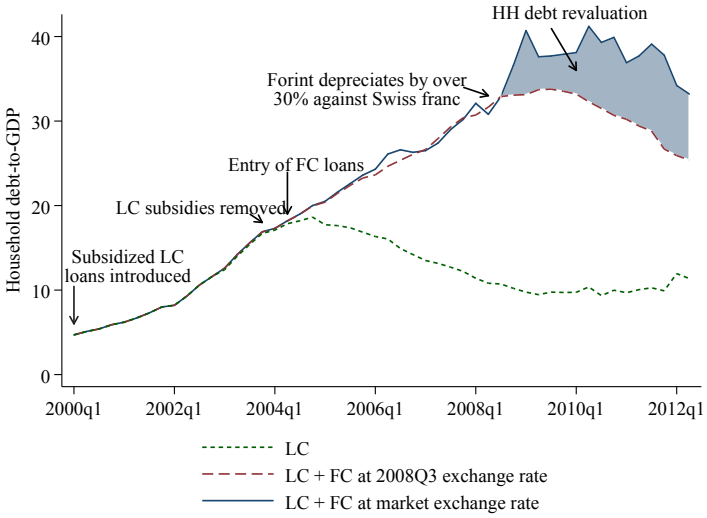
Foreign currency retail lending was prevalent throughout Europe prior to the 2008 financial crisis, especially in new EU member states.[3] Hungary experienced a particularly rapid expansion in household credit in both domestic and foreign currency. Figure 1 shows that between 2000 and 2008 household debt to GDP increased by 28 percentage points. The expansion was financed by two categories of loans: government-subsidized local currency (LC) housing loans and unsubsidized foreign currency (FC) loans. In September 2008, 69% of outstanding housing debt was denominated in foreign currency, primarily Swiss franc. This directly exposed household balance sheets to the large depreciation of the Hungarian forint starting in October 2008.

Household lending was initially spurred by a government housing program that provided interest rate subsidies on LC mortgages. The subsidy was introduced in 2000 and fixed nominal interest rates for borrowers at levels similar to euro interest rates (4-6%).[4] Subsidized LC lending was driven primarily three major domestic mortgage banks, who had a tax advantage in originating subsidized loans (Rózsavölgyi and Kovács 2005). Since average retail banking density following the transition from

[3]Lending to households in foreign currencies was widespread during the 2000s in Austria, Iceland, Estonia, Latvia, Lithuania, Poland, Slovenia, Croatia, Serbia, Bulgaria, Romania, and Ukraine. Household lending in Swiss franc and yen was also common in Denmark, Greece, Spain, and the UK. Household foreign currency debt also played a role in previous emerging market crises. For example, prior to Argentina's crisis and devaluation in 2002, 80% of mortgages were denominated in U.S. dollars (IMF 2003).

[4]Unsubsidized local currency loans with market interest rates comprised 7% of local currency housing loans in September 2008. The typical subsidized mortgage loan had a 15- to 20-year maturity with a fixed rate for the first five years and capped interest rates paid by households at 6%. This placed all interest rate risk on the government budget. See Vas and Kiss (2003) for an overview of housing finance policies in Hungary.

Figure 1: Household Debt Revaluation



Notes: This figure shows the expansion in total household debt-to-GDP by currency and the revaluation of foreign currency debt induced by the depreciation of the Hungarian forint.

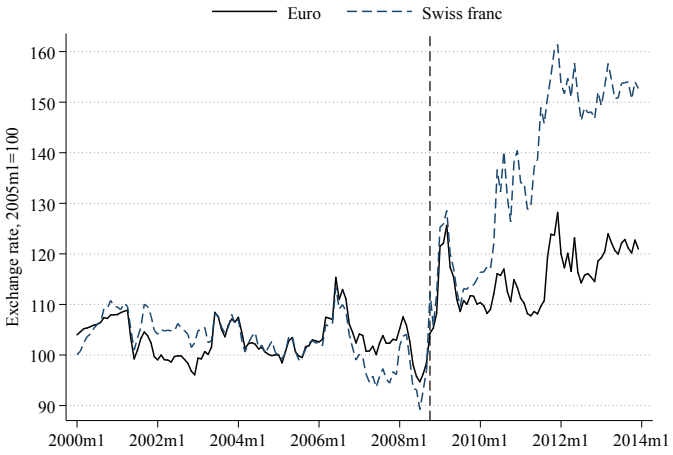
communism was low, subsidized LC housing credit growth was strongest in regions with a higher historical density of domestic mortgage banks. However, the subsidy program placed a significant burden on public finances, and subsidies on new loans were unexpectedly cut back in early 2004.

The increased cost of LC loans led foreign banks to enter the retail lending market and compete with domestic banks by offering low-interest-rate FC housing loans. Figure 1 shows that FC credit expansion began in the middle of 2004. Foreign banks competing for market share expanded FC credit aggressively, especially to areas with a lower density of domestic subsidized credit (Banai, Király, and Nagy 2011). Interest rates on Swiss franc and euro loans averaged 4% to 6%, which implied savings of about 5 percentage points relative to domestic currency loans at market rates, holding the exchange rate constant. The increased foreign currency debt exposure was almost entirely unhedged, as households income and assets in foreign currency were negligible (Backé, Ritzberger-Grŭnwald, and Stix 2007).

The foreign currency credit expansion occurred during a stable exchange rate environment, which led market participants to believe that a large depreciation was unlikely. Figure 2 shows that the forint exchange rate remained stable against the euro and Swiss franc up to October 2008. The National Bank of Hungary (MNB)

maintained a crawling band with respect to the euro. Meanwhile, the Swiss franc was quasi-fixed against the euro.[5] In a survey from November 2008, Pellényi and Bilek (2009) find that 87% of respondents with an FC loan did not expect exchange rate volatility at the late 2008 level. Appendix Figure A.1 shows that the mid-2008 Consensus Forecast also predicted a stable forint-euro exchange rate. Further, Hungary ascended to the EU in May 2004 and initially targeted adopting the euro in 2007. Survey evidence shows that the expectation of adopting the euro boosted FC loan demand (Fidrmuc, Hake, and Stix 2013).

Figure 2: Exchange Rate Dynamics



Notes: This figure shows the evolution of the forint-euro and forint-Swiss franc exchange rates. The *de facto* ±5% crawling band target up to 2008:2 was followed by a series of depreciations starting in October 2008. The vertical dashed line represents September 2008, the month prior to the forint depreciation.

Following a decade of exchange rate stability, the forint depreciated by 27.5% against the euro and 32.3% against the Swiss franc between September 2008 and March 2009. The initial depreciation was caused by the general flight to safety away from emerging markets and was exacerbated by investor concerns about the Hungarian government's large external financing needs.[6] The forint weakened further against the Swiss franc in 2010 and 2011, as the Swiss franc appreciated during the Eurozone

[5]Ilzetzki, Reinhart, and Rogoff (2010) classify the forint regime as a *de facto* ±5% band around the euro and the Swiss franc regime a ±2% band around the euro.

[6]Hungary received a $25 billion IMF loan to meet the government's external financing gap in late October 2008.

crisis. From the perspective of this study, the depreciation provides a promising shock, as it was not caused by distress in household credit markets. This allays concerns of reverse causality from household distress to exchange rate depreciation.

Figure 1 compares the value of aggregate household debt at market exchange rates relative to a counterfactual where the exchange rate had remained at its September 2008 value. The large depreciation revalued household debt burdens by 6 percent of GDP by mid-2010.[7] The depreciation was associated with a current account reversal and a severe recession, marked by an especially sharp fall in consumption. Appendix Figure A.2 presents the dynamics of other key aggregate variables. It shows that private consumption fell more than output and had yet to recover to its pre-crisis level by early 2015.

2 Data and Summary Statistics

We construct a novel dataset at the region level with information on household debt by currency and loan type, default, spending, unemployment rate, house prices, wages, and demographic variables. The primary level of aggregation in our data is a *settlement* (municipality). There are 3,124 settlements in Hungary with an average population of 3,196 in 2010. We match this regional dataset with firm-level census data on employment, exports, balance-sheet information, and bank credit. For the analysis on individual defaults and local spillovers in section 6, we also use the underlying loan and individual-level credit registry data. This section summarizes the key features of the data. Online Appendix B provides further details on the data sources and variable definitions.

2.1 Household Credit Registry

The Hungarian household credit registry contains all loans extended by all credit institutions to individuals outstanding on or after April 2012. The credit registry records information on the loan type, loan amount, date of origination, maturity,

[7]Starting in 2011, the newly elected conservative government implemented a variety of policies to alleviate the sharp rise in monthly installments. These efforts culminated in the conversion of the entire stock of foreign currency loans into domestic currency in November 2014. Our analysis focuses on the period between 2008 and 2011, prior to when these policies were implemented.

monthly payments, default status, and currency.[8] The household credit registry also reports the borrower's settlement of residence.

In order to measure a settlement's FC debt exposure prior to the 2008 forint depreciation, we reconstitute the credit registry going back to 2000. Specifically, we use an annuity model with detailed interest rate data to estimate monthly payments and outstanding debt prior to 2012 for all loans in the credit registry. We then rescale local debt measures to match the aggregate Financial Accounts. The unscaled credit registry accounts for 80.5% of aggregate housing debt in the Financial Accounts in September 2008. The default rate for loans in the credit registry closely matches the aggregate default rate reported separately from bank balance sheets prior to and during the crisis. In Appendix B we show that the annuity model also performs well at the loan level.

Loans that are terminated (repaid or refinanced) before 2012 but were outstanding in September 2008 present a potential measurement error problem for the estimation of a settlement's FC debt exposure. In the fall of 2011, the Hungarian government implemented an Early Repayment Program (ERP) that retired 21% of outstanding foreign currency debt. Accounting for the ERP raises the coverage of the credit registry in 2008:9 from 80.5% to 96% of housing debt in the flow of funds.

In Online Appendix B, we show that all the main results in this paper are robust to two adjustments that proxy for debt prepaid in the ERP. The first adjustment uses a separate dataset on the universe of loans for three anonymous large banks in Hungary to approximate the amount of debt repaid through the 2011 ERP in each settlement. The second approach imputes the amount of debt prepaid in a settlement with the amount of new domestic currency borrowing (refinancing) during the window when the ERP was in operation.

2.2 Settlement and Firm-Level Data

The main settlement-level variables are from the Hungarian Central Statistics Office (KSH). We proxy for settlement household durable spending using new auto registrations. KSH also provides settlement-level information on the unemployment rate, household income, tax payments, population, and net migration. We estimate settlement-level nominal hourly wages from the Structure of Earnings Survey, an an-

[8]Default status is effectively available starting in 2008. The household credit registry was preceded by a negative registry that contained information on delinquency.

nual survey of about 150-200 thousand workers, adjusting for compositional changes in the workforce following the procedure outlined in Beraja, Hurst, and Ospina (2016). We also use subregional (NUTS-2) house price indexes estimated from the National Bank of Hungary's home purchase transactions database.

Firm-level data are from corporate tax filings to the Hungarian Tax Authority (NAV) and include employment, payrolls, export sales, and value-added at the firm level for all double-bookkeeping firms in Hungary. The median firm has one establishment (including the headquarters), and, on average, a firm has establishments in 1.66 settlements. We therefore define a firm's exposure to local household FC debt by the settlement of the headquarters.[9] We exclude firms with fewer than 3 employees and firms in the finance, real estate, public administration, education, and health and social work sectors. This yields a sample of 80,447 firms in 2008 that we follow through the crisis. Finally, we compute firm FC debt exposure by matching loan-level data from the Hungarian Firm Credit Registry.

2.3 Summary Statistics

Panels A and B of Table 1 report summary statistics for the 3124 settlements in our sample. The household FC debt share in September 2008, s_{z08}^{FC}, has a mean of 66% and a standard deviation of 8.7 percentage points. The household default rate rose by 4.1 percentage points between 2008 and 2010, and the unemployment rate increased by 2.1 percentage points. Auto spending fell by 70% (1.2 log point) on average, while house prices declined 7%. The mean level of settlement debt to disposable taxable income is 67%. Panel C reports summary statistics for our sample of firms. Average employment growth from 2008 to 2010 was -12.9%. The average firm size is 22 employees, a quarter of firms are exporters, and 18% are in the manufacturing sector.

[9]Results are similar if we only use single-establishment firms or if we take the establishment weighted average of household FC debt exposure.

Table 1: Summary Statistics

	N	Mean	Std. dev.	10th	90th
A: Foreign Currency Exposure					
HH FC debt share, s_{z08}^{FC}	3124	0.66	0.09	0.56	0.77
HH debt revaluation, $\Delta_{08-10}\tilde{d}_z$	3124	22.15	2.35	19.64	25.04
HH debt to inc. revaluation, $\Delta_{08-10}\tilde{d}_z^{Inc}$	3124	16.11	4.35	11.10	22.06
Fraction of loans in FC, 2008:9, f_{z08}^{FC}	3124	0.64	0.08	0.56	0.75
B: Settlement Variables					
Default rate change, 2008-10	3108	4.14	2.53	2.42	6.45
Unemployment rate change, 2008-10	3124	2.06	1.48	0.82	3.51
New auto registration growth, 2008-10	3124	-120.39	45.00	-177.31	-83.30
House price growth , 2008-10	3124	-6.98	18.49	-23.60	9.85
Debt to disp. income, 2008	3124	0.67	0.23	0.44	0.89
Disp. income p.c., 1000 HUF, 2008	3124	904.97	225.31	591.79	1,178.82
Vocational share	3124	0.20	0.05	0.12	0.26
High school share	3124	0.27	0.07	0.17	0.35
College share	3124	0.15	0.09	0.05	0.29
Share of population age 18-59, 2008	3124	0.61	0.03	0.59	0.64
Share of population age 60+, 2008	3124	0.22	0.03	0.18	0.25
C: Firm-Level Variables					
Employment growth, 08-10	80447	-16.63	49.46	-97.44	33.33
Investment growth, 08-10	80447	-39.11	140.03	-200.00	191.52
Inv. to capital ratio change, 08-10	80447	-22.62	82.27	-112.34	38.01
Employment, 2008	80447	22.37	212.82	3.00	31.00
Firm has positive FC debt	80447	0.18	0.39	0.00	1.00
Firm FC debt share, 2008:9	80447	0.11	0.29	0.00	0.62
Exporter, 2008	80447	0.20	0.40	0.00	1.00
Export share of sales, 2008	80447	0.05	0.19	0.00	0.10
Manufacturing	80447	0.18	0.38	0.00	1.00
State owned	80447	0.00	0.06	0.00	0.00
Foreign owned	80447	0.08	0.28	0.00	0.00

Notes: Panels A and B report summary statistics for settlement (municipality) level variables, and panel C presents summary statistics for the firm-level census sample.

3 Theory and Empirical Framework

3.1 Theory

Our approach to isolating the impact of higher debt burdens is to obtain direct variation in real debt burdens using a foreign currency debt revaluation as a natural experiment. In theory, the consequences of a foreign currency debt revaluation

differ depending on the market structure and economic frictions. Under the extreme benchmark case of complete markets, the currency composition of debt does not affect household consumption or aggregate activity. Even without complete markets, households may be naturally hedged against exchange rate depreciation through tradable income or wealth. Households may select into borrowing in foreign currency based on their foreign currency asset positions.

Therefore, a necessary condition for a foreign currency debt revaluation to affect the real economy is for households to have unhedged exposure to FC debt. To fix ideas, assume that markets are incomplete and that domestic households can only borrow in domestic and foreign currency risk-free debt. Assume that in the initial steady state the household has $D^* > 0$ foreign currency debt, where debt is measured relative to steady state income. Suppose at $t = 0$ there is an unanticipated, one-time exchange rate depreciation from one to $1 + \Delta e > 1$. Total debt after the depreciation increases by $\Delta e D^*$. The domestic output response at time $t \geq 0$ to the exchange rate shock in the presence of household foreign currency debt can be written as:

$$y_t = \underbrace{\beta_t \Delta e D^*}_{\substack{\text{Debt} \\ \text{revaluation}}} + \underbrace{\gamma_t \Delta e}_{\substack{\text{Expenditure} \\ \text{switching}}}. \tag{1}$$

In appendix C we show that this equation can be derived from a New-Keynesian small open economy model, following Galí and Monacelli (2005) and Farhi and Werning (2017). The model provides expressions for β_t and γ_t as a function of the underlying parameters.

The first channel on the right-hand-side of (1) is the household debt revaluation channel. The debt-revaluation can have opposing expansionary supply and contractionary demand effects. 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.[10] At the same time, the increase in the households' real

[10] Chari, Kehoe, and McGrattan (2005) and Lorenzoni (2014) show that higher external debt or a sudden stop can boost output by inducing households to expand labor supply. The labor supply expansion channel holds for most standard preferences assumed in the literature. An exception is GHH (quasi-linear) preferences, which eliminate the wealth effect on labor supply. Debt can also lower labor supply through a debt overhang effect (e.g. Donaldson, Piacentino, and Thakor 2016). Given that there was no consumer bankruptcy code in Hungary at the time of the crisis and therefore a small degree of limited liability, the wealth effect likely dominates the debt overhang

debt burden will depress consumption and therefore demand. The decline in demand should have a stronger impact on output and employment of goods produced for local consumption, including non-tradable goods. With nominal rigidities, the demand channel dominates, 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.

An important implication of nominal rigidities is that the contractionary effect of a debt-induced decline in demand is not internalized by individuals when making financing decisions. This implies that there is a demand externality of borrowing decisions (Farhi and Werning 2016, Korinek and Simsek 2016). This is especially true for riskier forms of borrowing that impose greater losses in bad times, as households undervalue insurance against adverse shocks.

In addition to nominal rigidities, the rise in debt may further depress consumption in the presence of financial constraints. The rise in debt may increase defaults and foreclosures, leading to fire sales that depress local house prices. A decline in house prices can tighten collateral constraints, further lowering consumption (Kiyotaki and Moore 1997). A worse recession also depresses house prices, creating a two-way feedback between the demand and fire-sale channels. Finally, real rigidities, such as frictions that inhibit a reallocation of employment towards exporting firms, strengthen the negative effects of debt on output (Huo and Ríos-Rull 2016).

The second channel in (1) 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 (1) 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.

3.2 Empirical Specification

Our empirical specification isolates the debt revaluation channel by comparing the evolution of outcomes in regions with high exposure to foreign currency debt, relative to regions with low exposure, around the October 2008 depreciation of the Hungarian

effect in this context.

forint. The basic specification is:

$$\Delta y_{z,08-10} = \alpha + \beta \cdot (\text{HH FC Debt Exposure})_{z08} + \epsilon_z, \tag{2}$$

where $\Delta y_{z,08-10}$ is the change in an outcome such as spending or unemployment in a settlement z between 2008 and 2010 and $(\text{HH FC Debt Exposure})_{z08}$ is a measure of household exposure to FC debt prior to the depreciation. We also estimate the impact of the household debt revaluation over time to test for pre-trends and the full dynamic propagation of the shock using

$$y_{zt} = \alpha_z + \gamma_t + \sum_{y \neq 2008} [\beta_y \cdot (\text{HH FC Debt Exposure})_{z08} \cdot \mathbf{1}_{y=t}] + \epsilon_{zt}, \tag{3}$$

where $\mathbf{1}_{y=t}$ is an indicator that equals one in year t and zero otherwise.

We estimate (3) using 3124 *settlements*, but we cluster standard errors on 175 subregions based on a test of the appropriate level of clustering developed by Ibragimov and Müller (2016). Our preferred specification weights by settlement population in 2007, but we report robustness checks for alternative weighting schemes.

Our baseline measure of local exposure to foreign currency debt is the *share* of household debt in foreign currency in September 2008, s_{z08}^{FC}.[11] As Figure 2 shows, the forint depreciated by a similar magnitude against the Swiss franc and the euro in the initial phase of the crisis between 2008 and 2010. Further, in September 2008, 97% of FC debt was denominated in Swiss franc. A settlement's share of household debt in FC thus captures most of the variation in exposure to the depreciation.

Figure 3 presents a map of the spatial variation in the household FC debt share, s_{z08}^{FC}. The share of household debt in foreign currency is not strongly clustered in specific regions. The average FC debt share ranges from 48% on average in the lowest decile to 90% in the highest decile, and there is variation in the currency composition of debt within and across major regions.

To obtain estimates that are more easily interpretable, we also directly estimate

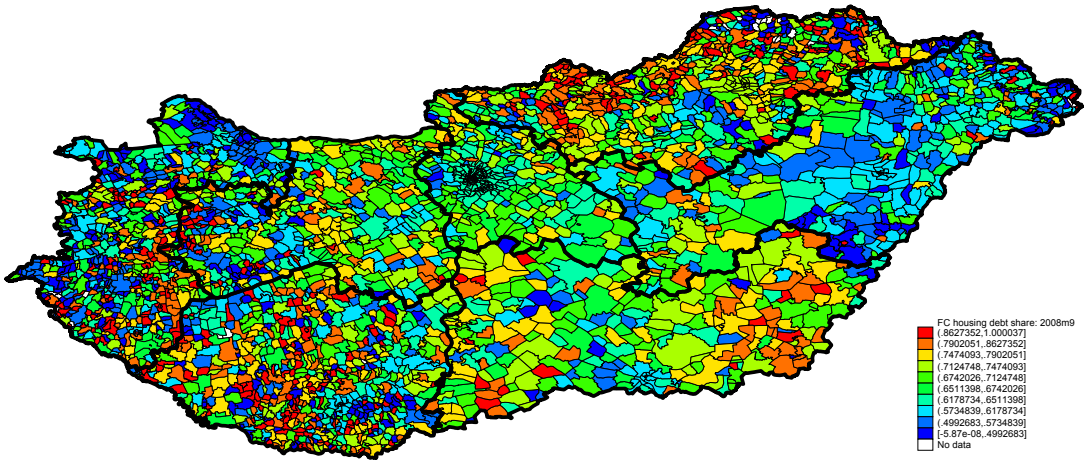
[11] Results are similar using earlier months in the summer of 2008 or instrumenting the 2008 FC debt share with the share in 2006.

the effect of the *household debt revaluation shock* from 2008:9 to t, defined as

$$\Delta \tilde{d}_{z,08-t} = \frac{\sum_{j \in C} \left(\mathcal{E}_t^j D_{z08}^j - \mathcal{E}_{08}^j D_{z08}^j \right)}{\sum_{j \in C} \mathcal{E}_{08}^j D_{z08}^j}, \tag{4}$$

where C is the set of currencies, $\mathcal{E}_t^j$ is the forint price of currency j at time t, and D_{z08}^j is debt in currency j in September 2008. The debt revaluation shock captures the percentage increase in debt induced by the depreciation. It can be related to the FC debt shares in each currency j as: $\Delta \tilde{d}_{z,08-t} = \sum_{j \in C} [(\mathcal{E}_{t+h}^j - \mathcal{E}_{08}^j)/\mathcal{E}_{08}^j] s_{z08}^j$.

Figure 3: Geographic Distribution of Household FC Debt Exposure



Notes: This figure presents a map of the household FC debt share across 3124 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.

The FC debt share and the debt revaluation shock exploit variation in the currency composition of household debt, but not the overall *level* of leverage. This allows us to hold fixed the overall expansion in debt, which may be correlated with other cyclical factors. While this is attractive from an identification perspective, from a theoretical perspective the overall exposure to FC debt relative to household resources is what matters. We therefore also present results using the household debt revaluation relative to income, which is defined as

$$\Delta \tilde{d}_{z,08-t}^{Inc} = \frac{\sum_{j \in C} \left(\mathcal{E}_t^j D_{z08}^j - \mathcal{E}_{08}^j D_{z08}^j \right)}{(\text{Household disp. income})_{z08}}. \tag{5}$$

This measure and the FC debt share have a correlation of 0.26. They therefore capture different components of variation. Below we argue this helps address concerns about omitted variable bias. Finally, we present robustness using the fraction of loans on FC, the number of FC loans per adult, the share of mortgage debt in FC (i.e. excluding home equity loans), and the share of debt in FC only for loans originated in years 2003 to 2005.

3.3 Identification and Variation in Household FC Debt Exposure

Equation (2) provides a consistent estimate β under the identifying assumption of parallel trends. More precisely, identification assumes that the change in an outcome y_{zt} in low s^{FC}_{z08} settlements is a valid counterfactual for high s^{FC}_{z08} settlements, had those regions not been exposed to the depreciation through household FC debt. The threat to identification is a time-varying, region-specific shock that affects y_{zt} and is correlated with exposure to foreign currency debt. In particular, identification does not require that FC debt exposure is distributed randomly.

A potential concern with our empirical strategy is that FC and LC borrowers may have different exposure to business cycle risk. *A priori*, the sign of such potential selection into FC loans is ambiguous, both at the individual and regional level. Households with higher or less risky income may be more likely to borrow in foreign currency.[12] Foreign banks, which are the main providers of FC credit, may also "cherry-pick" borrowers with low default risk (Beck and Brown 2015). On the other hand, less financially sophisticated households who are more exposed to recession risk may be more likely to borrow in FC because they do not adequately assess exchange rate risk.

Table 2 presents the average characteristics of LC borrowers, FC borrowers, and non-borrowers from a representative survey of households in Hungary collected by the Austrian Central Bank's Euro Survey Project. We use households from the 2008 to 2011 waves of the survey.[13] The survey reveals that, compared to LC borrowers, FC

[12]For example, Beer, Ongena, and Peter (2010) find that Swiss franc borrowers in Austria are typically high-income and financially sophisticated households.

[13]The Euro Survey Project is a biannual survey that collects information on the role of the euro in Central and Eastern European countries. Results are similar, but less precise, using only the 2008 wave. Because FC lending effectively stopped after the depreciation, most borrowers with an FC loan after 2008 would have borrowed prior to the shock.

borrowers have similar or slightly higher education, income, and employment rates and tend to live in smaller towns. Other studies using the Euro Survey and other households surveys also find that FC and LC borrowers in Hungary are broadly similar along observable dimensions (Fidrmuc, Hake, and Stix 2013, Pellényi and Bilek 2009). A borrower's loan currency denomination is largely determined by whether the loan was taken out during the subsidized LC period or the period of FC loan expansion.

Table 2: Characteristics of Local and Foreign Currency Borrowers in Survey Data

	LC mean	FC mean	Non-borr. mean	LC-FC b	se(LC-FC) se
Low education	0.18	0.12	0.27	0.06	0.01
Medium education	0.64	0.67	0.57	-0.04	0.02
High education	0.18	0.20	0.16	-0.02	0.02
Low Income	0.30	0.24	0.35	0.06	0.02
Medium Income	0.30	0.26	0.25	0.04	0.02
High Income	0.27	0.32	0.21	-0.05	0.02
Age in 2008	41.50	40.56	48.26	0.93	0.49
Size of Household	2.91	3.05	2.44	-0.14	0.05
Employed	0.62	0.69	0.43	-0.07	0.02
City pop. $<$ 5,000	0.33	0.32	0.29	0.01	0.02
City pop. 5,000-100,000	0.42	0.46	0.40	-0.04	0.02
City pop. $>$100,000	0.25	0.22	0.31	0.02	0.02
Observations	1171	1355	6587	2526	2526

Notes: This table presents average individual level characteristics of local currency borrowers (LC), foreign currency borrowers (FC), and non-borrowers from the Austrian Central Bank's Euro Survey Project. We use the biannual samples from 2008 to 2011. Education and income are reported in three categorical groups (low, medium, and high). Foreign (local) currency borrowers are borrowers who report have loans that are solely or predominantly in foreign (local) currency.

While FC and LC borrowers are similar at the individual level, our analysis primarily exploits regional variation to examine the impact on local aggregate economic activity. Table 3 presents regressions of s_{z08}^{FC} on various settlement-level characteristics to provide a sense of the correlates of HH FC debt exposure. The FC debt share is uncorrelated or weakly correlated with export exposure of local firms, overall household debt to income, manufacturing and construction employment shares, the working age population share, labor productivity, and corporate FC indebtedness.

Below, we also find that s_{z08}^{FC} is uncorrelated with the change in other outcomes, including house prices and durable spending prior to the depreciation. This allows us to disentangle the impact of higher debt from other housing-related factors that may contribute to a more severe recession.

Table 3 also reveals that high s_{z08}^{FC} areas have significantly lower disposable income per capita, education levels, and population. Thus, while FC and LC borrowers are approximately comparable at the individual level according to survey data, FC borrowers tend to live in smaller cities where overall income and education levels are lower. To ensure that our results are not driven by unobserved shocks that differentially affect poorer areas, we show that results are similar when using the household debt revaluation to income and the mortgage FC debt share. These measures are uncorrelated or even positively correlated with local income and education (Appendix Table A.1).

Table 3: Correlates of Household Foreign Currency Debt Exposure across Settlements

Right-hand-side variable	Coefficient	S.E.	R^2	N
Debt to disposable income, 2008	-0.030	0.016	0.006	3124
Log disposable income per capita, 2008	-0.062	0.014	0.041	3124
Log population, 2008	-0.006	0.002	0.028	3124
Share of population age 18-59, 2008	-0.052	0.119	0.000	3124
Vocational education share	0.331	0.094	0.040	3124
College share	-0.274	0.087	0.072	3124
Export sales share, 2008	-0.021	0.029	0.004	2718
Export sales per capita, 2008	-0.078	0.410	0.000	2718
Log sales-employment ratio, 2008	-0.006	0.008	0.003	2718
Corporate FC indebtedness, 2008, $s_{z08}^{FC,Firm}$	-0.011	0.022	0.001	2718
Manufacturing employment share, 2008	0.021	0.020	0.004	2718
Construction employment share, 2008	-0.002	0.036	0.000	2718
Agriculture employment share, 2008	0.042	0.023	0.005	2718

Notes: The table presents regressions of the September 2008 household foreign currency debt share on various settlement level characteristics:

$$s_{z08}^{FC} = \alpha + \beta x_z + u_z.$$

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

One explanation for the negative relation between s_{z08}^{FC} and local population and

education comes from the credit supply side. Following the transition from communism, average retail banking depth and competition were low, but varied substantially across regions.[14] Areas with a higher density of domestic banks experienced stronger growth in subsidized domestic currency household credit. Following the removal of domestic currency subsidies in 2004, foreign banks filled into areas with lower branch density, providing FC credit to previously underserved areas. Appendix Table A.2 shows that areas with a lower banking density in 1995 have a higher domestic currency debt-to-income in 2008, lower FC debt-to-income, and therefore a lower share of debt in FC.

In the empirical analysis below, we report estimates that control for the settlement-level observables in Table 3 to capture any time-varying shocks that interact with these observables. In particular, we control for the 2008 debt to disposable income, log 2008 population, log 2008 disposable income per capita, education (vocational, high school, and college) shares, the share age 18-59, the share age 60 or above, industry employment shares, export revenues as a share of total firm revenues, and export revenues per capita. We also control for the intensity of a public jobs program that was expanded in 2011.[15] In firm-level employment regressions, we include firm-level measures of productivity, size, firm leverage and firm FC indebtedness, ownership structure, two-digit industry fixed effects, and fixed effects for firm-bank relationships prior to the depreciation.

We take a number of additional steps to provide support for the parallel trends assumption. First, we confirm that pre-trends are parallel prior to depreciation. Second, we present tests that control for time-varying regional shocks and trends by including fixed effects for 20 regions and 175 subregion-specific time trends. Third, we find null effects on exporting firms, which should not be exposed to changes in local household demand. Fourth, we present additional checks that rule out that the household debt revaluation effects are spuriously driven by specific alternative hypotheses, such as a local bank lending channel and corporate FC debt. Finally, we also conduct placebo tests using the 1998 Russian Sovereign Debt Crisis that spilled

[14] Gál (2005) provides a detailed analysis of the geographic differences in the density of retail banking after the transition from communism, showing that there are significant differences in the number of retail banks per capita across regions. He argues these differences are driven by a high degree of centralization in a few major cities dating back to communism.

[15] The public jobs program lowered unemployment sharply starting in 2011. The program attenuates the estimated effect on unemployment (but not employment) starting in 2012, as it was targeted toward regions with the largest rise in unemployment.

over to emerging markets.

4 Results

4.1 Household Defaults

Table 4 panel A analyzes the effect of debt revaluation on the household default rate. Default is defined as payments being at least 90 days in arrears. Housing loans in Hungary are full recourse loans, and debt cannot be discharged in bankruptcy. Thus, a household's decision to default mainly reflects limited ability, as opposed to willingness, to repay.

Column 1 in Table 4A shows a regression of the change in the fraction of housing loans in default between 2008 and 2010 on the household FC debt share. The estimate implies that taking the FC debt share from zero to one is associated 7.2 percentage point higher default rate. The coefficient is large in magnitude. A one standard deviation increase in s_{z08}^{FC} implies a one-quarter of a standard deviation increase in the household default rate.

In columns 2-4 we progressively add controls for demographic characteristics, education shares, debt to income, log disposable income, export exposure, one-digit industry employment shares, and fixed effects for 7 major regions. The estimate falls to 4.4, but remains significant at the 1% level. Once we control for education shares, the estimates are stable when adding additional controls.

Figure 4 presents the effect of FC debt exposure on the default rate over time. It plots the estimates of $\{\beta_y\}$ from estimating equation (3) for the settlement default rate on housing loans at a quarterly frequency. The omitted period is 2008Q1, the first period default information is available in the credit registry. The evolution of the default rate in high and low FC debt regions is similar prior to the depreciation. Higher FC debt regions only begin experiencing higher default rates starting in 2009Q2. The default rate rises gradually in more exposed settlements through 2014. The gradual rise is likely due to a combination of the additional depreciations and the full recourse environment, which provides an incentive to avoid default.

Columns 5 and 6 of Table 4 present the estimated effect in terms of the household debt revaluation shock, defined in (4). This specification can be thought of as the "second stage" regression of the effect of debt revaluation on default, where the

Table 4: Household Debt Revaluation, Local Default Rates, and Household Spending

Panel A: Default Rate Change, 2008-10

	$\Delta_{08-10}\text{Default}_z$					
	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, s_{z08}^{FC}	7.20	4.92	5.22	4.41		
	(0.90)	(0.75)	(0.77)	(0.80)		
HH debt revaluation, $\Delta_{08-10}\tilde{d}_z$					0.24	0.15
					(0.031)	(0.027)
Baseline Controls		Yes	Yes	Yes		Yes
Export Exposure Controls			Yes	Yes		Yes
Industry Employment Shares			Yes	Yes		Yes
Region FE (7 units)				Yes		Yes
R^2	0.062	0.20	0.23	0.26	0.052	0.26
Observations	3108	3051	2678	2678	3109	2678

Panel B: New Auto Registrations Growth, 2008-10

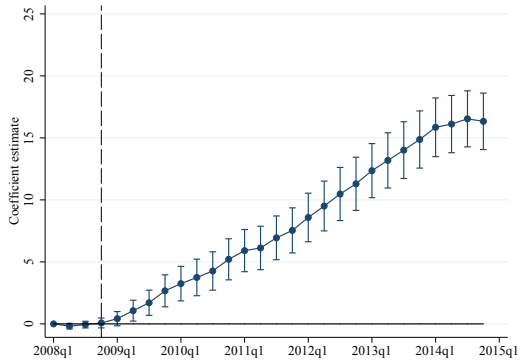
	$\Delta_{08-10}\ln(\text{Auto Registrations})_z$					
	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, s_{z08}^{FC}	-99.5	-43.7	-52.4	-48.7		
	(19.5)	(14.1)	(13.8)	(11.5)		
HH debt revaluation, $\Delta_{08-10}\tilde{d}_z$					-3.77	-1.86
					(0.67)	(0.43)
Baseline Controls		Yes	Yes	Yes		Yes
Export Exposure Controls			Yes	Yes		Yes
Industry Employment Shares			Yes	Yes		Yes
Region FE (7 units)				Yes		Yes
R^2	0.037	0.27	0.30	0.35	0.039	0.35
Observations	3124	3067	2679	2679	3124	2679

Notes: Columns 1 through 4 report regressions of the form: $\Delta_{08-10}Y_z = \alpha + \beta s_{z08}^{FC} + \Gamma X_z + \epsilon_z$, where the dependent variable is the change in the settlement default rate on housing loans (panel A) or growth in households' new auto registrations (panel B). The default rate is measured as the fraction of loans in arrears in a settlement (city or municipality). Columns 5 and 6 replace the independent variable with the household debt revaluation shock, defined in equation (4) as the change in debt induced by exchange rate depreciations. Baseline controls are household disposable income, household debt to income, log population, education shares, and working age and retired population shares. Export exposure controls are the export share of firm revenues and total firm export revenues per capita. Industry employment shares refers to one digit NACE industries. Columns 4 and 6 include fixed effects for the 7 NUTS-2 regions. Controls are measured in 2008. Observations are weighted by 2007 population. Standard errors are clustered at the subregion level (175 units).

second stage variable is computed as the exact debt revaluation shock implied by FC debt exposure.[16] In terms of magnitudes, column 6 implies that a 10% increase in household debt raises the settlement default rate by 1.7 percentage points.

Appendix Table A.3 presents the same regression with the household debt revaluation to income, defined in (5), as the right-hand-side variable. According to that specification, a 10 percentage point increase in debt-to-income raises the local default rate by 1 percentage point. In contrast to the FC debt share (s_{z08}^{FC}), the debt revaluation relative to income is *positively* correlated with income (see Appendix Table A.1). The fact that we find similar results rejects the notion that our results are driven by some unobservable negative shock that differentially affected poorer regions.

Figure 4: Household Foreign Currency Debt Exposure and Default Rates



Notes: This figure presents estimates of $\{\beta_q\}$ from

$$\text{Default}_{zt} = \alpha_z + \gamma_t + \sum_{q \neq 2008Q1} \beta_q (s_{z08}^{FC} \cdot \mathbf{1}_{q=t}) + \sum_{q \neq 2008Q1} \Gamma_q (X_{z08} \cdot \mathbf{1}_{q=t}) + \epsilon_{zt}.$$

The outcome variable is the settlement default rate on housing loans, defined as the fraction of housing loans in default. For reference, the aggregate default rate on housing loans increased from 0.9% in 2008:9 to 4.7% in 2010:9 and 13.9% in 2014:9. Error bars represent 95% confidence intervals from standard errors clustered at the subregion level.

[16] Results are almost identical if we instead instrument the increase in household debt with the FC debt share.

4.2 Durable Spending

In Table 4 panel B we ask whether spending growth is related to the household debt revaluation across local areas. Columns 1-4 report regressions of the change in log new auto registrations from 2008 to 2010 on the household FC debt exposure, s_{z08}^{FC}.[17] Between 2008 and 2010, settlements with only FC debt see a 39% (.487 log point) decline in auto spending relative to regions with no foreign currency debt. A one standard deviation increase in s_{z08}^{FC} is associated with one-fifth of a standard deviation lower auto expenditure. The estimated effect is highly significant and robust to including a host of controls. The estimates are also robust to using the household debt revaluation to income as the shock. A one percentage point increase in debt-to-income depresses durable spending by 1.43% (Appendix Table A.3).

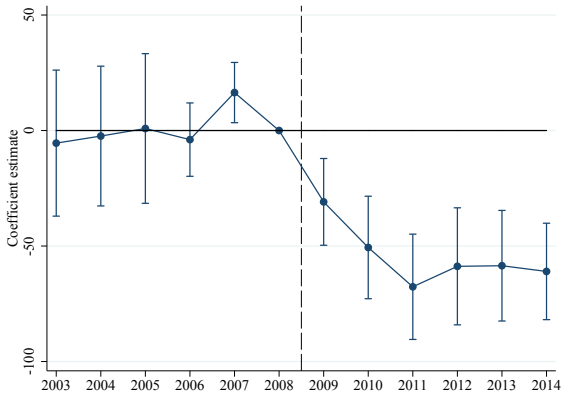
Figure 5 illustrates how FC debt exposure affects new auto registrations over time by plotting estimates of $\{\beta_y\}$ from equation (3). In the years leading up to the depreciation there is no differential change in auto spending in high relative to low s_{z08}^{FC} settlements. In particular, there is no evidence of differential "boom-bust" dynamics. The estimated effect on durable spending is therefore unlikely to be explained by a consumption boom reversal, an overhang of consumer durables, or a reversal in optimistic growth expectations. In 2009, following the depreciation, auto spending falls sharply in regions with a higher FC share and continues to fall in 2010. Durable spending begins a slow recovery starting in 2012, but remains significantly below the pre-crisis level even by 2014. The persistent effect on durable expenditure is consistent with the fact that debt revaluation permanently lowers household wealth.

4.3 Main Result: Local Unemployment

The rise in the real burden of debt for households with foreign currency exposure leads to a rise in default rates and a sharp decline in household spending. How does the local economy absorb this shock? Table 5 explores the effect of household debt revaluation on the settlement unemployment rate. Column 1 reveals that settlements with higher exposure to household FC debt see a larger rise in unemployment from 2008 to 2010. The coefficient implies that a region with all debt denominated in FC experiences a

[17] To allow for small settlements with zero registrations, we add one before taking logs, i.e. $\ln(1+C_{zt})$. The estimates are quantitatively similar when dropping small settlements with zero spending in either period or when using the symmetric growth rate, $\frac{C_{10z}-C_{z08}}{.5(C_{10z}+C_{z08})}$, which allows for the start or end value to be zero.

Figure 5: Foreign Currency Debt Exposure and Household Spending



Notes: This figure presents estimates of $\{\beta_q\}$ from

$$\ln(C_{zt}) = \alpha_z + \gamma_t + \sum_{y \neq 2008} \beta_y (s_{z08}^{FC} \cdot \mathbf{1}_{y=t}) + \sum_{y \neq 2008} \Gamma_q (X_{z08} \cdot \mathbf{1}_{q=t}) + \epsilon_{st}$$

for durable spending (new auto registrations), durable financing (new auto lending), and non-durable consumption (household electricity consumption). Coefficients are multiplied by 100. Error bars represent 95% confidence intervals from standard errors clustered at the subregion level.

2.3 percentage point increase in unemployment from 2008 to 2010, relative to a region with only domestic currency debt. Columns 2 through 4 reveal that the estimate is quantitatively similar when including a range of controls. This result implies that a higher burden of debt leads to a significantly weaker local economy, which, in turn, exacerbates the burden of debt repayment.

Figure 6 presents the full dynamic impact of FC debt exposure on unemployment from estimating equation (3). Between 2003 and 2008, there is no relation between s_{z08}^{FC} and the change in unemployment, consistent with parallel trends. Notably, parallel trends hold during 2005 and 2006, when the aggregate unemployment rate increased by 1.5 percentage points following the implementation of a fiscal consolidation program. After the depreciation in 2008Q4, the coefficient rises to 1.8 percentage points, and unemployment remains persistently higher in more exposed regions for several years. By 2014, six years after the shock, unemployment in exposed regions had still not fully recovered to its relative pre-crisis level.[18]

[18]Appendix Figure A.3 presents the dynamic estimates from (3) without controls. The pre-trends

Table 5: Impact of Household Debt Revaluation on Local Unemployment

	Δ_{08-10}Unemployment rate$_z$					
	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, s_{z08}^{FC}	2.34	1.63	1.77	1.80		
	(0.62)	(0.63)	(0.65)	(0.62)		
HH debt revaluation, $\Delta_{08-10}\tilde{d}_z$					0.085	0.057
					(0.023)	(0.023)
Baseline Controls		Yes	Yes	Yes		Yes
Export Exposure Controls			Yes	Yes		Yes
Industry Employment Shares			Yes	Yes		Yes
Region FE (7 units)				Yes		Yes
R^2	0.019	0.13	0.15	0.17	0.019	0.17
Observations	3124	3067	2679	2679	3152	2686

Notes: This table presents regressions of the form

$$\Delta_{08-10}\text{Unemployment rate}_z = \alpha + \beta s_{z08}^{FC} + \Gamma X_z + \epsilon_z.$$

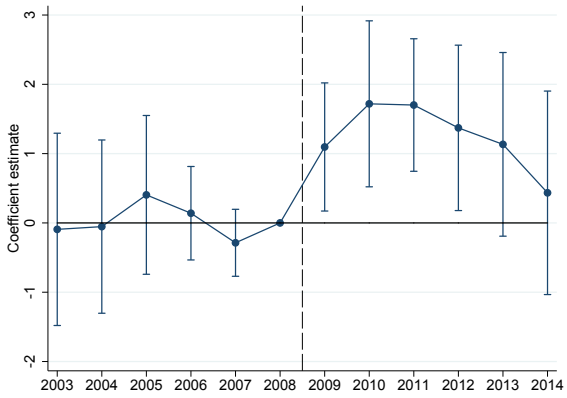
The unemployment rate is defined as the number of registered unemployed workers divided by the working age population. Columns 5 and 6 replace the household foreign currency debt share with the household debt revaluation shock defined in equation (4) as the right-hand-side variable. Standard errors are clustered at the subregion level (175 units).

4.4 Interpretation of the Unemployment Estimate

The rise in unemployment caused by the household debt revaluation is qualitatively consistent with the presence of nominal rigidities. In terms of economic magnitudes, the estimates imply that a 10 percentage point increase in household debt-to-income raises the local unemployment rate between 0.4 and 0.8 percentage points (from the estimates on $\Delta\tilde{d}_{z,08-10}^{Inc}$ and $\Delta\tilde{d}_{z,08-10}$, respectively). To provide a sense of the aggregate impact of the debt revaluation channel, we can compute the aggregate partial equilibrium counterfactual in which all settlements have zero foreign currency liabilities. We sort settlements into 20 equal population bins and apply the estimated coefficient from Table 5 to the average foreign currency exposure in each bin and aggregate over all bins. This exercise is only meant to provide a sense of the size

and short-run effects through 2011 are quantitatively similar to the specification without controls. However, the specification without controls shows that unemployment recovers by 2013.

Figure 6: Foreign Currency Debt Exposure and Unemployment



Notes: This figure presents the estimates of $\{\beta_y\}$ from

$$u_{zt} = \alpha_z + \gamma_t + \sum_{y \neq 2008} \beta_y (s_{z08}^{FC} \cdot \mathbf{1}_{y=t}) + \sum_{y \neq 2008} \Gamma_q (X_{z08} \cdot \mathbf{1}_{y=t}) + \epsilon_{st},$$

where u_{zt} is the settlement unemployment rate. Error bars represent 95% confidence intervals from standard errors clustered at the subregion level.

of the estimates and is subject to the caveat that cross-sectional elasticities do not capture a variety of aggregate general equilibrium effects.

The partial equilibrium counterfactual implies a 0.64 ($\Delta \tilde{d}^{Inc}_{z,08-10}$ estimate) to 1.2 ($\Delta \tilde{d}_{z,08-10}$ estimate) percentage point increase in unemployment relative to the counterfactual where all debt is denominated in local currency, which accounts for 32-58% of the increase in the registered unemployment rate between 2008 and 2010. Given the aggregate increase in unemployment of 120 thousand between 2008 and 2010, the estimates imply that the debt revaluation destroyed 37.8 to 69.6 thousand jobs.

How many dollars of additional debt destroys one job? The aggregate household debt revaluation is HUF 1,513 bn between 2008Q3 and 2010Q4, or $11.55 bn PPP using the 2008 HUF-USD PPP exchange rate. This amounts to 5.7% of 2008 GDP or 16% of net taxable household income. Using the conservative estimate of the number of jobs destroyed by the debt revaluation, this implies that a $306 thousand PPP increase in household debt burdens destroys one local job ($11.5bn/37.8 thousand jobs).

4.5 Robustness

Alternative Hypotheses. An important threat to identification is that areas with higher exposure to foreign currency debt are inherently more cyclical. Appendix Table A.4 column 1 shows that the estimates are robust to controlling for a settlement's historical loading on business cycle risk. Appendix Figure A.4 uses the 1998 Russian Sovereign Debt Crisis as a placebo sample to further support the argument that regions with higher exposure to FC debt are not generally more sensitive to business cycle shocks. Russia's devaluation and sovereign default in August 1998 led to capital outflow from Hungary and a collapse in Hungary's exports to Russia. These adverse shocks were associated with a 1.3 percentage point increase in the aggregate unemployment rate in 1998, followed by a strong recovery in 2000. Figure A.4 shows that re-estimating (3) on the 1995-2001 sample yields estimates that are close to zero and insignificant for all years. We conclude that there is no evidence that high s_{z08}^{FC} regions are generally more sensitive to business cycle risk.

A related concern is that high s_{z08}^{FC} areas are worse credit quality and therefore would have had a worse recession even without exposure to FC debt. Table A.4 column 2 shows that the unemployment estimate is robust to controlling for the *level* of the unemployment rate and the default rate in the month prior to the depreciation. Column 3 instruments s_{z08}^{FC} with the FC debt share for mortgage loans and finds a similar estimate. The mortgage FC debt share measure excludes home equity loans, and anecdotal evidence suggests mis-selling of foreign currency mortgages was most prevalent for home equity loans. The mortgage FC debt share is therefore uncorrelated with 2008 household disposable income (see Appendix Table A.1).

Foreign currency borrowers generally borrowed later in the cycle, so a specific concern is that credit quality deteriorated during the boom. Table A.4 column 4 instruments the overall FC debt share with the FC debt share using only loans originated in years 2003 through 2005. The estimates using this instrument are similar to the baseline.

Another concern is that high exposure areas simultaneously experienced a boom and reversal in credit supply. In Table A.4 column 5 we control for the expansion in overall household debt-to-income from 2004 to 2008 and find similar results. Below we also use firm-level data and credit registry to rule out a bank-lending channel through firms. To account for other potential shocks operating at a regional level, Table A.4 column 6 includes region fixed effects for 20 major regions (NUTS-3). The

effect remains highly significant, albeit 25% smaller, which is likely because exploiting variation within NUTS-3 regions absorbs some labor-market level variation.

Measurement of the Shock. Our results are robust to measuring household FC debt exposure using the fraction of loans in FC (column 7) and the number of FC loans relative to the working age population (column 8). The latter measure ensures that the results are not spuriously driven by settlements with a small number of loans but a high FC debt share. Column 9 finds a null effect using the number of LC loans per adult.

Weights, Heterogeneity by City Size, and Aggregation. Appendix Table A.5 column 1 shows that the estimate falls by half when weighting settlements equally. This is because the effect is stronger among larger, more densely populated settlements, which generally constitute their own labor markets (columns 2, 3, and 4). Larger cities are more closed economies and therefore subject to less "leakage" of local demand. Table A.5 column 5 addresses the concern that settlements may be too fine a unit of analysis to capture local labor market effects.[19] Specifically, we estimate our main specification using 175 subregions that correspond to commuting zones (Paloczi et al. 2016). The point estimate is quantitatively similar using this higher level of aggregation.

5 Mechanisms

Why does the household debt revaluation translate into a large local rise in unemployment? This section presents evidence on the role of a local demand channel, labor market frictions, and housing market distress in explaining the worse local recession. In addition, we compare the real effects of household and firm FC debt exposure, and we rule out a bank lending channel interpretation of our results.

[19] Lalive, Landais, and Zweimüller (2015) conduct a local labor markets analysis of unemployment insurance spillovers using a similar level of aggregation in Austria (2,361 communities). According to the 2001 census, 70% of households in Hungary live and work in the same settlement.

5.1 Firm Level Evidence

5.1.1 Local Demand: Outcomes at Tradable and Non-tradable Firms

The differential decline in consumption and rise in unemployment in regions that are more exposed to FC debt is evidence that household debt revaluation affects the local economy through a decline in household demand. Debt revaluation should therefore more strongly affect firms catering to local markets (Mian and Sufi 2014b). To provide further evidence for a local household demand channel, we draw on firm-level census data to test whether the debt-revaluation shock leads to a stronger decline in employment and output for non-exporting firms.

Table 6 panel A displays estimates of the effect of household FC debt exposure on firm-level employment growth:

$$g^{E}_{i,08-10} = \beta s^{FC}_{z08} + X_{i08}\Gamma^{firm} + X_{z08}\Gamma^{settlement} + \alpha_{industry} + \epsilon_{ib},$$

Following the employment dynamics literature (Davis and Haltiwanger 1999), we measure firm-level employment growth as the symmetric growth rate in employment between 2008 and 2010, $g^{E}_{i08-10} = \frac{100(E_{i10}-E_{i08})}{.5(E_{i10}+E_{i08})}$. Panel B presents the same regressions for the symmetric growth rate in firm real value added. Real value-added is calculated as profits plus depreciation and labor costs, deflated by two-digit sectoral GDP deflators.

In Table 6 column 1, we find that firms in settlements with greater exposure to the household debt revaluation shock experience a significant decline in employment and output. Estimating the equation at the firm level allows us to control for detailed firm characteristics. Column 2 shows that the elasticity is stronger when including firm-level controls, our baseline settlement level controls, and two-digit NACE industry fixed effects. Firm-level controls are a firm's own FC debt share, a quadratic in 2008 log employment, 2008 log sales, leverage (debt-to-sales ratio) in 2008, and indicator variables for whether the firm is majority state or foreign owned. Two-digit industry fixed effects ensure that the estimate is not driven by industry-specific employment shocks that are correlated with regional variation in s^{FC}_{z08}.[20]

[20] Table A.6 shows that results are similar when controlling for firm-level lagged employment growth, ensuring that the estimates are not driven by trends in firm employment. Table A.7 shows results are robust to using the household debt revaluation to income shock. Table A.8 presents the same regression for firm-level data aggregated to the settlement level and finds similar results.

Table 6: Impact of Household Debt Revaluation on Tradable and Non-tradable Firms

Panel A: Employment Growth, 2008-10

	All Firms		Non-Exporters		Exporters		Non-Tradable	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HH FC debt share, s_{z08}^{FC}	-9.35	-14.2	-10.0	-16.4	-0.49	-3.26	-6.91	-14.0
	(3.81)	(3.17)	(4.02)	(3.43)	(5.31)	(5.37)	(6.58)	(6.08)
Firm-level controls		Yes		Yes		Yes		Yes
Settlement controls		Yes		Yes		Yes		Yes
2-Digit Industry FE		Yes		Yes		Yes		Yes
R^2	0.00016	0.066	0.00018	0.072	0.000	0.045	0.000	0.066
Observations	80447	80447	64422	64422	16025	16025	20306	20306

Panel B: Real Value-Added Growth, 2008-10

	All Firms		Non-Exporters		Exporters		Non-Tradable	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HH FC debt share, s_{z08}^{FC}	-9.96	-16.8	-11.5	-18.9	-1.37	-4.72	-12.6	-24.2
	(4.59)	(4.24)	(5.01)	(4.87)	(7.14)	(7.06)	(8.54)	(8.37)
Firm-level controls		Yes		Yes		Yes		Yes
Settlement controls		Yes		Yes		Yes		Yes
2-Digit Industry FE		Yes		Yes		Yes		Yes
R^2	0.00011	0.021	0.00014	0.022	0.000	0.031	0.000	0.013
Observations	80447	80447	64422	64422	16025	16025	20306	20306

Notes: This table presents regressions of the symmetric growth in a firm-level employment and output from 2008 to 2010 on household FC debt exposure. Export status is defined as whether a firm has positive export revenues in 2008. Non-tradable industries are defined as retail and catering industries and four-digit NACE industries with a geographic Herfindahl index below the median, following Harasztosi and Lindner (2017)'s implementation of the Mian and Sufi (2014b) classification for Hungary. Standard errors are clustered at the subregion level (175 units).

Table 6 columns 3-6 estimate the effect separately for non-exporters and exporters. The decline in employment and output is driven entirely by non-exporting firms. Relative to a settlement with no FC debt, non-exporting firms in a settlement with all debt in FC experience a 16% greater decline in employment. In contrast, employment at exporting firms is shielded from the variation in local demand induced by the debt revaluation. This test provides evidence that the household debt revaluation effect on employment is not spuriously driven by the exchange rate channel or another shock to exporters. It also suggests that real rigidities may inhibit a reallocation of

labor toward exporting firms. The fact that exporters do not differentially expand employment, despite the large depreciation, suggests that there is limited adjustment through "exporting out of the downturn" in the short run.

In columns 7 and 8 we focus on firms in the non-tradable sector. Specifically, we classify the restaurant and retail industries and four-digit NACE industries with below-median geographic Herfindahl indexes as non-tradable, following Harasztosi and Lindner (2017)'s implementation of the Mian and Sufi (2014b) classification for Hungarian firm-level census data.[21] We also exclude firms that have positive exports in 2008, since these are less likely to cater primarily to local markets. Focusing on the subset of firms in the non-tradable sector yields an estimate on household FC debt exposure of -14% with controls, which is similar to the overall decline for non-exporters.

5.1.2 Household and Firm Foreign Currency Exposures

Since the Latin American and East Asian crises of the 1990s, several studies have found that firm FC indebtedness leads to a fall in business investment and a higher probability of bankruptcy after a devaluation. Prior to the forint depreciation in 2008Q4, 48% of Hungarian non-financial firm debt was denominated in FC. This raises two questions. First, are the determinants of FC borrowing similar for households and firms? Second, in a currency crisis, does it matter whether households or firms have FC debt exposure?

Unlike households, in this setting, firms with FC debt are strongly positively selected. Appendix Table A.9 shows that firms with FC debt are larger, more productive, and more likely to be exporters.[22] Three-fourths of firm FC debt is in euro, the primary export destination and invoicing currency. In contrast, 97% of household FC debt is in Swiss franc, but household income and assets in Swiss franc are negligible. In addition, firm FC financing started already in the mid-1990s and was a more mature market. These differences in the determinants of household and firm FC borrowing explain why household and firm FC debt shares are uncorrelated across space, as we saw in Table 3. Table A.10 confirms that this holds across the firm

[21] A limitation of the NAV data is that we do not observe employment at the establishment level, only at the firm (tax ID) level. This means that we cannot capture local employment changes for national retailers. This data limitation biases the estimates toward zero.

[22] Salomao and Varela (2016) also find that firms with a higher share of debt in FC are more productive and have a higher share of revenues from exports.

size distribution. Thus, the contractionary effect of the household debt revaluation channel is not explained by firm FC debt.

Did firm balance sheet effects play a complementary role in the currency crisis? Table A.11 presents regressions of the change in firm-level outcomes from 2008 to 2010 on a firm's FC debt share and the local household FC debt share, both measured in 2008. Columns 1 and 2 in Table A.11 find that firms with a higher fraction of debt denominated in FC reduce their investment between 2008-10. This result is robust to a rich set of controls. However, columns 3 through 6 show that firms with a higher fraction of debt in FC do *not* experience weaker sales and employment growth. In several specifications the effect of firm FC debt on sales and employment is positive and significant. One explanation for the limited employment effect is that firms with FC debt are more productive and hedged against the depreciation through their exports. These firms therefore temporarily cut back on investment following a balance-sheet shock, but retain their employees in anticipation of stronger growth in the future.[23]

Household FC debt exposure, meanwhile, predicts a decline in all measures of firm performance. Nevertheless, there is suggestive evidence of an interaction effect between household and firm FC exposures. As argued by Giroud and Mueller (2017), firms with balance-sheet distress may be more likely to lay off workers following a negative product demand shock. In our data, FC indebted firms do reduce employment more in regions with more household FC debt exposure (column 7). The interaction is not statistically significant, but implies a 25% larger decline in employment for FC indebted firms.[24]

5.1.3 Controlling for a Bank Lending Channel

Credit booms, high household debt, and credit supply cycles are closely related (Krishnamurthy and Muir 2017, Mian, Sufi, and Verner 2017). One may wonder if the household debt revaluation results are explained by a differential contraction in bank lending to firms. In Appendix Table A.13 we rule this out by explicitly controlling

[23]Salomao and Varela (2016) also find that firms with foreign currency debt had stronger sales growth and did not have higher exit rates following the exchange rate depreciation. Salomao and Varela (2016) and Endrész and Harasztosi (2014) find similar negative effects of foreign currency exposure on firm investment around the forint exchange rate depreciation.

[24]Table A.12 in the appendix confirms that results in Table A.11 are similar using the FC debt to assets ratio. Moreover, sorting firms by the FC debt-to-assets ratio yields a stronger interaction effect.

for bank lending 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 2005 and 2008. Ongena, Schindele, and Vonnák (2017) demonstrate a strong bank lending channel of monetary policy for these firm-bank pairs. We estimate employment growth specifications at the firm-bank relationship level and incorporate bank fixed effects, re-weighting observations by the inverse of a firm's number of relationships. Table A.13 shows that including bank fixed effects does not substantially change the estimated effect of household FC debt exposure. For example, with controls, the coefficient declines slightly from -14.3% to -12.6%.[25]

5.2 Does the Labor Market Adjust through Wage Declines and Migration?

Appendix Table A.15 presents evidence that there is limited labor market adjustment following the household debt revaluation shock. Columns 1-4 present estimates of the impact of the household debt revaluation on nominal wages. Columns 1 and 2 compute wages as firm payrolls per worker in the firm-level census data. Columns 3 and 4 use settlement-level composition-adjusted residual wages estimated from the Structure of Earnings Survey.[26] Both sources suggest that there is limited downward adjustment in wages between 2008 and 2010 (columns 1 and 3). By 2012 there is evidence of a decline in wages in more exposed regions. However, comparing panels A and B shows that the estimates are smaller and less significant without controls.

[25]There are several additional reasons why we do not believe the household debt revaluation results are explained by a bank lending channel. First, prior to the currency crisis, banks operating in Hungary did not have currency mismatch on their own balance sheets, and Hungary did not experience a severe banking crisis. Second, the effect of household FC debt on employment is stronger among non-exporters and non-tradable sector firms, which are firms that are less reliant on bank credit. In our sample 62.7% of exporters have bank credit in 2008, while only 45.3% of non-exporters and 44.8% of non-tradable firms have a bank loan in 2008. Third, bank credit contractions generally affect small firms the most (Chodorow-Reich 2014). But Table A.14 shows that the impact of household debt revaluation on firm employment is similar across the firm size distribution.

[26]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 811 settlements, the sum of the weights (2007 population) amounts to over 82.4% of the overall 2007 population.

These results are consistent with downward nominal wage rigidity generating higher unemployment following a negative demand shock, as in Schmitt-Grohé and Uribe (2016).

Columns 5 and 6 focus on migration. We find no evidence of an increase in net migration from settlements with higher FC debt exposure between 2008 and 2010 or 2012. The estimates are close to zero and, if anything, indicate an increase in net in-migration. The lack of adjustment through migration accords with recent studies that find limited adjustment to local labor market shocks through interregional migration (e.g., Autor, Dorn, and Hanson 2013).

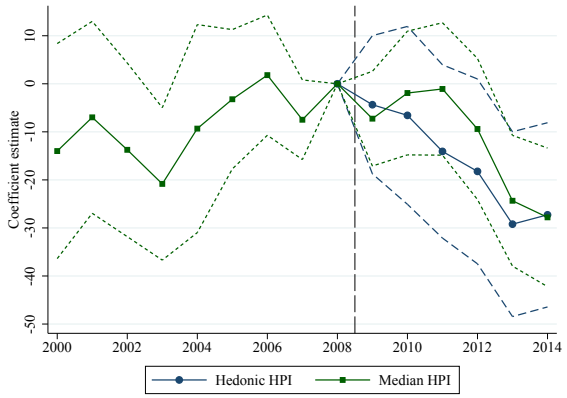
5.3 House Prices and Housing Markets

House price declines can amplify the effects of a shock to borrower debt burdens in the presence of collateral constraints. Figure 7 examines the dynamic effect of FC debt exposure on subregional house prices, and Appendix Table A.16 presents the regression version of this figure. We have median subregional home sale prices going back to 2000 and hedonic house price indices starting in 2008, so we present estimates for both indices. Both the median and hedonic HPI estimates show a relative decline in house prices in high exposure areas after the depreciation. The effects are gradual, but persistent. The decline in house prices reinforces the direct loss to household wealth from the debt revaluation and limits the scope for refinancing into an LC loan, which may further depress spending.

The household debt revaluation channel and housing market dynamics are closely related. However, one concern is that our estimated effects of the household debt revaluation are in fact driven by a housing market cycle. The median HPI estimates in Figure 7 reveal that pre-trends are approximately parallel between 2005 and 2008, though there is some evidence of an uptick in prices in high exposure regions prior to 2005. The worse recession in high s_{z08}^{FC} regions is, therefore, unlikely to be driven by a boom and bust in house prices.

Appendix Table A.16 columns 4-6 focuses on new housing unit construction. There is limited evidence of a boom and reversal in the number of new housing units in areas with more exposure to household FC debt. Therefore, the worse recession is not driven by an overhang of housing supply that constrains demand. Column 7 in Table A.16 confirms this by showing that the effect of the FC debt share on

Figure 7: Foreign Currency Debt Exposure and House Prices



Notes: This figure presents the estimates of $\{\beta_y\}$ from

$$\ln(P_{zt}^H) = \alpha_z + \gamma_t + \sum_{y \neq 2008} [\beta_y (s_{z08}^{FC} \cdot \mathbf{1}_{y=t}) + \Gamma^y (X_{z08} \cdot \mathbf{1}_{y=t})] + \epsilon_{st},$$

where $\ln(P_{zt}^H)$ is (100 times) the log of the settlement median or hedonic home price index. The hedonic home price index is available starting in 2008. The specification includes controls as in Table A.16. See Figure A.3 for the estimates without controls. Error bars represent 95% confidence intervals computed from standard errors clustered at the subregion level.

the unemployment rate is not affected by controlling for house price growth and new housing units growth in the run-up to the depression. In addition, all of our results are robust to controlling for the pre-depreciation construction employment share.

6 Financial Spillovers

Models with demand and fire-sale channels imply that household financing decisions can have negative externalities on other agents (Farhi and Werning 2016, Korinek and Simsek 2016). Therefore, in addition to the direct effect on FC borrowers, the debt revaluation may also negatively affect other nearby households indirectly through its negative effect on the local economy. In this section, we use loan-level data on individual FC debt positions to separately estimate the direct and spillover effects of the household debt revaluation on defaults.

Table 7: Financial Spillovers: Loan-Level Evidence from Defaults

	LC and FC Housing Loans				LC Borrower	FC Borrower
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign currency loan, FC_i	2.61	2.19	11.9	2.59		
	(0.16)	(0.18)	(0.97)	(0.17)		
Local HH FC debt share, $s^{FC}_{z,-b,08}$				2.30	1.96	3.15
				(0.82)	(0.96)	(1.00)
$FC_i \times$ High Leverage Indicator$_b$		0.86				
		(0.17)				
$FC_i \times$ Maturity (years)$_i$			-0.52			
			(0.039)			
Loan Controls	Yes	Yes	Yes	Yes	Yes	Yes
Borrower Controls	Yes	Yes	Yes	Yes	Yes	Yes
Settlement Controls	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.012	0.014	0.058	0.012	0.014	0.0068
Observations	650193	650193	650175	650193	215394	434799

Notes: This table presents loan-level regressions of the change in default status from 2008 to 2010 on an indicator for whether a loan is in foreign currency (FC_i) and foreign currency exposure in the borrower's settlement of residence, excluding borrower b ($s^{FC}_{z,-b,08}$). Columns 1-4 present estimates for both local and foreign currency borrowers. Columns 5 and 6 split the sample into local and foreign currency borrowers. Local currency borrowers are defined as borrowers who have no individual exposure to FC debt. Loan controls are a loan type fixed effect (mortgage or HE) and a quadratic in log loan size. Borrower controls are the total number of mortgage and HE loans, log total borrower debt in 2008, and five-year age bin fixed effects. Settlement controls are log population, debt-to-income, disposable income per capita, education shares, the fraction of the population age 18 to 59 and fraction age 60 or more, export revenue share, exports per capita, one-digit industry employment shares, and fixed effects for seven major regions. Controls are measured in 2008. Standard errors are clustered at the subregion level (175 units).

Table 7 presents estimates from loan-level default models of the form

$$\Delta_{08-10}\text{Default}_{i,b,z} = \beta_0 + \beta_1 FC_i + \beta_2 s^{FC}_{z,-b,08} + X^L_i \Gamma^L + X^B_b \Gamma^B + X^S_z \Gamma^S + \epsilon_{iz}, \quad (6)$$

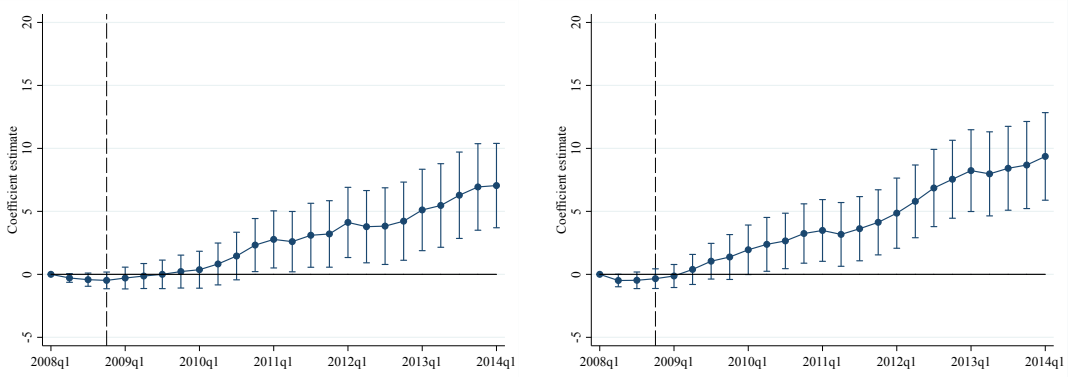
where $\Delta_{08-10}\text{Default}_{i,b,z}$ is the change in loan i's default status between 2008 and 2010, FC_i is an indicator that equals one if the loan is in foreign currency, $s^{FC}_{z,-b,08}$ is settlement z's FC debt share excluding borrower b, and X^L, X^B, and X^S are loan-, borrower-, and settlement-level controls. Column 1 in Table 7 reveals that FC loans

on average have a 2.6 percentage point higher probability of default than LC loans. Columns 2 and 3 show that borrowers with higher total leverage and shorter maturity loans are more likely to default.

Next, we ask whether a borrower is more likely to default if many nearby households have FC debt. Column 4 includes the overall settlement FC debt share, excluding the borrower's own debt, $s^{FC}_{z,-b,08}$. Both the currency of the loan, FC_i, and the local settlement FC exposure, $s^{FC}_{z,-b,08}$, raise the probability of default. The positive effect of $s^{FC}_{z,-b,08}$ on loan i's default rate is consistent with local financial spillovers through the negative effect of FC debt on local employment and house prices.

Does local foreign currency exposure affect individuals that did not borrow in foreign currency? Columns 5 and 6 split the sample of loans by borrowers who only have LC debt and borrowers who have at least one FC loan. Local exposure to the household debt revaluation, $s^{FC}_{z,-b,08}$, predicts a higher probability of default for both types of borrowers. The effect on LC borrowers supports the hypothesis that borrowing in FC imposes negative externalities on individuals who do not borrow in FC.

Figure 8: Financial Spillovers over Time



(a) Local currency borrowers

(b) Foreign currency borrowers

Notes: This figure presents estimates of

$$\text{Default}_{i,b,z,t} = \beta_0 + \sum_{q \neq 2008Q1} \beta_q \cdot \mathbf{1}_{t=q} \cdot s^{FC}_{z,-b,08} + \sum_{q \neq 2008Q1} \Gamma_q \cdot \mathbf{1}_{t=q} \cdot X^L_{i,b,z} + \epsilon_{iz}$$

separately for local and foreign currency borrowers. Error bars represent 95% confidence intervals computed from standard errors clustered at the subregion level.

Despite the impact on LC borrowers, the spillover effect is stronger for FC borrowers. FC borrowers are presumably more sensitive to local shocks because the exchange rate depreciation simultaneously impairs their own balance sheets.[27] Figure 8 shows the dynamic effect of local FC debt exposure on LC and FC borrowers. The spillover effect on defaults is not driven by pre-trends and is highly persistent.

7 Conclusion

In this paper, we provide new evidence that household debt acts as a strong contractionary channel during crises. We trace the effects of a sudden, large-scale revaluation of household foreign currency debt burdens on household defaults and consumption, local economic activity, and house prices. The existing literature has analyzed the consequences of a build-up in debt over the credit cycle. By instead studying a sharp increase in the value of foreign currency debt in a currency crisis, we isolate the effect of household debt from other factors that co-move with leverage over the credit cycle, such as house prices, housing supply, bank credit supply, and firm balance sheet conditions.

Exploiting spatial variation in exposure to foreign currency debt, we find that a revaluation in household debt burdens sharply reduces local consumption, house prices, employment, and firm output. Employment and output losses are driven by firms that are reliant on local demand. These results are consistent with demand and fire-sale externalities of foreign currency financing. Highlighting the externalities associated with foreign currency debt, we find that local exposure to foreign currency debt increases a borrower's default probability, conditional on the borrower's own foreign currency debt status.

Our results have several interesting policy implications. First, we provide an empirical rationale for macro-prudential policies to limit leverage. The case for prudential policy is particularly strong for risky financing, such as foreign currency borrowing by agents without a natural hedge against exchange rate risk. Second, our results imply that monetary policy faces a dilemma in a crisis in economies with foreign currency debt, as in Lorenzoni (2014). When foreign currency leverage is high, it be-

[27] Gupta (2016) shows evidence of foreclosure spillovers through an information channel or peer effects. The spillovers in Gupta (2016) dissipate beyond a 0.1 mile radius and therefore do not appear to be driven by a local demand externality.

comes counterproductive to stimulate external demand by depreciating the exchange rate because a weaker exchange rate deteriorates private-sector balance sheets. By using information on the foreign currency exposures of both households and firms, our results indicate that the debt revaluation channel is particularly strong when households have foreign currency debt.

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ONLINE APPENDIX

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

Emil Verner and Győző Gyöngyösi

October 2018

A Appendix Tables and Figures

Table A.1: Correlates of Alternative Measures of Household FC Debt Exposure

Panel A: Household debt revaluation to income, $\Delta_{08-10}\tilde{d}_z^{Inc}$

Right-hand-side variable	Coefficient	S.E.	R^2	N
Debt to disposable income, 2008	15.294	1.293	0.638	3152
Log disposable income per capita, 2008	2.673	1.002	0.031	3152
Log population, 2008	0.143	0.141	0.007	3152
Share of population age 18-59, 2008	7.778	5.382	0.002	3152
Vocational education share	-2.102	4.374	0.001	3152
College share	5.794	4.454	0.013	3152
Export sales share, 2008	-2.109	1.175	0.015	2725
Export sales per capita, 2008	-16.618	18.150	0.003	2725
Log sales-employment ratio, 2008	-0.279	0.346	0.002	2725
Corporate FC indebtedness, 2008, $s_{z08}^{FC,Firm}$	-0.467	1.176	0.001	2725
Manufacturing employment share, 2008	-1.267	1.256	0.006	2725
Construction employment share, 2008	7.587	2.732	0.018	2725
Agriculture employment share, 2008	-4.573	1.188	0.020	2725

Panel B: Mortgage FC debt share, September 2008

Right-hand-side variable	Coefficient	S.E.	R^2	N
Debt to disposable income, 2008	-0.034	0.018	0.005	3076
Log disposable income per capita, 2008	0.015	0.020	0.002	3076
Log population, 2008	0.005	0.001	0.012	3076
Share of population age 18-59, 2008	-0.202	0.155	0.003	3076
Vocational education share	-0.031	0.136	0.000	3076
College share	-0.013	0.096	0.000	3076
Export sales share, 2008	0.004	0.031	0.000	2702
Export sales per capita, 2008	0.081	0.416	0.000	2702
Log sales-employment ratio, 2008	0.022	0.011	0.023	2702
Corporate FC indebtedness, 2008, $s_{z08}^{FC,Firm}$	0.049	0.032	0.013	2702
Manufacturing employment share, 2008	0.004	0.037	0.000	2702
Construction employment share, 2008	-0.09	0.047	0.005	2702
Agriculture employment share, 2008	-0.063	0.034	0.007	2702

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

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

Standard errors are clustered at the subregion level.

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	-0.027	0.071	-0.098	-0.12
	(0.082)	(0.036)	(0.063)	(0.035)
Baseline 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	0.37	0.37	0.27	0.34
Observations	2686	2686	2686	2679

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

Table A.3: Robustness: Household Debt Revaluation to Income Shock

	Δ_{08-10}Default$_z$		Δ_{08-10}Auto Reg.$_z$		Δ_{08-10}Unemp.$_z$	
	(1)	(2)	(3)	(4)	(5)	(6)
HH debt to inc. reval., $\Delta_{08-10}\tilde{d}_z^{Inc}$	0.046	0.100	-0.85	-1.43	0.027	0.040
	(0.016)	(0.020)	(0.35)	(0.36)	(0.012)	(0.013)
Baseline Controls		Yes		Yes		Yes
Export Exposure Controls		Yes		Yes		Yes
Industry Employment Shares		Yes		Yes		Yes
R^2	0.0064	0.25	0.0068	0.35	0.0062	0.17
Observations	3109	2678	3152	2686	3152	2686

Notes: This table shows hat the main settlement level results are robust to using the household debt revaluation to income shock defined in equation (5). Standard errors are clustered at the subregion level (175 units).

Table A.4: Household Debt Revaluation and Unemployment: Robustness to Other Measures of Exposure

	Alternative Hypotheses						Other Measures of Exposure		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	IV: Mort. FC share	IV: 03-05 FC share	OLS	OLS	OLS	OLS	OLS
HH FC debt share, s_{z08}^{FC}	1.78	2.64	1.61	2.23	1.54	1.56			
	(0.63)	(0.56)	(0.71)	(0.97)	(0.67)	(0.62)			
Fraction of loans in FC, f_{z08}^{FC}							2.02		
							(0.63)		
FC loans per adult (std.)								0.23	
								(0.087)	
LC loans per adult (std.)									-0.12
									(0.090)
Unemployment rate $\hat{\beta}_z$	0.23								
	(0.060)								
Unemployment rate in 2008		-0.27							
		(0.024)							
Default rate in 2008:9		-0.0050							
		(0.029)							
DTI Increase, 2004-2008					0.012				
					(0.0092)				
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Export Exposure Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Employment Shares	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Region FE (20 units)						Yes			
R^2	0.18	0.32	0.16	0.16	0.17	0.19	0.17	0.17	0.16
Observations	2663	2679	2663	2608	2673	2679	2679	2679	2679

Notes: This table shows that the effect of household foreign currency debt exposure on local unemployment is robust to a variety of specification and sample checks. Standard errors are clustered at the subregion level (175 units).

Table A.5: Household Debt Revaluation and Unemployment: Robustness Weighting and Subsamples

	(1)	(2)	(3)	(4)	(5)
HH FC debt share, s_{z08}^{FC}	0.95	0.75	1.34	2.68	1.90
	(0.47)	(0.55)	(0.63)	(1.53)	(0.74)
Controls	Yes	Yes	Yes	Yes	Yes
Sample	Full	50% smallest	50% largest	Largest cities	175 subreg.
Weights	None	None	None	None	Pop.
R^2	0.14	0.17	0.18	0.22	0.073
Observations	2679	1152	1527	306	175

Notes: The dependent variable is the change in the unemployment rate between 2008 and 2010. Standard errors are clustered at the subregion level (175 units).

Table A.6: Firm Employment Regressions Controlling for Lagged Employment Growth

	All Firms	Non-Exporters	Exporters	Non-Tradable
	(1)	(2)	(3)	(4)
HH FC debt share, s_{z08}^{FC}	-15.4	-16.6	-8.18	-15.1
	(3.07)	(3.20)	(5.42)	(5.82)
Lagged empl. growth (06-08)	-0.011	-0.025	0.064	-0.015
	(0.0037)	(0.0042)	(0.0077)	(0.0082)
Firm-level controls	Yes	Yes	Yes	Yes
Settlement controls	Yes	Yes	Yes	Yes
2-Digit Industry FE	Yes	Yes	Yes	Yes
R^2	0.064	0.070	0.050	0.064
Observations	71075	56139	14936	17837

Notes: This table shows that the firm employment growth estimates in Table 6 are robust to controlling for firm-level lagged employment growth. Lagged employment growth is computed from 2006 to 2008. Standard errors are clustered at the subregion level (175 units).

Table A.7: Household Debt Revaluation to Income and Firm Employment

	All Firms		Non-Exporters		Exporters		Non-Tradable	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta_{08-10}\tilde{d}_z^{Inc}$	-0.20	-0.40	-0.22	-0.44	-0.076	-0.12	-0.18	-0.42
	(0.073)	(0.10)	(0.082)	(0.10)	(0.11)	(0.18)	(0.092)	(0.15)
Firm-level controls		Yes		Yes		Yes		Yes
Settlement controls		Yes		Yes		Yes		Yes
2-Digit Industry FE		Yes		Yes		Yes		Yes
R^2	0.00023	0.066	0.00025	0.072	0.000036	0.045	0.00019	0.066
Observations	80450	80450	64424	64424	16026	16026	20308	20308

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

Table A.8: Settlement Level Employment Regressions

	Total Employment		Non-Exporters		Exporters		Non-Tradable	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HH FC debt share, s_{z08}^{FC}	-11.0	-13.9	-14.6	-13.6	-1.18	1.03	-7.72	-8.20
	(6.35)	(5.64)	(7.77)	(6.45)	(9.41)	(9.60)	(5.81)	(6.69)
Baseline controls		Yes		Yes		Yes		Yes
Export Exposure Controls		Yes		Yes		Yes		Yes
Ind Emp Shares		Yes		Yes		Yes		Yes
R^2	0.0020	0.044	0.0028	0.035	0.000010	0.034	0.00045	0.019
Observations	2679	2679	2679	2679	2679	2679	2679	2679

Notes: The table presents employment growth regressions with firm level data aggregated to the settlement level. The specification is:

$$g_{z,08-10}^{E} = \beta_0 + \beta s_{z08}^{FC} + X_{z08}\Gamma + \epsilon_z,$$

where $g_{z,08-10}^{E}$ is settlement symmetric employment growth from 2008 to 2010. Standard errors are clustered at the subregion level (175 units).

Table A.9: Determinants of Firm Foreign Currency Financing

Right-hand-side variable	Coefficient	S.E.	R^2	N
Log employment, 2008	0.039	.002	0.019	80447
Log sales per worker, 2008	0.026	.001	0.011	80447
Employment growth, 2004-08	0.016	.002	0.001	62219
Export sales share, 2008	0.140	.014	0.008	80447
Exporter	0.076	.008	0.011	80447
Manufacturing	0.052	.003	0.005	80447

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

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

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

Table A.10: 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}	0.0094	0.028	-0.019	-0.051
	(0.034)	(0.032)	(0.042)	(0.11)
R^2	0.0000048	0.000051	0.000017	0.000092
Observations	80447	54273	21371	4803

Notes: The dependent variable is a firm's foreign currency debt share in 2008. Standard errors are clustered at the subregion level (175 units).

Table A.11: Firm FC Debt, Household FC Debt, and Firm-Level Outcomes

	Inv.-Capital Change, 08-10		Sales Growth, 08-10		Employment Growth, 08-10		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firm FC debt share	-10.0	-11.4	1.76	2.60	4.05	0.70	
	(1.27)	(1.34)	(0.68)	(0.68)	(0.50)	(0.48)	
HH FC debt share, s_{z08}^{FC}		-5.42		-12.1		-14.1	-13.4
		(4.69)		(4.18)		(3.15)	(3.53)
s_{z08}^{FC} × Firm has FC debt							-3.23
							(5.48)
Firm has FC debt							3.17
							(3.61)
Exporter		2.11		4.62		1.31	1.28
		(0.60)		(0.65)		(0.42)	(0.42)
Firm Controls		Yes		Yes		Yes	Yes
Settlement Controls		Yes		Yes		Yes	Yes
2-Digit Industry FE		Yes		Yes		Yes	Yes
R^2	0.0012	0.0084	0.000065	0.028	0.00055	0.067	0.067
Observations	80447	80447	80447	80447	80447	80447	80447

Notes: This table presents firm-level regressions comparing the effects of local household FC debt and firm FC debt on the evolution of firm outcomes from 2008 to 2010. The dependent variables are the change in the investment to lagged capital ratio (columns 1-2), firm sales growth (columns 3-4), and employment growth (columns 5-7). Growth rates are computed using the symmetric growth rate to mitigate the influence of outliers and allow for zeros. Firms with a higher fraction of FC debt experience falling investment, but stronger sales growth and no difference in employment growth. Household foreign currency debt exposure robustly predicts falling sales and employment. Appendix Table A.12 shows that these results are similar when measuring firm foreign currency exposure using FC debt to assets ratio. Standard errors are clustered at the subregion level (175 units).

Table A.12: Firm FC Debt, Household FC Debt, and Firm Level Outcomes: Robustness using Firm FC Debt to Assets

	Inv.-Capital Change, 08-10		Sales Growth, 08-10		Employment Growth, 08-10		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firm FC debt to assets	-15.0	-15.6	1.55	3.02	4.57	0.88	9.47
	(1.21)	(1.23)	(1.04)	(0.91)	(0.65)	(0.63)	(5.55)
HH FC debt share, s_{z08}^{FC}		-5.68		-12.1		-14.1	-12.1
		(4.75)		(4.18)		(3.15)	(3.41)
s_{z08}^{FC} × Firm FC debt to assets							-13.2
							(8.53)
Exporter		1.79		4.69		1.33	1.33
		(0.60)		(0.65)		(0.42)	(0.42)
Firm Controls		Yes		Yes		Yes	Yes
Settlement Controls		Yes		Yes		Yes	Yes
2-Digit Industry FE		Yes		Yes		Yes	Yes
R^2	0.0020	0.0089	0.000037	0.028	0.00051	0.067	0.067
Observations	80447	80447	80447	80447	80447	80447	80447

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

Table A.13: Controlling for Bank Credit Supply Shocks

	Firm Employment Growth, 2008-10			
	(1)	(2)	(3)	(4)
HH FC debt share, s_{z08}^{FC}	-9.35	-7.24	-14.2	-12.5
	(4.13)	(3.83)	(3.25)	(3.24)
Bank FE		Yes		Yes
Firm-level controls			Yes	Yes
Settlement controls			Yes	Yes
2-Digit Industry FE			Yes	Yes
R^2	0.00016	0.0040	0.066	0.069
N Firms	80447	80447	80447	80447
Observations	121084	121084	121084	121084

Notes: This table presents regressions at the firm-bank relationship to control for unobserved bank lending shocks. The specification is

$$g_{08-10,ib}^{E} = \alpha_{bank} + \beta s_{z08}^{FC} + X_{i08}\Gamma^{i} + X_{z08}\Gamma^{z} + \epsilon_{ib},$$

where the unit of observation is a firm-bank relationship in 2008. The dependent variable is symmetric firm employment growth between 2008 and 2010. α_{bank} is a bank fixed effect that absorbs bank-specific shocks. To recover the firm-level estimates, the observations are re-weighted by the inverse of a firm's total number of relationships. Two-thirds of firms have only one relationship, and the mean number of relationships per firm is 1.51. Standard errors are dually clustered on bank ID and subregion (175 units).

Table A.14: Effect of Household Debt Revaluation on Employment Growth: Effects by Firm Size

	Small (3 to 9)		Medium (10 to 50)		Large ($\geq$ 51)	
	(1)	(2)	(3)	(4)	(5)	(6)
HH FC debt share, s_{z08}^{FC}	-8.57	-13.1	-10.8	-17.2	-10.4	-15.2
	(5.01)	(4.55)	(5.57)	(5.01)	(8.47)	(8.16)
Firm-level controls		Yes		Yes		Yes
Settlement controls		Yes		Yes		Yes
2-Digit Industry FE		Yes		Yes		Yes
R^2	0.00013	0.071	0.00023	0.076	0.00027	0.056
Observations	54273	54273	21371	21371	4803	4803

Notes: This table reports firm level regressions by firm size of symmetric employment growth from 2008 to 2010 on the local household FC debt share. Standard errors are clustered at the subregion level (175 units).

Table A.15: Labor Market Adjustment: Wages and Migration

	Payroll Per Worker Growth		Nominal Wage Growth		In-Migration Rate Change	
	(1) 08-10	(2) 08-12	(3) 08-10	(4) 08-12	(5) 08-10	(6) 08-12
Panel A: No Controls						
HH FC debt share, s_{z08}^{FC}	-4.85	-5.26	2.68	-2.33	1.02	2.01
	(2.49)	(3.97)	(6.59)	(8.68)	(0.36)	(0.49)
Unit of Obs.	Firm	Firm	Settl.	Settl.	Settl.	Settl.
R^2	0.0045	0.0064	0.00026	0.00016	0.0049	0.015
Observations	79974	67389	811	811	2943	2924
Panel B: With Controls						
HH FC debt share, s_{z08}^{FC}	-3.06	-9.46	1.18	-9.81	0.68	0.53
	(2.53)	(3.32)	(7.70)	(7.67)	(0.32)	(0.34)
Unit of Obs.	Firm	Firm	Settl.	Settl.	Settl.	Settl.
Settlement Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes				
2-Digit Industry FE	Yes	Yes				
R^2	0.031	0.036	0.0099	0.041	0.12	0.24
Observations	79974	67389	811	811	2943	2924

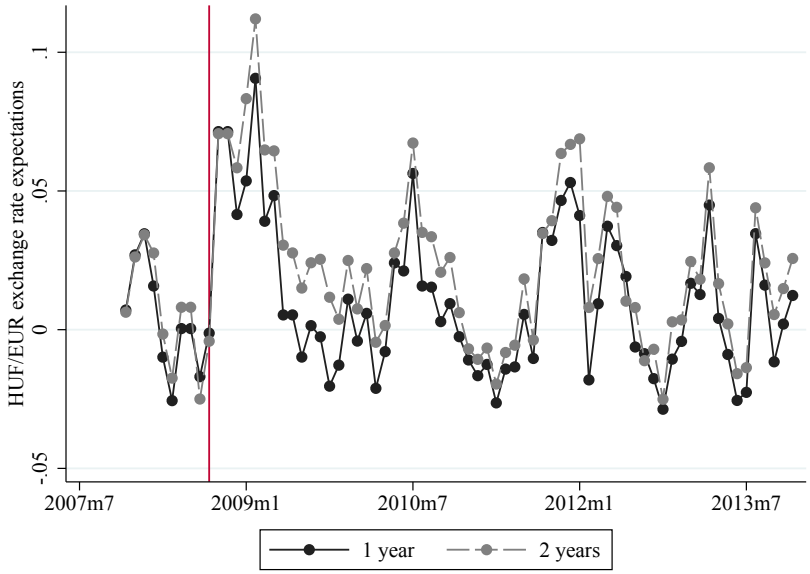
Notes: This table presents estimates of the effect of household FC debt exposure on wage growth and in-migration change. There is moderate evidence of a gradual downward adjustment in wages following the debt revaluation shock, but no evidence of an increase in out-migration. Payroll per worker is total payroll expenses divided by number of employees in the firm-level census data (NAV). Nominal wage growth refers to the change in log residualized hourly wages multiplied by 100, estimated from the worker-level Structure of Earnings Survey. The in-migration rate change is the change in the in-migration to population ratio. Changes are computed between 2008-2010 and 2008-2012 as indicated. Standard errors are clustered at the subregion level (175 units).

Table A.16: Household Debt Revaluation and Housing Markets

	House Price Growth			New Housing Units P.C. Change			Unem. Rate Change
	(1) 04-08	(2) 08-10	(3) 08-12	(4) 04-08	(5) 08-10	(6) 08-12	(7) 08-10
HH FC debt share, s_{z08}^{FC}	9.02	-6.16	-17.9	0.0026	0.0012	0.0027	1.78
	(11.0)	(9.59)	(9.94)	(0.0013)	(0.0012)	(0.0013)	(0.60)
House price growth, 04-08							-0.0068
							(0.0025)
New housing units P.C., 04-08							8.86
							(6.48)
Baseline Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Export Exposure Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Employment Shares	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE (7 units)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.50	0.25	0.33	0.096	0.17	0.31	0.17
Observations	2718	2679	2690	2712	2679	2690	2712

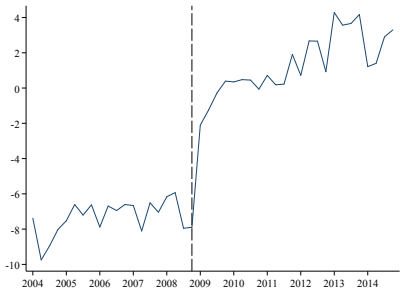
Notes: This table explores the connection between household foreign currency exposure and housing markets. The dependent variable in columns 1 is the median house price index. Columns 2 and 3 use the hedonic house price index (Figure 7 shows the estimates over time for both indices). House price indexes are measured at the subregion level. Standard errors are clustered at the subregion level (175 units).

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

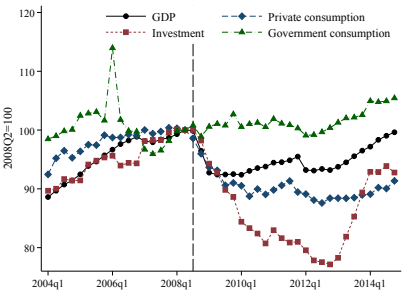


Notes: The figure plots the expected exchange rate depreciation from Consensus Forecasts, a survey of professional forecasters. The vertical line represents September 2008.

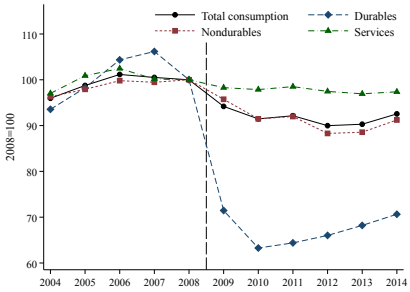
Figure A.2: Macroeconomic Context



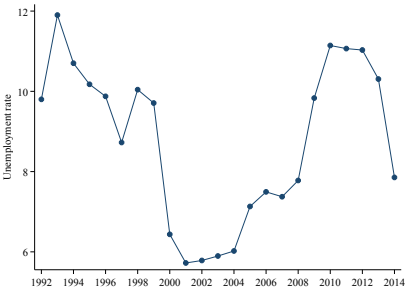
(a) Current account to GDP ratio (%)



(b) Components of GDP



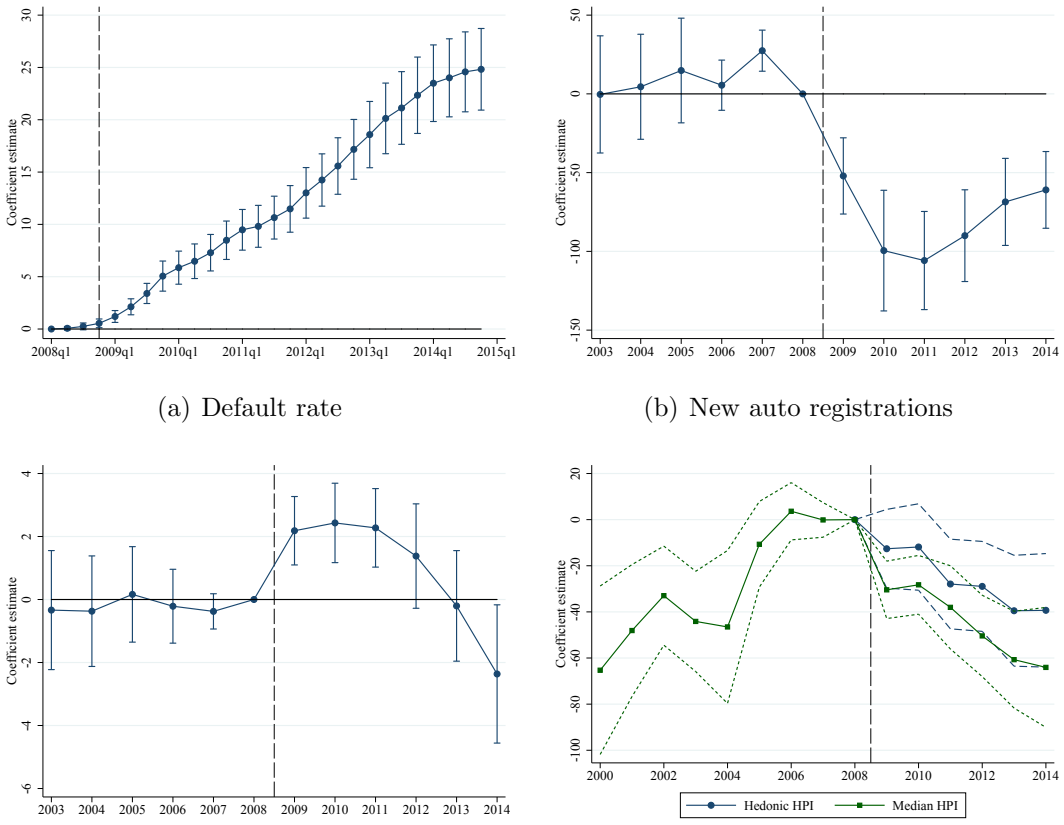
(c) Consumption



(d) Unemployment Rate

Notes: This figure presents the evolution of key macroeconomic aggregates up to and after the October 2008 forint depreciation.

Figure A.3: Estimates over Time without Controls



(a) Default rate

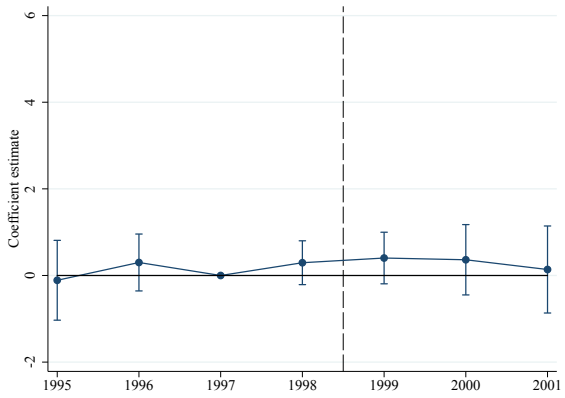
(b) New auto registrations

(c) Unemployment rate

(d) House prices

Notes: Error bars represent 95% confidence intervals computed from standard errors clustered at the subregion level.

Figure A.4: 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,

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

For the late 1990s placebo sample the coefficients $\{\hat{\beta}_y\}$ are precisely estimated and not significantly different from zero.

B Data Appendix

B.1 Household Credit Registry

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 2000:1 using information on the 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.[28]

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.[29]

[28] 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.

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

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 2012:12. Panel (a) plots the binned means for all mortgage and home equity loans in our sample, and panels (b)-(d) presents subsamples by loan type and 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 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.2 reports regressions of the true loan balance on the imputed balance in 2012:12. The table shows that the R^2 in the regression of the true balance on the imputed balance in 83% for all loans, and lies between 80-96% for various subsets of loans. The coefficient on the slope is naturally biased downward from unity because of classical measurement error in B_{it}, and similarly the coefficient on the constant is biased upward since the average loan balance is positive.

B.1.2 Missing Loans and Comparison with the Flow of Funds

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). The flow of funds is constructed from bank balance sheet data and measures 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% of total outstanding housing debt and 73.0% of foreign currency housing debt in 2008:9 (panels (a) and (b)). Panel (b) shows that we match the aggregate level of local currency debt almost perfectly. The shortfall in our imputed series thus comes from missing FC debt. As a result,

panel (d) shows that in 2008m9 the aggregate share of foreign currency debt is 62.7% in the imputed series compared to 69.1% in the flow of funds.

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.

B.1.3 Early Repayment Program of 2011

The primary reason for the FC housing debt shortfall in the Credit Registry relative to the flow of funds is that 21.3% of outstanding FC debt (15.9% 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%, with the majority of losses imposed on lenders.[30] 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.[31] 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 we control flexibly 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 4, the estimates are similar when controlling flexibly for income, which indicates that any systematic mis-measurement of s_{z08}^{FC} induces at most a modest bias in the estimates.

In addition, we take two different approaches to *explicitly correct* our measure of

[30] The discount varied by currency denomination and ranged from 20-36%.

[31] 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.

FC exposure for loans that are not in the Credit Registry because of the 2011 ERP.

ERP Adjustment #1. 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% of total consumer lending, and this database captures 34.4% 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

$$x_{bz} = x_z^{3b} \left(\frac{\overline{x}_b}{\overline{x}^{3b}} \right). \tag{7}$$

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 2008:9 assuming a representative Swiss franc loan for each bank-settlement that was originated in 2007:3, in the middle of the FC credit boom.[32] Summing over all banks in z gives us a measure of the 2008:9 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:

$$\tilde{s}_{z08}^{FC} = \frac{\sum_c \mathcal{E}_{08}^c D_{z08}^{*c} + \mathcal{E}_{08}^{chf} \hat{D}_{z08}^{prepaid}}{D_{z08} + \sum_{c \in C} \mathcal{E}_{08}^c D_{z08}^{*c} + \mathcal{E}_{08}^{chf} \hat{D}_{z08}^{prepaid}}. \tag{8}$$

[32] We choose 2007:3 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 of the bank-product interest rate for the representative loan.

ERP Adjustment #2. The second method draws on information contained in the volume of LC debt origination in a settlement around the time of the 2011 Early Repayment Program. Refinancing in LC loans accounted for 33.0% of the participation in the 2011 ERP (approximately HUF 349.4 bn),[33] so the volume of refinancing provides an alternative indication of how intensively households participated in the program.

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 2008:9 that were refinanced in the ERP.[34] 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 the first adjustments. With an estimate of the prepaid debt in settlement z we model the loan balance in 2008:9 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.

Performance of ERP Adjustments. Table B.2 compares the aggregate prepayment through the ERP with the prepayment implied by methods #1 and #2. Method #1 matches the aggregate level closely, with HUF 1058bn compared the target of HUF 1135bn, or 3.7bn euros. Recall that method #2 mechanically matches the aggregate.

Figure B.3 shows the impact of the ERP adjustment on aggregate FC debt. With the imputation we account for 95% of total debt in 2008:9 (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 is explained by the ERP.

We also obtained data on the total prepayment for each bank in our sample, and Figure B.4(a) 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 simply non-parametric in method #2 yields an R^2 of 90.1%.

[33]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% to reflect the 27.5% discount on the market exchange rate.

[34]The volume of new issuance in surrounding months is low, so this is a reasonable approximation.

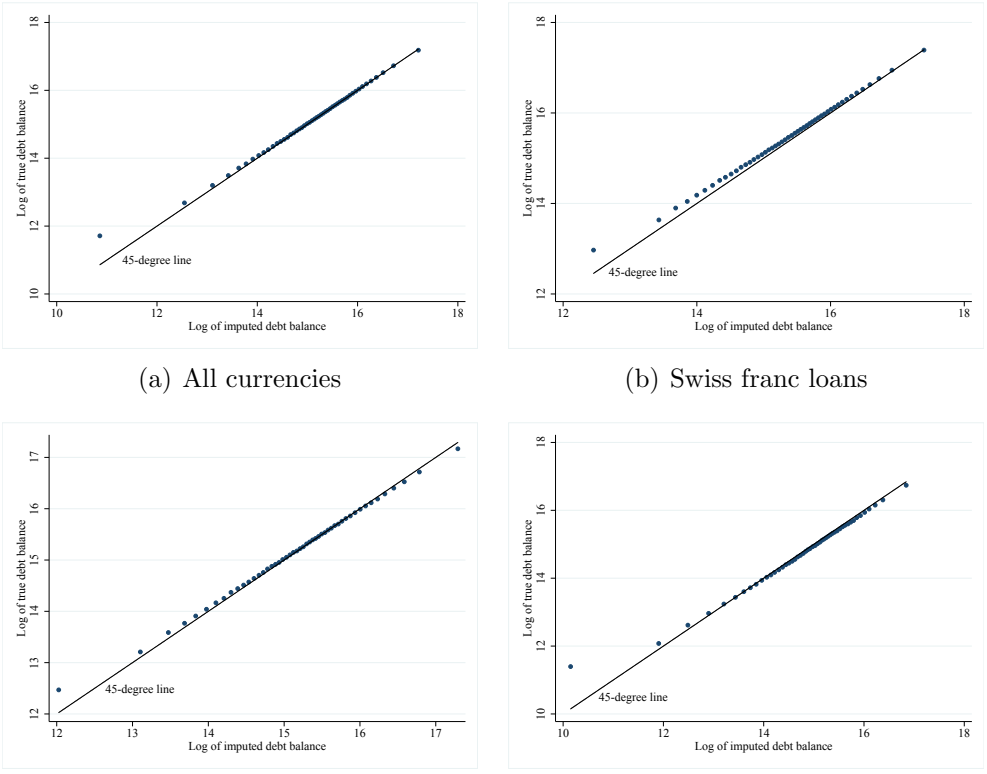
Figure B.5 compares the original and ERP-adjusted foreign currency debt shares, s^{FC} and $\tilde{s}^{FC}$. As expected, the adjustment raises the FC share in on settlements, and more so in settlements with a lower original share. The correlation between the original and the two adjusted measures is high (0.873 and 0.961).

Effect of Controlling for the Early Repayment Program on the Main Results. Table B.3 presents robustness tests for the main results using the two adjusted foreign currency exposure variables. For convenience we also report the baseline results. The point estimates are quantitatively quite similar to the baseline estimates, moving by at most 20%. The estimates for the adjusted variable tend to be slightly lower, although in some cases the estimates rise. While the standard errors increase, the main results retain their high statistical significance.

B.1.4 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), and these are long-dated. Aggregate credit series from MNB reveal that the fraction of housing loans with maturity shorter than 5 years in September 2008 is 1.69%, and the average of this fraction from January 2000 to September 2008 is 2.41%. 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 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 once accounting for the 2011 Early Repayment Program.

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.

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

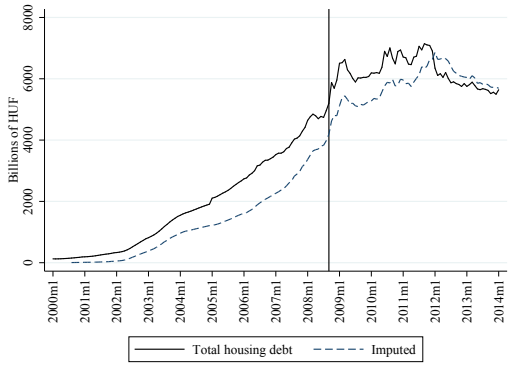
	Dependent variable: true balance in 2012:12, $\ln(D_{it})$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Imputed balance, $\ln(\tilde{D}_{it})$	0.873	0.890	0.840	0.871	0.916	0.835	0.930
	(0.00039)	(0.00048)	(0.00067)	(0.00053)	(0.0010)	(0.00060)	(0.0020)
Constant	1.942	1.672	2.471	2.088	1.290	2.411	1.259
	(0.0059)	(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

Standard errors in parentheses.

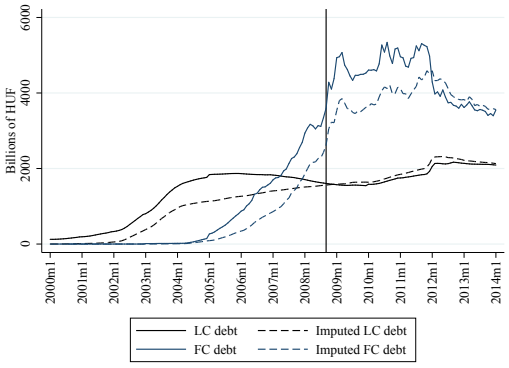
Table B.2: Aggregate Prepayment in 2011 Early Repayment Program

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

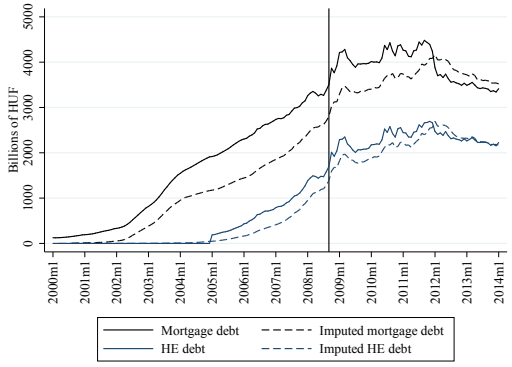
Figure B.2: Comparison of Imputed Aggregate Debt and Flow of Funds



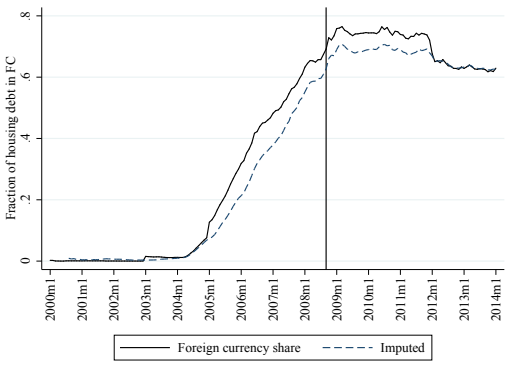
(a) All housing loans



(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 flow of funds 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%) fraction of outstanding balances in 2008:9. However, prepayments from the 2011 Early Repayment Program means that we fail to account for about 23% 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% compared to a true value of 69.1% in 2008:9).

Figure B.3: Early Repayment Program Adjustment and Aggregate FC Debt

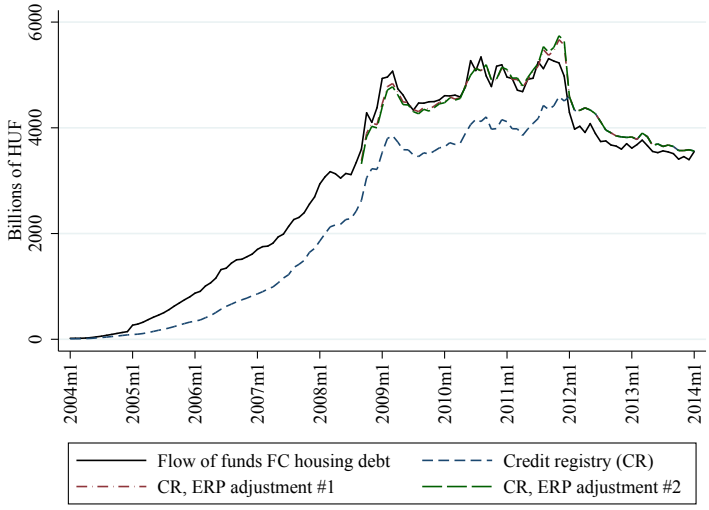
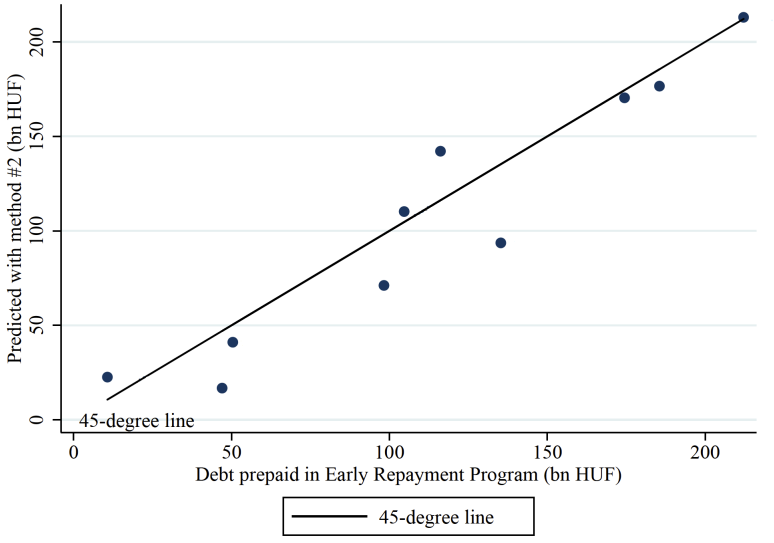
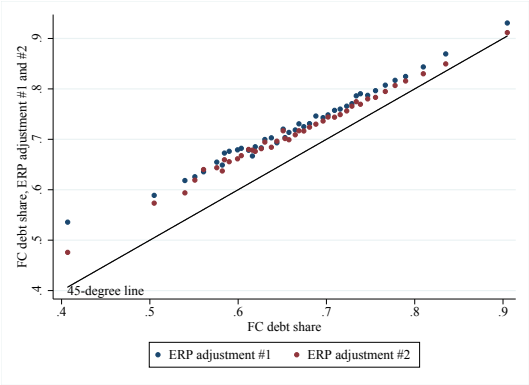


Figure B.4: Method #1 Predicted and Actual 2011 Early Repayment Program Debt Reduction by Bank



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 agains the predicted amount using Method #1.

Figure B.5: 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^{FC}_{z08}).

Table B.3: Robustness of Main Results to Missing Data Adjustments

Panel A: Default Rate Change, 2008-10

	(1)	(2)	(3)	(4)
HH FC debt share, ERP adj. #1	6.69	6.23		
	(1.07)	(0.88)		
HH FC debt share, ERP adj. #2			7.19	7.81
			(1.05)	(0.87)
Full Settlement Controls		Yes		Yes
R^2	0.039	0.17	0.041	0.19
Observations	3108	2678	3108	2678

Panel B: Durable Spending Growth, 2008-10

	(1)	(2)	(3)	(4)
HH FC debt share, ERP adj. #1	-74.5	-56.9		
	(18.6)	(16.8)		
HH FC debt share, ERP adj. #2			-66.2	-74.8
			(21.7)	(16.7)
Full Settlement Controls		Yes		Yes
R^2	0.017	0.27	0.013	0.27
Observations	3124	2679	3124	2679

Panel C: Unemployment Rate Increase, 2008-10

	(1)	(2)	(3)	(4)
HH FC debt share, ERP adj. #1	1.51	2.22		
	(0.61)	(0.69)		
HH FC debt share, ERP adj. #2			2.52	2.68
			(0.69)	(0.72)
Full Settlement Controls		Yes		Yes
R^2	0.0067	0.053	0.017	0.059
Observations	3124	2679	3124	2679

Panel D: House Price Growth, 2008-10

	(1)	(2)	(3)	(4)
HH FC debt share, ERP adj. #1	-32.7	-25.5		
	(6.91)	(7.55)		
HH FC debt share, ERP adj. #2			-25.3	-24.3
			(7.78)	(7.44)
Full Settlement Controls		Yes		Yes
R^2	0.024	0.096	0.013	0.095
Observations	1932	1856	1932	1856

Standard errors in parentheses clustered at the subregion level.

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% 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% random sample of employees based on employee date of birth. See Harasztosi and Lindner (2017) 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), 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 about 82% of the population. With reported hours we also compute the average monthly hours in a settlement, conditional on employment.

C Debt Revaluation in an Open Economy Model

C.1 Model Set-Up

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.[35] 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

$$\mathcal{E}_t\dot{D}_t^*+\dot{D}_t=\mathcal{E}_t i_t^* D_t^*+i_t D_t+P_tC_t-W_tN_t-T_t-\Pi_t,\quad t\geq 0,$$

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.[36] In the initial steady

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

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

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

$$mc_t = -\nu + w_t - p_{H,t} - a_H, \quad \nu \equiv -\ln(1+\tau). \tag{9}$$

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

$$p_t = (1-\alpha)p_{H,t} + \alpha p_{F,t} = p_{H,t} + \alpha s_t \Rightarrow \pi_t = \pi_{H,t} + \alpha \dot{s}_t. \tag{10}$$

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:

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

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

$$Y_t = C_t S_t^{\alpha} \left[(1-\alpha) + \alpha \Theta^{-1} \right], \tag{11}$$

which can be log-linearized as

$$y_t = c_t + \alpha s_t - \alpha \theta. \tag{12}$$

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

$$y_t = c_t^* + s_t + (1-\alpha)\theta. \tag{13}$$

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 (12) 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 (12) 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 (10), 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 (9) as

$$mc_t = -\nu + (w_t - p_t) + (p_t - p_{H,t}) - a_H \tag{14}$$

$$= -\nu + (1+\varphi)y_t + \alpha\theta - (1+\varphi)a_H \tag{15}$$

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

$$y_t^n = a_H + \frac{\nu - \mu}{1+\varphi} - \frac{\alpha\theta}{1+\varphi}. \tag{16}$$

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

$$\tilde{mc}_t = (1+\varphi)\tilde{y}_t + \alpha\theta. \tag{17}$$

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

$$\dot{\pi}_{H,t} = \rho\pi_{H,} - \lambda\tilde{mc}_t, \quad \lambda = \rho_\delta(\rho + \rho_\delta) \tag{18}$$

which, using (17), can be rewritten as

$$\dot{\pi}_{H,t} = \rho\pi_{H,} - \kappa\tilde{y}_t - \lambda\alpha\theta, \quad \kappa = \lambda(1+\varphi). \tag{19}$$

Initial Flexible Price Steady State. In the initial steady state $\theta = 0$. Moreover, we assume $a_H = c^* = 0$. From (13) and (16), the natural level of output and terms of trade are simply $y^n = 0, s^n = 0$.

C.2 Consequences of a Household Debt Revaluation

As discussed in section 3.1, 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 $\bar{D}^* + \bar{D} = 0$,

$\bar{D}^* > 0$.[37] The economy is in the natural allocation with $\theta = 0$ and balanced trade.

At time zero there is $\Delta e\%$ 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:

$$\dot{\pi}_{H,t} = \rho \pi_{H,t} - \kappa y_t + \lambda \rho \Delta e D^* \tag{20}$$

$$\dot{y}_t = i_t - \pi_{H,t} - \rho \tag{21}$$

$$y_0 = -\frac{1-\alpha}{\alpha} \rho \Delta e D^* + \Delta e. \tag{22}$$

Equation (20) is the standard New-Keynesian Phillips curve, adjusted for the wealth effect of the debt revaluation. Equation (21) 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 (22) 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.[38]

Analytical Solution. We can write the system in (20)-(21) as $\dot{X}_t = AX_t + B_t$ and apply the transformation $Z_t = V^{-1}X_t$, where $V^{-1}AV = D$. Here V is the matrix of

[37] 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.

[38] 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.

eigenvectors of A, and D is the diagonal matrix of eigenvalues of A:

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

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

$$\dot{z}_1 = \overline{\nu} z_1 + \frac{\lambda \rho \Delta e D^*}{\nu - \overline{\nu}} \tag{23}$$

$$\dot{z}_2 = \nu z_2 + \frac{\lambda \rho \Delta e D^*}{\overline{\nu} - \nu} \tag{24}$$

$$\tag{25}$$

The general solution is

$$z_{1t} = b_1 e^{\overline{\nu} t} - \frac{\lambda \rho \Delta e D^*}{\nu - \overline{\nu}} \frac{1}{\overline{\nu}} \tag{26}$$

$$z_{2t} = b_2 e^{\nu t} - \frac{\lambda \rho \Delta e D^*}{\overline{\nu} - \nu} \frac{1}{\nu}, \tag{27}$$

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

$$X_t = \begin{bmatrix} -\nu e^{\nu t} b_2 \\ b_2 e^{\nu t} - \frac{\lambda \rho \Delta e D^*}{\nu - \overline{\nu}} \left(\frac{1}{\overline{\nu}} - \frac{1}{\nu} \right) \end{bmatrix} \tag{28}$$

To obtain b_2, we use the initial condition (22)

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

The output response to the exchange rate shock is then of the form provided in the main text (1)

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

$$y_t = \left(-\frac{1-\alpha}{\alpha} e^{\nu t} + (1 - e^{\nu t}) \frac{1}{1+\varphi} \right) \rho \Delta e D^* + \Delta e \cdot e^{\nu t}$$

$$y_t = \beta_t \Delta e D^* + \gamma_t \Delta e \tag{29}$$

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.