Essays on Finance and Economic Growth

Submitted on the 2nd January 2023, in partial fulfilment of
the conditions for the award of the degree PhD Economics.

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Forward and Acknowledgements

This thesis is a combination of 3 different topics, related to finance and economic growth. The first chapter, ‘The Causal Effects of the Darker Side of Financial Development’, re-examines the empirical finance-economic development relationship, and vulnerability to crisis, utilizing new and improved methodologies. This chapter is co-authored with my supervisor, Markus Eberhardt and Rodolphe Desbordes, a colleague from SKEMA Business School. I am highly indebted to Markus for coaching me on the development of macro econometric techniques over the past couple of years.

The second chapter, ‘Cost of Collateral in a Firm Dynamics Model’, is a short paper, which utilizes a combination of econometric and simulation techniques to investigate the cost of financing for firms without sufficient collateral backing.

The third and final chapter, ‘Corporate Tax, Entrepreneurship and Financial Frictions’ investigates the effect of two frictions – corporate taxation and financial frictions, on entrepreneurial decisions. This is motivated by the UK government’s plans to increase the baseline corporate tax rate from 19% to 25% by April 2023. In this research, I calibrate a dynamic general equilibrium model with occupational choice to match moments in the UK economy, and study the effect of the increase in corporate tax rates on entrepreneurial decisions, and it’s subsequent effect on the macroeconomy.

I am thankful to my advisors, Omar and Markus for encouraging me to study and continuously improve on my computational skills throughout my PhD – this enabled me to work on my second and third chapter independently. I plan to use a polished version of the third chapter as my job market paper in the coming years.

Chapter 1: The Causal Effects of the Darker Side of Financial Development*

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September 2022

Abstract: We study the causal implications of financial deepening for economic development and financial crises, adopting a heterogeneous difference-in-difference framework. Using cross-country data for the past six decades we demonstrate that very high levels of finance, proxied by credit/GDP, are neither associated with lower long-run growth nor with higher short-run propensity of banking crises due to 'credit booms gone bust' cycles or unfettered capital inflows. When we investigate 'too much finance' at intermediate levels of credit/GDP we find increased crisis propensity due to capital inflows and commodity price movements, but, again, no detrimental long-run growth effects for these (emerging) economies.

Keywords: financial development, economic growth, financial crises, difference-in-difference, interactive fixed effects, heterogeneous treatment effects

JEL codes: F43, G01, G21, O40

*We thank Bertrand Gruss for kindly providing the monthly aggregate commodity price data series and Nicolas van de Sijpe for comments on the capital flow analysis. Comments and suggestions from seminar and conference session participants are gratefully acknowledged. Cho is indebted to the Nottingham School of Economics for funding her PhD studies. The usual disclaimers apply. Correspondence: Rodolphe Desbordes, SKEMA Business School, 5 Quai Marcel Dassault, 92150 Suresnes, France. Email: rodolphe.desbordes@skema.edu

1 Introduction

Following decades of concerns over identification and inference (e.g. Leamer 1983, Angrist & Pischke 2008) we are presently in the foothills of a *heterogeneity revolution*, which seeks to increase the policy-relevance of empirical insights by tying the analysis closer to subgroups of individuals, firms, or countries. This development is implicit in the debate surrounding heterogeneous treatment effects in difference-in-difference approaches for microeconomic analysis (De Chaisemartin & d'Haultfoeuille 2020, Athey & Imbens 2022, Goodman-Bacon 2022), while unsatisfactory policy-insights from 'pooled' models have already led to new approaches in diverse areas of international macro and political economy, including work on the trade gravity model (Baier et al. 2018), international migration (Bertoli & Moraga 2013), debt and growth (Eberhardt & Presbitero 2015), banking crises (Summers 2017), and the democracy-growth nexus (Boese & Eberhardt 2021).

In this paper we gain valuable new insights by taking a *heterogeneous* treatment approach to the analysis of financial deepening, long-run economic growth and financial crises. We focus on the 'new consensus' in the literature of a more complex link between finance and growth which has given rise to findings of 'too much finance'. We model country-experience of 'high' levels of finance as an endogenous binary treatment and estimate heterogeneous treatment effects in a factor-augmented difference-in-difference model, which controls for selection into treatment and differential pre-treatment trends between treated and control countries. We present our results relative to the 'years of treatment', focusing on the *long-run* relationship. Motivated by descriptive analysis we apply this strategy to countries near the top of the credit/GDP distribution (henceforth 'advanced country sample'),[1] and separately to countries at intermediate levels (henceforth 'developing country sample')[2] to reveal whether 'too much finance' can apply at, broadly speaking, different levels of development. In order to speak to the most recent literature highlighting more granular components of credit we employ the same methodology to study 'too much household finance' and 'too much corporate finance' in a sample of advanced and emerging economies. We then adapt our methodology to an early warning system approach for banking crises: we test whether elevated levels of finance increase the *within-country* effect of what are widely regarded as the dominant *short-term* triggers for banking crises, namely 'credit booms gone bust', excessive

[1]We adopt two cut-offs, 92% and 119% of credit/GDP, equivalent to the 90th and the 95th percentile of the full sample distribution (all countries, all years).

[2]We focus on countries which have crossed the 34% or 47% credit/GDP threshold (50th and 60th percentiles of the full sample distribution). These are primarily middle income economies while the countries at the top of the distribution are virtually all advanced economies.

capital inflows, and, in the developing country sample, aggregate commodity price movements.

Our analysis in advanced economies finds no evidence for a diminishing long-run effect of high levels of finance on income per capita or increased financial vulnerability in the short-run. The former result extends to the analysis of disaggregated credit (household vs corporate credit), with the caveat of modest sample sizes for treated countries. In contrast, developing countries are subject to an amplified effect of large capital inflows and aggregate commodity price movements on banking crisis propensity when experiencing high levels of finance. However, this increased vulnerability does not appear to undermine long-run prosperity.

The link between finance and growth has been studied extensively[3] and the various beneficial aspects of finance for development are well-known (e.g. Schumpeter 1912, Greenwood & Jovanovic 1990, Beck, Levine & Loayza 2000, Levine et al. 2000, Levine 2005), also for less-developed countries (Beck et al. 2004, Gambacorta et al. 2014), although there is no consensus whether these or advanced economies benefit more (Deidda 2006, Loayza et al. 2018). On the 'darker side' of financial development (Loayza et al. 2018), back in focus among academics and policy-makers following the 2007/8 Global Financial Crisis (GFC), it potentially crowds out productive activity (Rioja & Valev 2004, Law & Singh 2014, Arcand et al. 2015)[4] and/or increases susceptibility to financial crises (Demirgüç-Kunt & Detragiache 1998, Kaminsky & Reinhart 1999, Loayza & Rancière 2006, Rancière et al. 2006). Carré & L'Œillet (2018) speak of a 'paradigm shift' whereby a pre-GFC consensus of a strictly positive and linear relationship between finance and development has more recently been replaced by a new consensus of a more complex, likely concave relationship. The financial crisis literature has always recognised that asset price growth and credit expansion play a key role (Kindleberger 1978). The renewed interest following the GFC fostered the creation of long time series data, which have helped consolidate the primary significance of credit and asset price growth for financial crisis prediction (Bordo & Meissner 2016, Sufi & Taylor 2021): First-order factors predicting banking crises in advanced economies are 'credit booms gone bust' (Jordà et al. 2011, Schularick & Taylor 2012, Müller & Verner 2021) and 'excessive' capital inflows (Reinhart & Rogoff 2013, Ghosh et al. 2014, Caballero 2016); in low-income economies dominant triggers include aggregate commodity price movements (Eberhardt & Presbitero 2021).

[3] Comprehensive surveys are available in Levine (2005), Carré & L'Œillet (2018), Loayza et al. (2018), and Popov (2018).

[4] 'Excessive' financial deepening may advance services with lower growth potential (e.g. household rather than firm credit, see Beck et al. 2009, Jordà et al. 2015, Sufi & Taylor 2021, Müller & Verner 2021), and a human capital 'brain drain' to vacuous but highly-paid finance jobs away from the pursuit of real economy activity and/or its innovation (Popov 2018).

Few studies investigate growth and vulnerability in an integrated approach (Arcand et al. 2015, Rancière et al. 2006),[5] given that they address very different *timings* of effects: the link between finance and development should be viewed over the long-term (Loayza & Rancière 2006), while the analysis of banking crises adopts specifications which investigate the *'trigger'* function of various determinants (e.g. credit growth, capital inflows) in an 'early warning system' (EWS) approach focused on the short-run (e.g. Bussière & Fratzscher 2006).

Our empirical approach adopts a treatment effects framework following Rancière et al. (2006), but in contrast to these authors we do not focus on the *overall* effect of finance on economic performance but investigate growth and crisis vulnerability separately. There are at least two sound reasons for this separation: (i) we are able to employ factor-augmented heterogeneous difference-in-difference (growth) and EWS (crisis) models which allow us to get closer to a causal interpretation of the results; and (ii) our specifications can speak to the long-run vs short-run effect of 'too much finance' in the growth and crisis analysis, respectively.

Our paper makes a number of contributions to the literature: we investigate the potential nonlinearity of the finance-growth nexus in a *heterogeneous* parameter framework, where each country has its own equilibrium relationship. Although there is an earlier literature which employed time series (e.g. Arestis & Demetriades 1997) or panel time series (e.g. Christopoulos & Tsionas 2004) methods, these were carried out within the confines of a linear finance-growth nexus and furthermore relied on weaker concepts of causality. We adopt a difference-in-difference setup which allows us, under reasonable assumptions, to get closer to causal identification without resorting to internal or external instrumentation. The Chan & Kwok (2022) Principal Component Difference-in-Difference (PCDID) estimator is a recent contribution to the literature on treatment estimators adopting a multi-factor error structure (Gobillon & Magnac 2016, Xu 2017). The PCDID augments the estimation equation for each treated country with common factors estimated from the control group of countries which remained below the treatment cut-off. These factors enable us to account for selection into treatment (endogeneity of 'high' financial development) as well as non-

[5] Arcand et al. (2015) adopt a 'reduced form' approach whereby their finance-growth model (levels and squared credit/GDP terms) is augmented with a crisis dummy (negative significant) alongside interaction terms (insignificant for both levels and squared credit/GDP). Rancière et al. (2006), whose analysis pre-dates the 'too much finance' debate, adopt a more 'structural' approach: in a first step they model financial crises in a probit model, while the second-step equation for per capita GDP growth incorporates financial liberalisation, a crisis dummy along with the estimated hazard rates from the first step equation. They show that finance is positive and significant in both equations, their decomposition however suggests that the former dominates substantially, by an order of between five-to-one and seven-to-one.

parallel trends between treated and untreated countries.[6] When focusing on potentially attenuated growth effects of 'too much finance' it is self-evidently important whether a country spent one or thirty years above some suitable threshold. Our approach here enables us to model this length *in treatment* while by-passing the concerns debated in the microeconometric literature cited at the top of this paper. Finally, we extend the heterogeneous treatment approach to the study of banking crises in a simple but intuitive way. Our approach is novel because we are among the first to employ a heterogeneous crisis model (the only study we are aware of is Summers 2017) based on factor-augmented implementations for the generalised linear model (Boneva & Linton 2017) and combine this with the PCDID setup of our growth analysis.

The remainder of this paper is structured as follows: in the next section we take a first look at the data, providing a motivation for the analysis of 'too much finance' not just at the top of the credit/GDP distribution, but also at intermediate levels. In Section 3 we study the finance-growth nexus, also in the context of household versus corporate finance, Section 4 turns to the investigation of banking crises. In both sections we first introduce the data and methods used and then present empirical findings. Section 5 concludes.

2 Stylised Facts

This section uses descriptive analysis to highlight the widely-discussed 'too much finance' nonlinearity for countries near the top of the credit/GDP distribution and an under-appreciated empirical fact: a similar pattern for countries at intermediate levels of the credit/GDP distribution.[7]

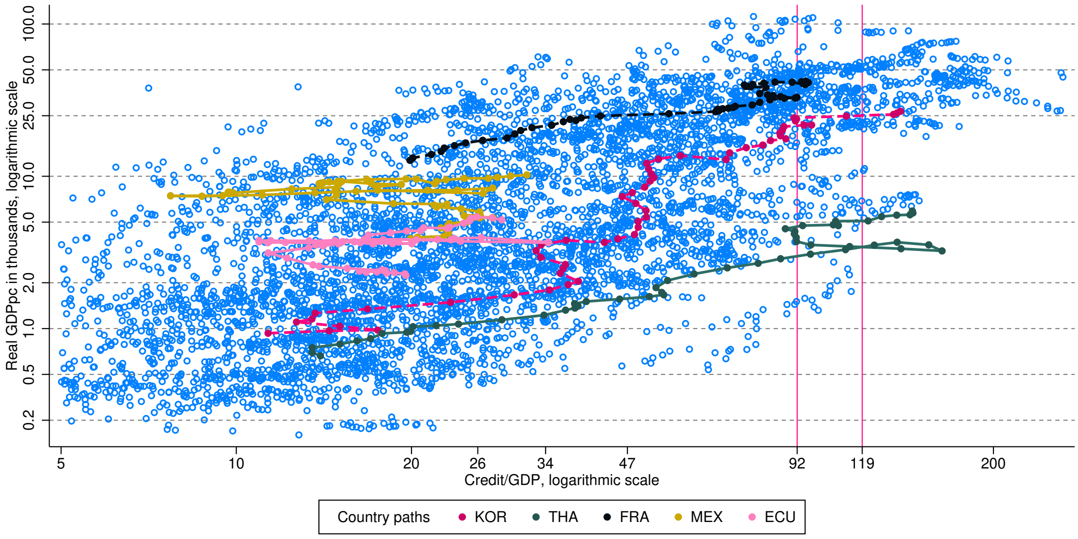
Figure 1 is a simple scatter for real income per capita and the credit/GDP ratio (both in logs), which clearly shows a positive correlation, although this is not self-evident once we look at individual country experiences. Naturally, this correlation does not speak to the direction of causation. The vertical lines mark the 'thresholds' for 'too much finance' we adopt throughout our analysis: the 90th and 95th percentiles of the credit/GDP distribution (92% and 119%).

In the upper panel of Figure 2 we study the *relative* growth performance of countries in

[6] We also provide results based on restricted control groups: we decimate the control sample by requiring that countries at least have to have exceeded 20%, 26%, 34% or 47% credit/GDP. The intuition is that the economic implications of 'too much finance' in a highly (financially and economically) developed economy (e.g. Australia) should not be benchmarked against those in an economy with significantly underdeveloped financial institutions (e.g. Mali). Curtailing the control sample moves the counterfactual closer to the treated sample in terms of shared characteristics.

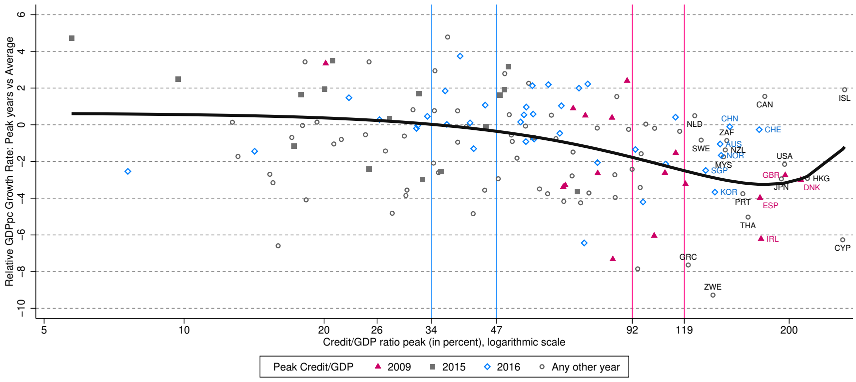
[7] Our sample for 152 countries has just under 6,000 observations — see Section 3.1 for details.

Figure 1: Financial Development and Economic Performance

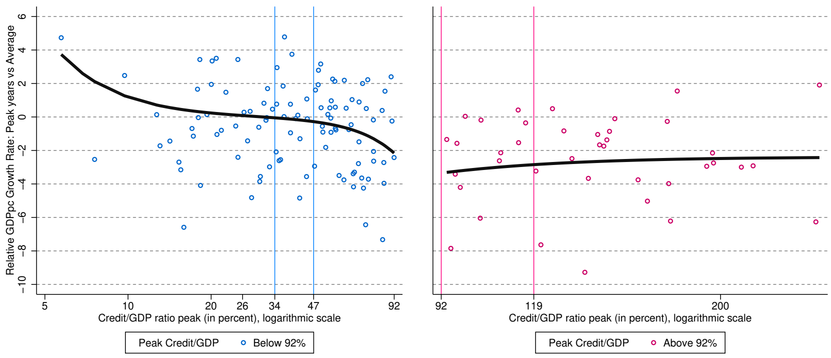


Notes: This is a scatter plot for log real GDP pc (in thousands of US$) and log of credit/GDP.

Figure 2: Peak Credit/GDP and Relative Growth Performance



(a) Relative GDPpc growth rate and Peak Credit/GDP

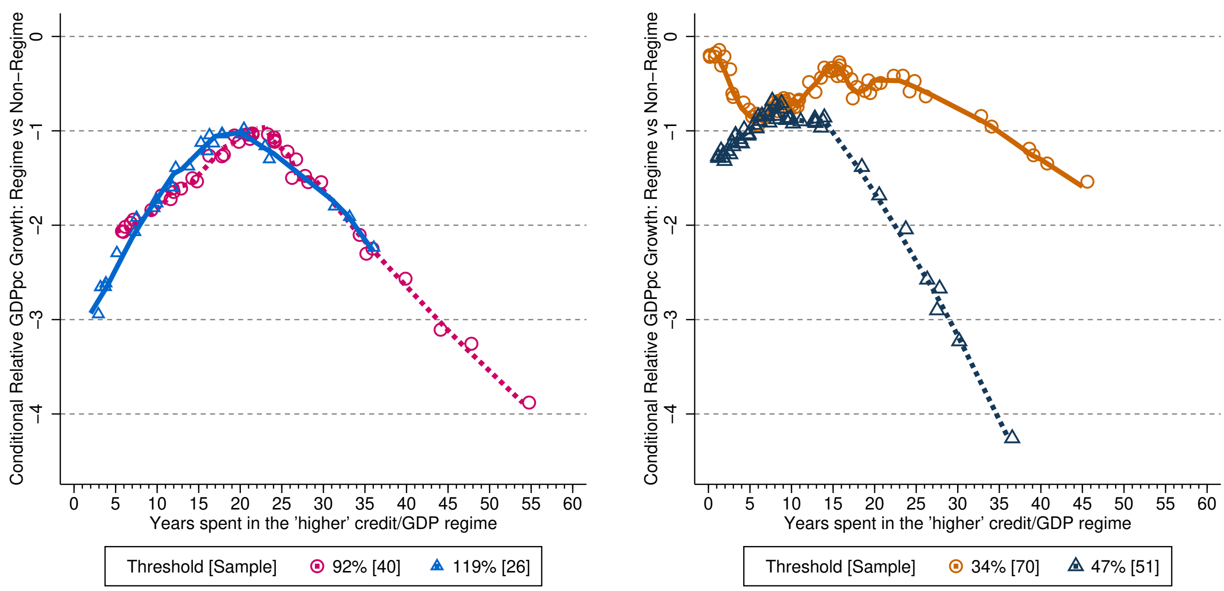


(b) Relative GDPpc growth rate and Peak Credit/GDP – split

Notes: This plot shows the log of peak credit/GDP (x-axis) and 'relative' growth performance: average growth for the five years around the peak relative to the average in 'non-peak' years. The black lines are fitted fractional polynomial regression lines.

relation to their credit/GDP peak: we adopt the ratio of average per capita GDP growth in the five years around the peak to the average for all other years. Here the finance-growth nexus, in form of a fractional polynomial regression line, looks distinctly rotten: countries which peaked with credit/GDP ratios over 34% experienced *negative* relative growth, and those at the top-end of the distribution had on average *3% lower growth rates* than in non-peak times. There are of course many problems with this interpretation (e.g. secular growth slowdown in high-income, financially-developed economies) but we can use this descriptive analysis to pinpoint an important insight, highlighted in the lower panel of the figure, where we split the sample and regression lines into those countries below and above 92% credit/GDP: if a simple plot like that in Figure 2 (a) is used to motivate the study of 'too much finance' *at the top of the credit/GDP distribution*, then the plot on the left in Figure 2 (b) suggests that we should also study this relationship *at intermediate levels of financial development* (credit/GDP thresholds around 34% or 47%).

Figure 3: Treatment Length and Relative Growth Performance



Notes: We present predictions from multivariate running line regressions of average GDPpc growth above the specified 'too much finance' threshold relative to the average below (y-variable) regressed on years spent above the threshold (x-variable), further conditioning on per capita GDP level in the year of crossing the threshold. The country-specific predictions are minimally perturbed to aid illustration (sample sizes in square brackets). Virtually all estimates are statistically significantly different from zero (not highlighted in the plots for ease of illustration).

A final set of graphs in Figure 3 focuses on the notion that if 'too much finance' affects growth *in the long-run*, then it should matter how many years a country spends in the 'danger zone': we should see a deterioration of the growth performance, the longer countries have spent above some 'too much finance' threshold. In these figures we subtract the average growth in those years not above the threshold from that during the above-threshold years and plot this difference against the number of years spent above the threshold — instead of a scatter we show the predictions from the multivariate running line regression which controls for per capita GDP level in the year the country crossed the threshold as well as a dummy for that year.

Once again, this analysis is simplistic as we cannot account for the passing of time or aspects of convergence, so we put more emphasis on the *shape* of the predicted regression lines: in the advanced country sample in panel (a) this points to an inverted-U shape, which suggests that adopting a 92% or 119% credit/GDP threshold countries first experience an improvement of their economic prospects, but eventually see their fortunes decline. In the developing country sample in panel (b) the 34% credit/GDP threshold portrays a less straightforward picture, whereas the 47% threshold repeats the inverted-U patterns of the advanced country sample.

We close with a brief analysis of the 'dominant narratives' for banking crisis prediction to demonstrate that these can be traced in the raw data. In Appendix Figure A-1 we present event analysis plots for per capita GDP growth, change in credit/GDP, change in the gross capital inflows/GDP, and change in gross fixed capital formation/GDP in the run-up and aftermath of banking crises. We produce these plots for the 'full sample' in Panel (a), for the sample of countries which exceeded the 92% credit/GDP threshold in Panel (b), and for those which had peak credit/GDP between 47% and 92% in Panel (c). Real GDP growth does not show any statistically significant patterns prior to the crisis date, although it drops over 3% below trend in the aftermath. The 'credit boom gone bust' narrative comes out clearly in all three sample. Investment share of GDP is slightly elevated two years prior to the crisis in the two 'restricted' samples but not in the full sample. Finally, the change in gross capital inflows/GDP shows elevated levels two years prior to the crisis onset in full and 'advanced country' samples, while in the 'developing country' sample there is an effect one year before the crisis. This points to a capital flow bonanza narrative, while only the 'advanced country' sample gives an indication of substantial decline in capital inflows after the crisis.

3 Financial Development and Growth

In this section we study the long-run implications of high levels of finance on economic prosperity. Our sample contains a mix of developing and developed economies, and spans 1960 to 2016. We employ a Difference-in-Difference (PCDID) method (Chan & Kwok 2022), modelling 'too much finance' as an endogenous treatment using alternative credit/GDP thresholds. Our results are presented with the aid of multivariate running line regressions, which allow us to plot the treatment effect of 'high' financial development against the years spent in this 'high' regime, while conditioning on country-specific data coverage (start year), minimum credit/GDP level, and 'regime dynamics' (the number of times a country crosses the threshold). In the following, we describe our data and methodology (Section 3.1), present results for top percentiles (3.2) and intermediate levels of financial development (3.3). We conclude with an exploratory analysis of disaggregated credit data (households versus corporate) in a moderate sample of advanced and emerging economies (3.4).

3.1 Data and Methodology

Data and Transformations The literature studying the causal link between finance and growth (initiated by King & Levine 1993, Levine et al. 2000) adopts three main proxies for financial development: (i) private credit to GDP; (ii) liquid liabilities to GDP; and (iii) commercial bank assets relative to commercial bank plus central bank assets. Measures (i) and (ii) cover the activities of all financial intermediaries scaled by the size of the economy, while the third measure proxies the extent to which the government captures the financial activities in the economy relative to deposit taking institutions. Empirical research has stressed the growing importance of the non-bank financial intermediaries, particularly market financing (Levine & Zervos 1998) and measures (i) and (ii) relate to this growing segment. We follow Arcand et al. (2015) in adopting credit/GDP as our indicator for financial development, as it best captures financial activity as opposed to the size of the financial system (liquid liabilities) and furthermore provides the best data coverage.

We take 'private credit by deposit money banks and other financial institutions to GDP' from the July 2018 version of the *Financial Development and Structure Dataset* (FSFD; Beck, Demirgüç Kunt & Levine 2000, Beck et al. 2009). Our dependent variable, real GDP per capita in 2005 US$ values, as well as additional controls (inflation, trade as a share of GDP) are taken from the World Bank *World Development Indicators* — all (except inflation) are log-transformed and the income variable is further multiplied by 100: our treatment estimates provide the percentage effect of 'high' finance (see below for definitions) on per capita income. The parsimonious choice of controls is selected on the basis of the existing literature (Beck, Demirgüç Kunt & Levine 2000, Arcand et al. 2015). In robustness checks we effectively estimate production functions augmented with a 'too much finance' dummy (with and without capital stock), using Penn World

Table (Feenstra et al. 2015, PWT v. 10) data — see Appendix C. Following some restrictions on minimal number of observations[8] the full sample covers close to 6,000 observations in 152 countries. Appendix Table A-1 offers detailed information on our treatment and control sample make-up alongside descriptive information on income per capita and financial development.

In additional analysis we use quarterly data from the Bank of International Settlements (BIS) for 1991Q1 to 2018Q3 to disaggregate credit to the non-financial sector into 'household credit' and 'firm (non-financial corporation) credit'. These data are compiled for 44 countries, though the availability of per capita GDP and the inclusion of control variables reduce this to 41 countries. Our income variable is constructed from nominal GDP data, CPI data (benchmark year 2010) and local currency to US$ exchange rates averaged for the benchmark year (all quarterly) along with annual population data (interpolated to cover quarterly frequency) from the IMF IFS. Quarterly data on inflation (change in CPI) is from the same source, from the IMF Direction of Trade (DOT) dataset we obtain quarterly data for imports and exports to construct the export/trade control variable. Appendix Figure D-1 shows a simple scatterplot for the two credit ratios with per capita GDP, the sample makeup is reported in Appendix Table D-1.

Regime Thresholds For our main results we adopt the 90th and 95th percentiles of the credit/GDP variable in the full 152-country sample as 'thresholds' for a 'high' financial development regime. These cut-offs, equivalent to 92% and 119% of credit/GDP, are similar to the 88% threshold found by Law & Singh (2014) and the 100% found by Arcand et al. (2015). For our two thresholds we observe 38 and 24 treated countries, respectively. We refer to these samples and related analysis as pertaining to 'advanced countries'.[9] In the analysis of intermediate levels of the credit/GDP variable we select the 60th (34% credit/GDP) and 70th (47%) percentiles of the full 152-country sample. We choose these cut-offs on the basis of our above discussion of Figure 2. As we want to exclude economies like Singapore, which evolved from 33% to 132% credit/GDP, from this 'intermediate-level' sample, we impose percentile *ranges* for our treated samples: 60th to 70th or 60th to 80th percentiles, alongside 70th to 80th or 70th to 90th percentiles — the narrower ranges capture 18 and 26 countries for the respective cut-offs, the wider ones 42 for the 34% and 47 countries for the 47% cut-off. We refer to these samples and related analysis as

[8]We require each country to have at least 14 observations. This excludes 115 observations for 15 countries (such as Afghanistan, Equatorial Guinea, Iraq, Lao, Libya, and Zambia).

[9]Over 80% (79%) of observations in the treated sample using the 90th (95th) percentile cut-off are for high-income countries, seven (four) are middle-income countries, Zimbabwe (one observation above either threshold) is the sole low-income country. See Appendix Table A-1 for details.

pertaining to 'developing countries'.[10] We detail the adopted regime thresholds for our analysis using quarterly data on household versus firm credit in Section 3.4.

Threshold PCDID We estimate country regressions for treated countries only, but augment each country-regression with common factors estimated from the residuals of the same regression model *in the control sample*. Using potential outcomes, the observed outcome of treatment D_{it} for panel unit i at time T_0 can be written as

$$y_{it} = D_{it}y_{it}(0) + (1 - D_{it})y_{it}(1) = \Delta_{it}\mathbf{1}_{\{i\in E\}}\mathbf{1}_{\{t>T_0\}} + y_{it}(0) \quad (1)$$

$$\text{with} \qquad y_{it}(0) = \varsigma_i + \beta_i' x_{it} + \mu_i' f_t + \widetilde{\epsilon}_{it}, \quad (2)$$

where the two indicator variables $\mathbf{1}_{\{.\}}$ are for the treated panel unit and time period, respectively, Δ_{it} is the time-varying heterogeneous treatment effect, x is a vector of control variables with associated country-specific parameters β_i,[11] $\mu_i' f_t$ represents a set of unobserved common factors f_t (which can be nonstationary) with country-specific factor loadings μ_i, and $\widetilde{\epsilon}_{it}$ is the error term.

The treatment effect is assumed to decompose into $\Delta_{it} = \overline{\Delta}_i + \widetilde{\Delta}_{it}$, with $E(\widetilde{\Delta}_{it}|t > T_0) = 0$ $\forall i \in E$ since $\widetilde{\Delta}_{it}$ is the demeaned, time-varying idiosyncratic component of Δ_{it}; we refer to $\overline{\Delta}_i$ as ITET, the treatment effect of unit i averaged over the treatment period — our parameter of interest. The reduced form model is

$$y_{it} = \overline{\Delta}_i\mathbf{1}_{\{i\in E\}}\mathbf{1}_{\{t>T_0\}} + \varsigma_i + \beta_i' x_{it} + \mu_i' f_t + \epsilon_{it}, \quad (3)$$

with $\epsilon_{it} = \widetilde{\epsilon}_{it} + \widetilde{\Delta}_{it}\mathbf{1}_{\{i\in E\}}\mathbf{1}_{\{t>T_0\}}$. Given the treatment effect decomposition ϵ_{it} has zero mean but may be heteroskedastic and/or weakly dependent.

The factor structure has a long tradition in the panel time series literature to capture strong cross-section dependence (Pesaran 2006, Bai 2009), a form of unobserved, time-varying heterogeneity. Strong correlation across panel members is distinct from weaker forms of dependence, such as spatial correlation, and if ignored can lead to serious (omitted variable) bias in the estimated coefficients on observable variables (Phillips & Sul 2003, Andrews 2005). Here, the combination of common factors and heterogeneous parameters also allows for potentially non-parallel trends across panel units, most importantly between treated and control units. The above setup can

[10] Over 80% (63%) of observations in the 60th (70th) percentile cut-offs are for middle-income economies, the remainder largely for former transition economies.

[11] We assume $\beta_i = \bar{\beta} + \tilde{\beta}_i$ with $E(\tilde{\beta}_i) = 0$ (Pesaran, 2006). x can be a function of f.

further accommodate endogeneity of treatment D_{it} in the form of *inter alia* correlation between treated units and factor loadings, the timing of treatment and factor loadings, or between observed covariates and timing or units of treatment.

The estimation of the country-specific treatment effect (ITET) $\overline{\Delta}_i$ proceeds in two steps: first, using Principal Component Analysis (PCA), we estimate proxies of the unobserved common factors from data in the control group (details below); second, country-specific least squares regressions of treated countries are augmented with these factor proxies as additional covariates. We experiment with the make-up of the control sample based on 'peak' credit/GDP values: countries for which financial development peaked close(r) to the 'high' threshold studied are more plausible counterfactual cases than countries with very low peak levels.

The main identifying assumptions are that all unobserved determinants of GDP per capita are captured by the factors, a standard assumption in the panel time series literature (Pesaran 2006, Bai 2009) and related causal panel models (Athey & Imbens 2022). It is further assumed that conditional on the estimated factors the control variables x are jointly insignificant predictors for the treatment.[12] Since the factors are estimated with error, there is potential correlation between the errors of treated and control countries, which will bias the treatment estimate. This bias can be removed if we require that $\sqrt{T}/N_c \to 0$, where T is the time series dimension and N_c the number of control countries.

The estimation equation for each treated country $i \in E$ is then:

$$y_{it} = b_{0i} + \delta_i \mathbf{1}_{\{t>T_0\}} + a_i' \hat{f}_t + b_{1i}' x_{it} + u_{it}, \tag{4}$$

where $\hat{f}$ are the estimated factors obtained by PCA on the residuals $\hat{e}$ from the heterogeneous regression of $y_{it} = b_{0i} + b_{1i}' x_{it} + e_{it}$ in the control group sample, and δ_i is the country-specific parameter of interest. We estimate (4) augmented with one to six common factors. The average treatment effect (ATET, $\hat{\delta}^{MG}$) is simply the average of the country estimates $\hat{\delta}_i$. We follow the practice in the literature and use the robust mean group estimate (Hamilton 1992) with the associated standard errors based on $\Sigma^{MG} = (N-1)^{-1} \sum_i (\hat{\delta}_i - \hat{\delta}^{MG})$ (Pesaran 2006).

Conditional Local Mean Results The standard approach in the treatment effects literature is to report the ATET, $\hat{\delta}^{MG}$. However, this ignores the length of time a country has spent in

[12] We carry out Wald tests for this assumption — see Appendix Tables B-1 to B-3.

the higher regime — for some countries, e.g. Zimbabwe, only a single observation is above the threshold — and furthermore does not account for country data characteristics in an unbalanced panel or the 'regime dynamics'.

Below we follow the practice introduced in Boese & Eberhardt (2021) and adopt a multivariate smoothing procedure for the country estimates: running line regressions (Royston & Cox 2005), which are k nearest neighbour 'locally linear' regressions of the country treatment effect $\hat{\delta}_i$ on (i) the number of years in the higher regime, (ii) a dummy for the start year of the country series, (iii) the number of times the country crossed the threshold, and (iv) the country-specific minimum credit/GDP level. Our result plots present the evolution of the *predicted values* from this multivariate smoothing procedure[13] on the y-axis over the years in the higher regime on the x-axis. The associated standard errors are calculated based on the local weighted least squares fit and we highlight those local predictions for which the 90% confidence bound does (not) include zero with hollow (filled) markers.

Finally, the treatment effects graphs can be misleading if a few estimates in the right tail (countries with many years above the threshold) visually dominate the overall evolution of the relationship. In order to counter this impression we transform the 'years in regime' variable on the x-axis using the inverse hyperbolic sine (IHS): like a log transformation this stretches out low values and bunches up high values of treatment years, with the practical effect that the mean and median years spent in treatment are typically situated close to the *centre* of the plot.[14]

3.2 'Too much Finance'

In Figure 4 the upper panel presents results for the 92% credit/GDP threshold, the lower for the 119% threshold; ATET estimates for these specifications are presented in Appendix Table B-1.[15] These PCDID estimates show the causal effect of years spent in the 'higher' regime on per capita income relative to those countries which permanently stayed below the respective threshold. The different prediction lines are for the same treatment sample, but use different control samples: the orange line includes *any* country which stayed below 92% credit/GDP, the pink line excludes those control countries which always stayed below the 40th percentile, and so on. Similarly for

[13]These are not the $\hat{\delta}_i$ but the smoothed predictions from a multivariate running line regression.

[14]This also distracts from the 'extremes' of the result plots (0-5 years or >30 years): these sections of our plots likely do not speak to the aim of studying the *long-run* effects of 'too much finance'.

[15]Appendix Figure B-1 Panel (a) provides robustness checks by varying the 'too much finance' threshold from 65% to 115% (k), specifying control groups that are below k but have at least breached $k-25\%$. We cannot see any systematic negative effects for longer treatment.

the 119% threshold in the lower panel.[16]

There are three insights from the results in panel (a): first, the choice of control group clearly matters — when Angola or Chad are part of the control group to investigate the 'too much finance' hypothesis in Germany, France or the UK, we find the treatment effect trajectory is initially negative and at points statistically significant (control group lower cut-off from 0th, 40th or 50th percentile, orange, pink and blue lines), moving towards a positive insignificant value around the sample mean years in 'treatment'. When the control country sample is further restricted from below (from 60th or 70th percentile, all other coloured lines), creating arguably a closer match to the countries in the treated sample, the treatment effect trajectories turn positive and significant. Second, if we focus on the mean (14.6) or median (13) years of treatment, all estimates across different control samples find a small negative, albeit statistically insignificant effect: for the average country 'too much finance' does not appear to benefit economic performance... but does no harm either. Third, countries which spend only a handful of years in the 'higher' regime appear to have negative treatment effects.[17]

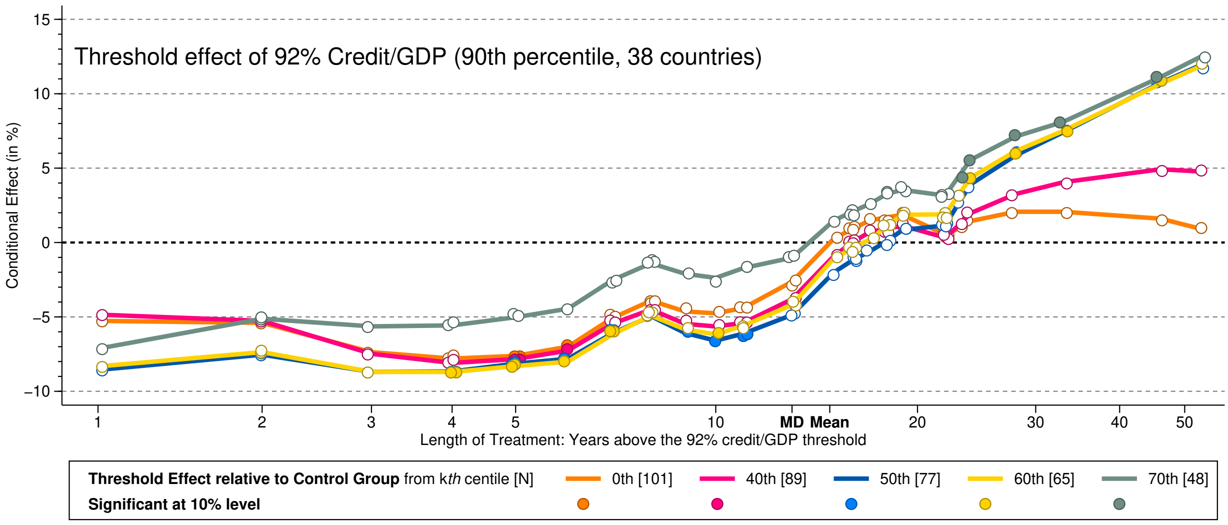
The analysis of the 119% credit/GDP threshold in the lower panel of the Figure provides similar evidence but with a strong divergence in the long-run between specifications with relatively indiscriminate control samples (orange and pink lines) and the more restricted control samples (all other coloured lines). For the latter, statistically significant treatment effects eventually reach around 15% higher per capita income after 30 years above the threshold, for the former the effect remains more modest but statistically significant. Predictions for countries with just a few years of treatment are again all negative, and as before none of the estimates below five years of treatment are statistically significant. The treatment effects for median and mean length of treatment measure are effectively zero.

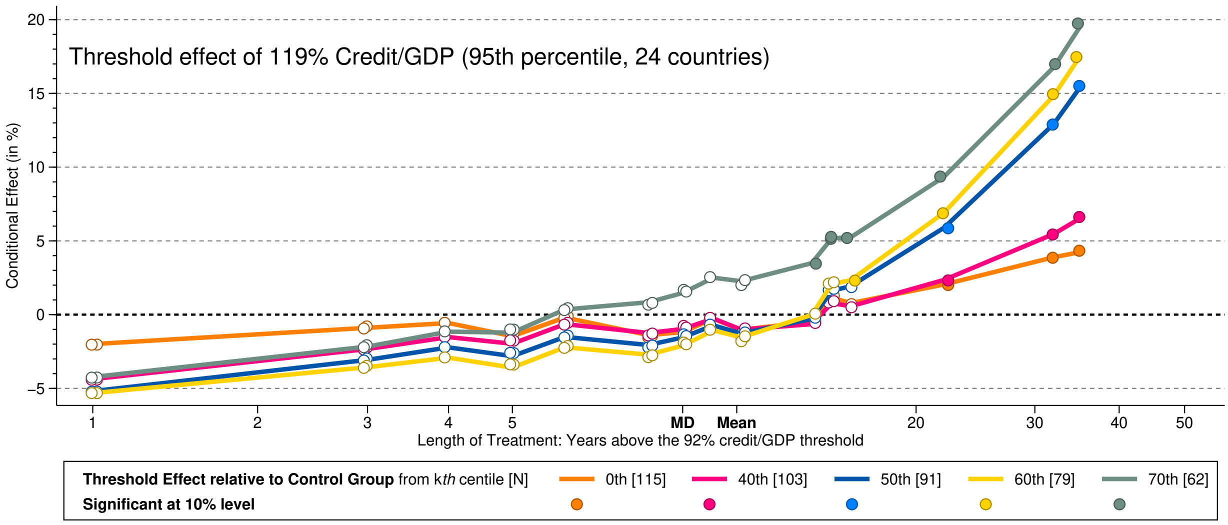
In Appendix C we estimate treatment effects in a production function specification using PWT data for per capita GDP and capital stock: the inclusion of the latter is controversial, in that higher financial development should raise gross fixed capital formation, implying that the finance effect in a production function should be interpreted as *relative* investment efficiency. An alternative view could argue that finance should be interpreted as an element of TFP exclusively. In

[16] Appendix Table B-1 reports the p-values for Wald tests in each specification: we regress the treatment dummy on the controls and one to six common factors, testing the hypothesis that the controls are jointly insignificant, which is the case in virtually all models.

[17] With the exception of Zimbabwe, all of these represent events in the aftermath of the GFC, a clear sign of *short-run* economic contraction: six of the eight countries with five or fewer years of treatment have *negative* average GDP pc growth at the time they cross the threshold.

Figure 4: Too much Finance? Running line presentation of PCDID results





Notes: Each plot investigates the prospect of 'too much finance' by studying the effect of being above the 90th or 95th percentile of the credit/GDP distribution. We consider restricted control group samples by dropping countries with low financial development (below the 40th, 50th, 60th and 70th percentile of the credit/GDP distribution). The first, orange plot is for the unrestricted control group. A filled (hollow) marker indicates statistical (in)significance at the 10% level. Mean and median (MD) treatment lengths and control sample sizes (N) are also reported.

the above results we followed the literature in excluding any proxies for investment in the estimation equation — here we compare the results when capital stock per capita is included or excluded.[18] Regardless of the inclusion or exclusion of capital stock the trajectories of the treatment effects in Appendix Figure C-1 are qualitatively identical, in terms of effect at the mean/median as well as for countries with few years of treatment, in line with those discussed above.

Taken together, these results provide strong evidence that when appropriate control samples are considered the effect of 'too much finance' is either meandering around zero and insignificant or rising over time and eventually, from around mean treatment length, positive and statistically significant. Our preferred estimates cannot provide definitive evidence for a positive, but they clearly rule out any *dramatic* long-run decline in economic prosperity as has been suggested in the existing literature.

3.3 Finance for Development?

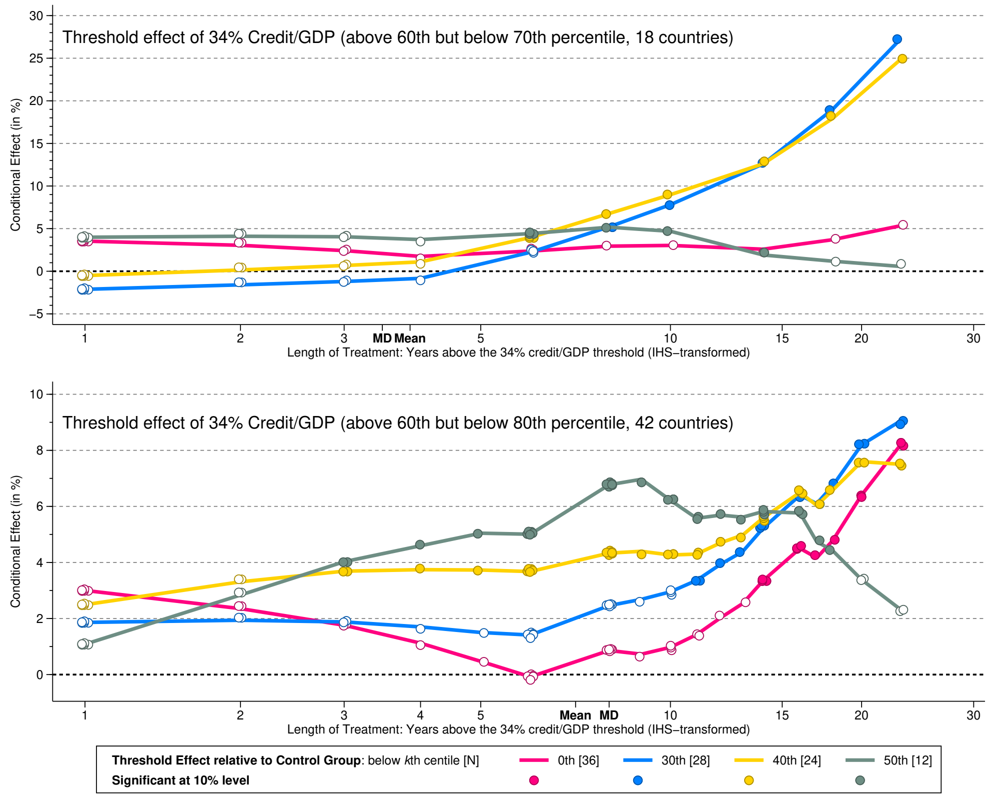
Panel (a) in Figure 5 presents results for the 34% credit/GDP threshold, Panel (b) for the 47% threshold[19] — the treated sample is restricted as indicated. The different regression lines in each plot are for the same treated sample but correspond to different control samples: again we curtail the control sample from below. In Panel (a) the treatment effects are positive for virtually all specifications and at times statistically significant and rising with treatment length. For the 47% threshold in Panel (b), the more curtailed specifications similarly yield positive significant and rising effects. Countries with just a few years above the threshold as well as those at mean or median treatment length often have positive but largely insignificant coefficients (the specifications with the *most* restricted controls sample only allow for 12 and 18 countries, respectively).

While the existing literature has acknowledged the beneficial aspects of finance at different levels of development (Levine 2005, Gambacorta et al. 2014), there has been no consensus over the *relative* benefit experienced between these two — our analysis suggests the effects for 'developing countries' are surprisingly similar to those at the very top of the credit/GDP distribution (119%).

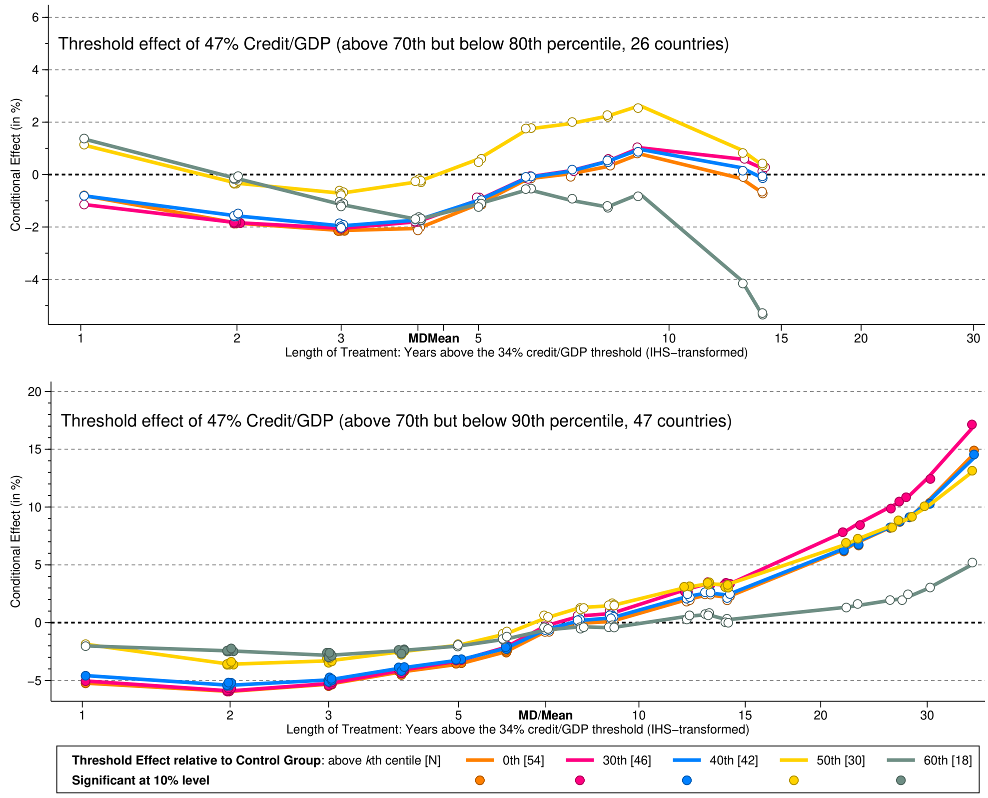
[18]The latter further acts as a robustness check on our main results which use WDI data for the dependent variable. We keep the same additional controls (openness and inflation).

[19]In Appendix Figure B-1, Panel (b) we provide detailed robustness checks by varying the 'too much finance' threshold from 30% to 65% (k) of the credit/GDP level, further restricting the treated sample to those countries which stayed below $k+$ 25%. The control sample is always all countries with a peak below k. The effects for around 30 years in treatment are between 5 and 10%. Appendix Tables B-2 and B-3 report ATET estimates and p-values from Wald tests carried out in analogy to those for the advanced country samples: basic assumptions of the model are violated in the 47-65% treatment sample but largely confirmed in all other specifications.

Figure 5: Finance for Development? Running line presentation of PCDID results



(a) 34% Credit/GDP Threshold(60th-70th %ile, top, 60th-80th %ile)



(b) 47% Credit/GDP Threshold (70th-80th %ile, top, 70th-90th %ile)

Notes: The different specifications in each plot are for control samples dropping countries with a maximum credit/GDP below 16% (30th percentile) 20% (40th), 26% (50th), 34% (60th) or, in the lower panel also 47% (60th). See Figure 4 for additional details.

3.4 Household versus Corporate Credit

Background While the 'credit booms gone bust' narrative in the financial crisis literature is now well-established, the more recent work has asked whether this relationship is crucially influenced by 'who borrows' (e.g. Beck et al. 2009, Mian et al. 2017, Müller & Verner 2021, among others). From a theoretical point of view, sectoral heterogeneity does not feature prominently in credit cycle theories (see discussion in Müller & Verner 2021), though most of the empirical literature has suggested household credit as the major driver of the aggregate credit-crisis relationship (Jordà et al. 2016*a*, Mian et al. 2017).[20] As an exploratory exercise, limited to 'too much finance' at the top of the credit/GDP distribution, we investigate whether the use of household credit and corporate credit leads to different insights into the finance-growth relationship.

Thresholds Like in our analysis of aggregate credit we adopt specific percentiles of the distribution of household credit/GDP and firm credit/GDP to define respective thresholds for 'too much finance'; due to modest sample sizes all countries permanently below the respective threshold are in the control sample. We adopt the 80th, 85th and 90th percentiles — highlighted in Appendix Figure D-1 — but the treated sample sizes are modest (12 to 19 countries), so that our results need to be interpreted with caution. In order to capture an imbalance between household and corporate credit[21] we construct a variable representing the *share* of household to total credit and take its 80th, 85th and 90th percentiles as alternative thresholds. Again, the treated sample size is small, only ten countries.

Results Empirical findings for the PCDID estimator are presented in Appendix Table D-2. These give no indication of a negative average treatment effect (ATET – computed using the robust mean across heterogeneous country estimates),[22] in fact two out of three household credit specifications have large positive results (13% higher income per capita). Our Wald tests that control variables are jointly insignificant in an auxiliary regression of the treatment dummy on the controls as well as the estimated factors are somewhat mixed: the null of no statistical significance is *not universally* maintained. With this and other caveats in mind, we conclude that once again *on average* there

[20]Recent work by Müller & Verner (2021) tackles the corporate credit side and demonstrates that, similar to household credit booms, lending to *non-tradable* sectors constitutes the 'bad booms' leading to productivity slowdowns and financial vulnerability. Analysis using their rich sectoral credit data is left for future research once these are publicly available.

[21]We experiment with including the household credit/GDP variable in the treatment equation for 'too much corporate credit' and vice versa, but our Wald tests always reject the null that the threshold variable is exogenous to the controls.

[22]Given the small treated samples the running line regressions do not yield reliable insights.

was no evidence for a detrimental 'too much finance' effect on economic development.[23]

4 Financial Development and Systemic Vulnerability

A large literature on financial crises has (re)emerged following the Global Financial Crisis of 2007/8, with the "new (near consensus) view" (Bordo & Meissner 2016, 31) that banking crises are 'credit booms gone bust' (Schularick & Taylor 2012). Yet the drivers of banking sector distress have been shown to differ across economies given their different structural characteristics (Hardy & Pazarbașioğlu 1999) and the differences in the identity of lenders (private in advanced, predominantly official in developing countries) and borrowers (private in advanced, government-owned banks in developing economies: Caprio & Klingebiel 1996).

In this section we connect the empirical literatures on 'high' financial development and financial crises: adopting banking crisis data from Reinhart & Rogoff (2009) and Laeven & Valencia (2020) we compare the propensity of credit booms (Giannetti 2007, Jordà et al. 2011, Schularick & Taylor 2012), unfettered capital inflows (Reinhart & Rogoff 2013, Caballero 2016), and aggregate commodity price movements (Eichengreen 2003, Eberhardt & Presbitero 2021) in predicting banking crises above and below different cutoffs of 'too much finance'. Our research question is whether *within countries* these 'dominant narratives' for banking crises are comparatively more compelling when countries are in the higher finance regime: if 'too much finance' goes hand in hand with increased vulnerability, then we would expect the dominant crisis determinants in the literature to be the primary suspects for driving this process (see also Kaminsky & Reinhart 1999), and our empirics should be able to detect increased vulnerability in the higher regime.

In the remainder of this section we introduce the additional data used as well as our EWS methodology (Section 4.1), before we discuss our findings for the countries at the top (4.2) and at intermediate levels (4.3) of the credit/GDP distribution.

4.1 Data and Methodology

Data and Transformations In addition to the credit/GDP data (see Section 3.1 above) we adopt the banking crisis data collated by Carmen Reinhart and co-authors, augmented with data from Laeven & Valencia (2020) to maximise coverage for the 1960-2016 period. Gross capital

[23] Given the sample sizes involved we did not pursue the analysis of banking crisis in this dataset. Substantially larger panel data from Müller & Verner (2021) are due to be made public in the second half of 2022.

inflows (in percent of GDP) are taken from the IMF Financial Flows Analytics database.[24] In order to capture 'excessive' capital inflows, the literature has adopted bonanza (Caballero 2016) or surge indicators (Ghosh et al. 2014) based on capital flow data. These dummy variables severely curtail the sample in our heterogeneous EWS analysis, since our lower versus higher regime setup is only identified if there are surges or bonanzas *in both regimes* of a country.[25] Our approach is thus wedded to the *continuous* financial flow variable (growth in capital flows/GDP), but to mimic the nature of capital flow *spikes* we alternatively adopt the square of capital inflows/GDP *levels*.[26]

In the developing country sample we add commodity price movements, constructed using data from Gruss & Kebhaj (2019): we employ the monthly country-specific aggregate commodity price index (based on country averages of net export/GDP weights) for 1962-2016 to construct two variables: (a) the first difference of the index, and (b) the predicted volatility from a simple GARCH(1,1) model for commodity price growth with just an intercept term (following Cavalcanti et al. 2015). We sum the monthly growth terms to compute annual values and take the annual mean of monthly volatility (see Eberhardt & Presbitero 2021, for details).

One important issue is how to capture the 'trigger' dynamics of crisis determinants but not to rule out slower-moving fundamentals (Eichengreen 2003): in their analysis over three centuries Schularick & Taylor (2012) adopt a fifth-order lag polynomial specification for credit growth and controls — in our dataset this would take up too many degrees of freedom in the country regressions, hence we resort to specifying moving averages to capture pre-crisis dynamics, following Reinhart & Rogoff (2011) and Jordà et al. (2011, 2016*b*). In line with Eberhardt & Presbitero (2021) we adopt an MA(3) transformation: $\overline{\Delta(\text{credit/GDP})}_{i,t-1/t-3} = (1/3)\sum_{s=1}^{3}\Delta(\text{credit/GDP})_{i,t-s}$, and similarly for all other controls.

Regarding additional control variables we follow the practice in Schularick & Taylor (2012) for the 'advanced country' analysis: our simplest empirical model includes only the MA(3)-transformed credit/GDP growth or capital flow variables; we then present results for a 'full model' where we add MA(3)-transformations of per capita GDP growth, the change in gross fixed capital formation over GDP, and inflation as additional controls — these variables are taken from the World Bank *WDI*. For the developing country analysis we adopt inflation and trade openness taken from the same

[24] In line with Caballero (2016) we find the most robust results using gross rather than net inflows. Our findings are qualitatively similar if we adopt gross non-official rather than gross total flows.

[25] Further problems arise if there are comparatively few years spent in the higher or lower regime.

[26] This square is not included alongside the inflows/GDP 'levels' variable to detect a concave or convex relationship with crisis propensity, but it is entered *on its own* as an accentuated measure for large swings in capital movements.

source in the specifications with additional controls.[27] These choices and restrictions regarding the operationalisation of our variables of interest and the limited additional controls represent a caveat for our analysis. Our set of additional controls represents a bare minimum compared with pooled empirical models in the existing literature (see Demirgüç-Kunt & Detragiache 1998, Kaminsky & Reinhart 1999, Papi et al. 2015, for additional crisis predictors); however, the parsimony imposed by our methodology as well as (in some cases) data availability at least avoids the concerns regarding overfitting when studying rare events like banking crises. We also gain insights by comparing results for specifications without additional controls with those when we, in comparative terms, saturate the model. Finally, it bears emphasising that our adopted methodology (discussed below) includes estimated effects of unobserved common factors in the spirit of Boneva & Linton (2017), which can capture relevant crisis determinants omitted from the model as well as global shocks or crisis spillovers (Cesa-Bianchi et al. 2019).

Factor-Augmented Early Warning System We specify a latent variable model of banking sector vulnerability Y_{it}^* as a function of the dominant crisis predictors in the literature (illustrated below using credit/GDP growth in the MA(3) transformation) for each country in a 'treated' sample of (a) 'advanced' economies; or (b) 'developing countries', respectively:

$$\begin{aligned} Y_{it}^* &= \alpha_i' d_t + \beta_i^A \, \overline{\Delta(\text{credit/GDP})}_{i,t-1\,/\,t-3} \\ &\quad + \beta_i^B \, \mathbf{1}_{\{t>T_{0i}\}} \, \overline{\Delta(\text{credit/GDP})}_{i,t-1\,/\,t-3} + \gamma_i' \overline{x}_{i,t-1\,/\,t-3} + \kappa_i' f_t + \varepsilon_{it}, \end{aligned} \tag{5}$$

where f is a set of unobserved common factors with heterogeneous factor loadings κ and additional controls are represented by x — these always include the 'rival' dominant crisis predictors (i.e. in the present case capital flows in both samples and further aggregate commodity price movements in the developing country sample) alongside the other controls. The indicator variable $\mathbf{1}_{\{\cdot\}}$ captures the time periods spent in the 'higher regime' above the credit/GDP threshold.[28]

We implement this model by combining work on common factors in a generalised linear model (Boneva & Linton 2017) with that on the PCDID (Chan & Kwok 2022) to create a factor-augmented EWS approach.[29] We adopt a linear probability model for the start year of a banking

[27] GFCF data are sparser for developing economies, while GDP growth was not found to be a significant crisis predictor in Eberhardt & Presbitero (2021), in contrast to inflation and openness.

[28] The more general setup with d_t allows for the inclusion of 'observed' common factors.

[29] Boneva & Linton (2017) provide an extension to the Pesaran (2006) common correlated effects estimator in the context of the probit model but also support the linear probability model. In contrast to our implementation in

crisis,[30] Y_{it}, in those countries which crossed the credit/GDP threshold. The country-specific estimation equation is augmented with up to k common factors, estimated from countries which always remained below the 'too much finance' threshold (for convenience: 'control sample').

For illustration, in the credit/GDP growth case: $\forall\, i \in E$

$$\begin{aligned} & Pr(Y_{it} = 1 \mid \overline{\Delta(\text{credit/GDP})}_{i,t-1\,/\,t-3},\, \overline{x}_{i,t-1/t-3},\, d_t,\, f_t) \qquad (6) \\ & = [\alpha_i + \tilde{f}_t'\kappa_i] d_t + \beta_i^A\, \overline{\Delta(\text{credit/GDP})}_{i,t-1\,/\,t-3} \\ & \quad + \beta_i^B\, \mathbf{1}_{\{t>T_{0i}\}}\, \overline{\Delta(\text{credit/GDP})}_{i,t-1\,/\,t-3} + \delta_i'\overline{x}_{i,t-1/t-3} + \psi_i'\hat{f}_t. \end{aligned}$$

In this specification the change in credit/GDP is split in two by means of the interaction with the 'higher regime' dummy $\mathbf{1}_{\{t>T_{0i}\}}$; as a benchmark we also provide results for a model where there is only one credit/GDP growth term. The common factors $\hat{f}$ are estimated via PCA from the residuals of the same model in the control group (albeit by construction with just a single credit/GDP growth term).[31]

We assume $d_t = 1$ and estimate for treated countries $i \in E$

$$\begin{aligned} Y_{it} \;=\;& a_i + b_i^A\, \overline{\Delta(\text{credit/GDP})}_{i,t-1\,/\,t-3} + b_i^B\, \mathbf{1}_{\{t>T_{0i}\}}\, \overline{\Delta(\text{credit/GDP})}_{i,t-1\,/\,t-3} \qquad (7) \\ & + c_{1i}\overline{\Delta(\text{cap inflow/GDP})}_{i,t-1/t-3} + c_{2i}\overline{\Delta(\text{GDP pc})}_{i,t-1/t-3} \\ & + c_{3i}\overline{\Delta(\text{GFCF/GDP})}_{i,t-1/t-3} + c_{4i}\overline{(\text{inflation})}_{i,t-1/t-3} + d_i'\hat{f}_t + \varepsilon_{it}, \end{aligned}$$

where we spell out the control variables in detail. ε is the error term, which can be heteroskedastic and/or serially correlated. Alternative specifications focusing on excessive capital flow (and, in the 'developing country' analysis, aggregate commodity price movements) are constructed analogously, with the credit growth variable as additional control. The factor augmentation captures the developments in the countries which never crossed the specified credit/GDP threshold, while the interaction term setup allows us to investigate differential effects of dominant crisis predictors below

their model the common factors are proxied by the cross-section averages (CA) of all regressors in the model. We could have adopted this strategy, using the CA based on control sample variables, but opted to keep the estimation approach as similar as possible to the linear PCDID adopted in the finance-growth regressions above.

[30] Subsequent 'ongoing crisis years' are dropped from the sample as per practice in this literature.

[31] The term in square brackets in equation (6) includes some estimation error of this process, $\tilde{f}_t$, which vanishes as $\sqrt{T}/N_C \to 0$ for T the time series dimension and N_C the number of control group countries, in which case this term in square brackets is time-invariant. Note further that the estimated factors are *not* MA(3)-transformed since they are estimated from the residuals of a regression analogous to equation (7) in which all regressors are already MA(3)-transformed.

and above the financial development threshold *within* individual countries. A positive (negative) significant interaction term suggests that being in the higher, 'too much finance' regime implies a higher (lower) propensity of banking crises for the dominant crisis predictors in the literature than in the lower regime. Note that we study the interaction with dominant crisis predictors in *separate* regressions, i.e. there is only ever one interaction term effect per specification, to keep the empirical model parsimonious and hence feasible for estimation.

Robust mean marginal effects and inference We present the robust mean estimates for the dominant crisis determinants (and the interaction with 'high financial development', if applicable) and do not, as in the previous section, follow a strategy of highlighting the crisis propensity effect across time spent in the higher regime: the EWS analysis focuses on *short-run* trigger effects, and it therefore seems more natural *not* to take time in the higher regime into account. Our reported estimates are Mean Group estimates computed using robust regression (Hamilton 1992) with associated standard errors computed non-parametrically (Pesaran 2006, Chan & Kwok 2022). All results are expressed as marginal effects (in percent) of a one standard deviation increase in the variable of interest. In the interaction specifications we still adopt the full sample standard deviation for ease of comparability.

4.2 Systemic Vulnerability due to Too Much Finance?

Table 1 presents the results for two thresholds of 'high financial development', the 90th percentile (92% credit/GDP, 'Group I') and the 95th percentile (119% credit/GDP, 'Group II'): there are 30 and 23 countries in these samples, which experienced 47 and 38 banking crises, respectively. The unconditional crisis propensities in our treated samples (4.8% and 5.0%) are broadly similar to those in the various 'control samples' (5.5-5.9% and 5.3-5.5%). The different columns of the table represent different 'control samples', which as we move to the right are defined with higher and higher cutoffs: the results in columns (5) and (10) adopt the 'control group' of countries with a peak of credit/GDP between the 70th and 90th percentiles.

In each of the three results panels (A-C) the first set of marginal effect estimates ignores separating out the effect of the variable of interest into a 'low' versus 'high' finance regime. These marginal effects (labelled $\hat{\beta}^{MG}$) are positive and significant in all specifications for credit/GDP growth and in many specifications of squared capital flow/GDP (but only sporadically significant for change in capital flow/GDP). Regarding credit booms in Panel (A), highly financially developed economies experience a 2-3% higher propensity of a banking crisis for a one standard deviation increase in credit/GDP growth when we estimate the EWS without any control variables, rising to 2.5%-5% with the full set of controls. Hence, as is well-established in the literature, credit booms have a substantial positive effect on crisis propensity, up to the magnitude of the unconditional crisis propensity of around 5%.[32] While the simple change in the capital flows/GDP measure yields disappointing, largely statistically insignificant results in Panel (B), our attempt at capturing *excessive* capital movements in Panel (C) suggests that a one standard deviation of the squared capital flows/GDP ratio leads to a 1.5-5.8% increase in the propensity of a banking crisis — these are the results for the sample of countries which crossed the 90th percentile of the credit/GDP distribution, the estimates for the countries which crossed the 95th percentile are more modest (around 1%) and only consistently statistically significant in the model without additional controls. We take these results as confirmation that our samples and methodology can replicate the current consensus in the literature that credit booms and perhaps to a lesser extent large capital inflows play an important role in triggering banking crises.

We now turn to the main purpose of this EWS exercise, the question whether *within* highly financially developed countries these credit boom and excessive capital flow effects are comparatively larger when countries are in the higher 'regime' of financial development compared with the effects in the lower 'regime'.[33] For credit booms in Panel (A), focusing on the specifications with additional controls, the below-threshold estimates in Group I are large, between 3.7% and 4.8%, and statistically significant, whereas the above-threshold effects, to be interpreted as deviations from these benchmark effects, are all negative and statistically insignificant. In column (5), for instance, the below-threshold effect is 4.8%, whereas the relative effect above the threshold is -1.8%, albeit statistically insignificant. In Group II the benchmark estimates for below the threshold are substantially lower and statistically insignificant, now the above threshold deviations are positive and comparatively larger but still insignificant.[34] Given that the $\hat{\beta}^{MG}$ estimates *ignoring the financial development regime* are all statistically significant, we interpret these findings as suggesting that a differential effect *by regime* in Group II is not supported by the data. Taken together, our results suggest that there is no evidence that credit booms create higher susceptibility to banking

[32] Comparing AUROCs between models with control variables which include or exclude the credit/GDP growth variable suggests that including them has significantly higher predictive power in the Group I results, but only in the specification in column (10) in the Group II results.

[33] A simple count of banking crises in the two regimes already indicates that 50% more crises (100% in case of the 95th percentile cutoff in columns (6) to (10)) occurred in the *lower* regime.

[34] AUROC comparison in either Group I or II results indicate that including the two credit growth terms has higher predictive power than a model with just a single credit growth term ignoring financial development.

Table 1: Too Much Finance & Banking Crises

Higher Cutoff	Group I 92% Credit/GDP (90th percentile)					Group II 119% Credit/GDP (95th percentile)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control Above	0%	20%	26%	34%	47%	0%	20%	26%	34%	47%
Percentile	0th	40th	50th	60th	70th	0th	40th	50th	60th	70th
Panel A: Change in Credit/GDP (Credit Booms Gone Bust)										
Without additional controls										
$\hat{\beta}^{MG}$	2.933	2.457	2.379	2.302	1.836	2.311	2.628	2.369	2.247	2.460
	[3.27]***	[2.60]***	[2.21]**	[2.34]**	[2.01]**	[2.38]**	[2.78]***	[2.47]**	[2.61]***	[2.66]***
$\hat{\beta}^{A}$	2.463	1.692	2.371	2.330	2.417	1.408	0.828	2.491	1.270	0.942
	[1.48]	[1.18]	[1.54]	[1.68]*	[1.62]	[1.01]	[0.71]	[1.67]*	[0.90]	[0.72]
$\hat{\beta}^{B}$	-2.263	-1.914	-2.488	-2.975	-2.769	0.464	1.374	0.132	2.797	2.186
	[0.90]	[0.79]	[0.96]	[1.11]	[1.11]	[0.18]	[0.55]	[0.06]	[0.83]	[0.57]
ROC Inter (p)	0.164	0.116	0.054	0.082	0.064	0.302	0.218	0.074	0.202	0.118
Controlling for Change in Capital Inflows/GDP, Inflation, GDPpc Growth and Change in GFCF/GDP (MA)										
$\hat{\beta}^{MG}$	4.909	3.736	4.103	4.721	4.214	2.607	2.592	2.454	2.770	2.484
	[4.25]***	[3.20]***	[3.39]***	[3.83]***	[3.80]***	[2.39]**	[2.37]**	[2.22]**	[2.55]***	[2.20]**
ROC Comp (p)	0.012	0.039	0.016	0.009	0.004	0.252	0.332	0.165	0.222	0.054
$\hat{\beta}^{A}$	4.267	3.753	3.923	4.474	4.833	0.895	0.830	0.763	0.922	0.248
	[1.89]*	[1.81]*	[1.76]*	[1.96]**	[1.96]**	[0.86]	[0.75]	[0.60]	[0.68]	[0.15]
$\hat{\beta}^{B}$	-1.721	-1.088	-0.874	-1.063	-1.793	2.590	2.752	2.048	4.377	4.241
	[0.54]	[0.69]	[0.74]	[0.69]	[0.52]	[0.45]	[0.43]	[0.54]	[0.27]	[0.32]
ROC Comp (p)	0.014	0.011	0.010	0.002	0.005	0.023	0.035	0.026	0.038	0.039
ROC Inter (p)	0.483	0.102	0.187	0.054	0.143	0.070	0.077	0.152	0.144	0.204
Panel B: Change in capital flows/GDP (Excessive Capital Flows I)										
Without additional controls										
$\hat{\beta}^{MG}$	2.125	6.237	3.818	6.204	4.558	-1.130	-0.756	-0.356	0.926	0.860
	[0.55]	[2.02]**	[1.19]	[1.95]*	[1.55]	[0.70]	[0.51]	[0.22]	[0.71]	[0.47]
$\hat{\beta}^{A}$	-9.189	-5.559	-5.203	-2.916	-4.788	-2.874	-2.736	-3.348	-2.916	-0.881
	[0.99]	[0.55]	[0.57]	[1.38]	[0.58]	[1.02]	[1.04]	[1.52]	[1.38]	[0.30]
$\hat{\beta}^{B}$	19.642	20.899	14.848	5.189	8.271	5.510	5.467	7.021	5.189	4.968
	[1.46]	[1.47]	[1.17]	[1.75]*	[0.86]	[1.09]	[1.14]	[1.89]*	[1.75]*	[1.23]
ROC Inter (p)	0.001	0.002	0.008	0.005	0.006	0.031	0.031	0.026	0.038	0.016
Controlling for Change in Credit/GDP, Inflation, GDPpc Growth and Change in GFCF/GDP (MA)										
$\hat{\beta}^{MG}$	4.02	1.832	0.235	3.12	4.513	-0.16	0.281	-1.051	-1.004	-0.717
	[0.80]	[0.39]	[0.04]	[0.57]	[0.94]	[0.08]	[0.14]	[0.45]	[0.34]	[0.27]
ROC Comp (p)	0.062	0.061	0.064	0.021	0.010	0.028	0.037	0.023	0.016	0.020
$\hat{\beta}^{A}$	-9.912	-2.821	-1.562	-1.773	5.071	-2.207	-2.349	-2.403	-2.433	-0.761
	[0.86]	[0.79]	[0.89]	[0.85]	[0.62]	[0.74]	[0.51]	[0.47]	[0.49]	[0.83]
$\hat{\beta}^{B}$	15.274	6.173	3.384	9.824	-1.380	0.739	1.354	3.075	1.310	2.453
	[0.97]	[0.45]	[0.81]	[0.48]	[0.92]	[0.90]	[0.83]	[0.57]	[0.81]	[0.70]
ROC Comp (p)	0.005	0.008	0.005	0.002	0.003	0.035	0.039	0.034	0.018	0.032
ROC Inter (p)	0.483	0.102	0.187	0.054	0.143	0.070	0.077	0.152	0.144	0.204

(Continued Overleaf)

Table 1: Too Much Finance and Banking Crises (continued)

Higher Cutoff	**Group I** **92% Credit/GDP (90th percentile)**					**Group II** **119% Credit/GDP (95th percentile)**				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control Above	0%	20%	26%	34%	47%	0%	20%	26%	34%	47%
Percentile	0th	40th	50th	60th	70th	0th	40th	50th	60th	70th
Panel C: Square of gross capital flows/GDP (Excessive Capital Flows II)										
Without additional controls										
$\hat{\beta}^{MG}$	1.597	2.145	2.534	3.067	2.671	0.636	0.810	0.745	0.726	0.718
	[1.71]*	[2.13]**	[2.93]***	[3.01]***	[3.03]***	[2.46]**	[2.52]**	[2.60]***	[2.49]**	[2.53]**
$\hat{\beta}^{A}$	2.011	1.872	1.912	2.721	2.884	0.309	0.468	0.831	0.771	0.726
	[1.29]	[1.33]	[1.23]	[1.38]	[1.34]	[0.89]	[1.34]	[1.73]*	[1.72]*	[1.55]
$\hat{\beta}^{B}$	-1.233	-1.352	-0.753	-0.720	-1.639	-0.690	-0.555	-0.687	-0.702	-0.936
	[0.54]	[0.65]	[0.39]	[0.35]	[0.70]	[1.20]	[0.76]	[0.83]	[0.85]	[1.25]
ROC Inter (p)	0.078	0.081	0.087	0.065	0.050	0.102	0.161	0.081	0.092	0.046
Controlling for Change in Credit/GDP, Inflation, GDPpc Growth and Change in GFCF/GDP (MA)										
$\hat{\beta}^{MG}$	5.313	4.758	5.737	5.816	5.760	0.930	1.135	1.360	1.035	0.806
	[3.31]***	[2.79]***	[2.87]***	[2.98]***	[2.90]***	[1.55]	[1.61]	[1.73]*	[1.60]	[1.21]
ROC Comp (p)	0.088	0.049	0.062	0.138	0.176	0.441	0.592	0.144	0.172	0.077
$\hat{\beta}^{A}$	4.621	4.691	4.845	4.489	4.115	0.915	0.902	1.071	1.617	1.622
	[2.06]**	[2.27]**	[1.77]*	[1.72]*	[1.63]	[0.91]	[0.89]	[0.86]	[1.42]	[1.43]
$\hat{\beta}^{B}$	-2.708	-3.767	-1.015	-1.878	-1.923	-0.018	-0.034	0.122	0.315	-0.523
	[0.80]	[1.06]	[0.35]	[0.59]	[0.57]	[0.02]	[0.04]	[0.15]	[0.34]	[0.56]
ROC Comp (p)	0.031	0.009	0.030	0.040	0.073	0.034	0.040	0.025	0.020	0.024
ROC Inter (p)	0.292	0.238	0.349	0.301	0.241	0.152	0.139	0.200	0.146	0.177
Treated Sample										
Countries	30	30	30	30	30	23	23	23	23	23
Observations	987	987	987	987	987	767	767	767	767	767
Crisis Prop.	0.048	0.048	0.048	0.048	0.048	0.050	0.050	0.050	0.050	0.050
Crises<cutoff	29	29	29	29	29	25	25	25	25	25
Crises>cutoff	18	18	18	18	18	13	13	13	13	13
Control Sample										
Countries	52	48	44	38	28	61	57	53	47	37
Observations	1518	1409	1289	1104	778	1807	1698	1578	1393	1067
Crises Prop.	0.055	0.056	0.056	0.055	0.059	0.053	0.054	0.054	0.053	0.055

Notes: We present robust means for country estimates (marginal effect of a one standard deviation in the variable, in percent) of MA(3)-transformed Δcredit/GDP or ΔCap Flows/GDP or (Cap Flows/GDP)^2 in the 'treated' sample of countries, where treatment is defined by having crossed a threshold of 92% or 119% of credit/GDP, following our model in equation (5). We present marginal effects for a lower regime, $\hat{\beta}^A$, and their *deviation* for a higher regime, $\hat{\beta}^B$. $\hat{\beta}^{MG}$ is the marginal effect when we ignore regimes; absolute t-ratios are reported in square brackets. Across columns we vary the control sample by setting a lower cutoff: countries below this cutoff are dropped from the control group. The full sample is labelled as 0th percentile. These results include four common factors estimated from the control samples, results for 1-6 factors are available on request. We confirm that the factor-augmented model has better predictive power than that without factors using comparison of AUROC statistics (not reported). 'ROC Comp (p)' reports p-values for equivalent tests for the exclusion of the variable of interest and 'ROC Inter (p)' for equivalent test for the exclusion of the interaction effect. 'Crisis Prop' is the unconditional propensity of a banking crisis in the sample indicated. The median number of years countries spend in the 'lower' and 'higher' regime is 19 and 14 in Group I and 24 and 9 in Group II.

crises when economies have very high levels of financial development.

Turning to the analysis of capital inflows, the change in capital flows/GDP measure in Panel (B) typically reveals patterns whereby the effect in the lower regime is negative while that in the higher regime is positive and often of substantially greater magnitude — however, none of these results are anywhere near statistical significance in the specifications which include additional controls. For the models using squared capital flows/GDP levels in Panel (C) the Group I results for specifications with all controls follow the same pattern as those discussed above for credit booms: below the threshold the effect is around 4.5% and almost always statistically significant, whereas the above-threshold results indicate a negative, i.e. lower, effect although this deviation is never statistically significant. In Group II we have mixed patterns though at times identical to those just described, with none of the estimates statistically significant. Our attempts at capturing excessive capital inflows have yielded no evidence that very high levels of financial development make countries more susceptible to banking crises through this channel.

For both crisis narratives investigated, the absence of evidence is of course not evidence for the absence of an effect, but the overall pattern of results — positive and significant effects when ignoring regimes, positive and at times significant effects for the benchmark *lower* regime alongside frequently negative albeit insignificant coefficients for the *higher* regime — suggests our finding is consistent across a great many specifications: having previously established that 'too much finance' on average does not affect relative long-run economic development, we can now conclude that on average it also does not *systematically* raise the propensity of financial crises vis-à-vis more moderate levels. It bears reminding that we carried out this EWS analysis in a factor-augmented regression framework (Boneva & Linton 2017, Chan & Kwok 2022), conditioning on the unobservables driving banking sector vulnerability in very similar economies, and comparing the effects *within* individual highly financially developed countries below and above the threshold.

4.3 Exposing Developing Countries to Financial Vulnerability?

In this section we investigate 'too much finance' for countries which exceeded the 34% or 47% credit/GDP. These samples are made up of 27 and 30 countries. The treated countries experienced 47 and 50 banking crises, respectively, of which one third occurred in the higher regimes. The unconditional crisis propensity is around 6%, compared with 4.9-5.5% in the control samples.

Our analysis follows the same approach as that for the finance-growth nexus in Section 3.3, limiting control samples 'from below' and treatment samples to specific ranges. Given that middle-income economies have rarely been studied on their own we adopt all three dominant banking crisis determinants found in existing studies of advanced and low-income economies. We again begin by estimating the effect of the canonical crisis predictors for the full sample of 'treated' countries, ignoring 'higher' and 'lower' regimes. In Panels (A) to (C) of Table 2 these are the estimates marked $\hat{\beta}^{MG}$. While credit growth on its own yields positive but not consistently significant results, once we include the controls we find a strong effect across all samples: a one standard deviation increase in credit/GDP growth is associated with a 3.1-4.4% increase in the propensity of a banking crisis. These are substantial economic magnitudes, given an unconditional crisis propensity of 6%. For the change in capital inflows/GDP in Panel (B) the simple specification yields statistically significant results in only two of the models, in the results with additional controls the coefficient magnitude drops substantially and none are statistically significant. The findings for excessive capital inflows are hence somewhat mixed for this group of countries.[35]

The results for commodity price (ACP) growth and volatility (Panel C) in the simple models are weak and counter-intuitive: since improving commodity terms of trade should improve an economy's external balance while increased volatility should weaken it, the pattern of signs is the opposite to what we would expect. This result is rectified in the models including additional controls, where the volatility terms now have large positive coefficients, which are statistically significant in a number of specifications. Hence, ignoring financial thresholds, our analysis confirms the 'credit booms gone bust' and commodity price movement narratives, but finds only limited evidence for the relevance of excessive capital flows in these samples.

Our second step repeats this analysis adding interaction terms with a 'higher regime' dummy for the credit, capital flow or ACP variables. For credit growth in Panel (A), while the simple model yields some evidence that this mechanism has a stronger effect for countries above the threshold, results for models with additional controls are mixed and very imprecise. This undermines the notion that 'credit boom gone bust' cycles could be more prevalent in 'too much finance' regimes.

The capital inflow results in Panel (B), especially for the 34% threshold, present a different outcome with, broadly, agreement between the simple specifications and those with additional controls: we see a consistent pattern of high and in one case statistically significant results for the

[35]This highlights that the sample in Caballero (2016) was dominated by high-income countries (fewer than 18% of observations for middle-income countries). If we adopt the squared capital flow/GDP measure this yields insignificant results, whether we distinguish 'low' versus 'high' regimes or not (results available on request).

Table 2: 'Too Much Finance' and Banking Crises in Developing Countries (LDCs)

Treatment Range	**34-65% Credit/GDP** (60th-80th percentile)			**47-92% Credit/GDP** (70th-90th percentile)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Control: Above	0%	16%	20%	0%	16%	20%	26%
Percentile	0th	30th	40th	0th	30th	40th	50th
Panel A: Change in Credit/GDP (Credit Booms Gone Bust)							
Without controls							
$\hat{\beta}^{MG}$	1.683	1.635	2.032	1.933	2.211	1.312	1.081
	[1.17]	[1.21]	[1.27]	[1.25]	[1.31]	[0.83]	[0.84]
$\hat{\beta}^{A}$	-1.291	-2.190	-1.423	-0.621	-0.252	-1.782	-1.252
	[0.50]	[0.90]	[0.53]	[0.46]	[0.15]	[1.06]	[0.95]
$\hat{\beta}^{B}$	5.332	4.563	4.232	6.860	5.579	6.166	4.965
	[1.54]	[1.34]	[1.26]	[1.90]	[1.64]	[1.57]	[1.44]
ROC Inter (p)	0.010	0.006	0.008	0.027	0.012	0.010	0.120
Controls: Change in Capital Inflows/GDP, Inflation, Openness and ACP movements							
$\hat{\beta}^{MG}$	4.400	3.344	3.881	3.429	3.099	3.654	3.773
	[3.45]***	[2.27]**	[2.52]**	[2.19]**			
ROC Comp (p)	0.028	0.026	0.031	0.086	0.051	0.057	0.060
$\hat{\beta}^{A}$	2.964	2.589	3.508	2.712	0.844	2.796	2.537
	[1.02]	[0.90]	[1.31]	[1.19]	[0.42]	[1.20]	[1.23]
$\hat{\beta}^{B}$	5.282	4.620	3.838	0.508	1.409	1.932	2.058
	[1.01]	[0.94]	[0.77]	[0.13]	[0.39]	[0.50]	[0.52]
ROC Comp (p)	0.017	0.028	0.029	0.045	0.094	0.058	0.078
ROC Inter (p)	0.012	0.008	0.010	0.030	0.011	0.015	0.025
Panel B: Change in capital flows/GDP (Excessive Capital Flows)							
Without controls							
$\hat{\beta}^{MG}$	1.043	0.984	0.689	6.080	5.198	5.948	1.358
	[0.90]	[0.82]	[0.51]	[1.77]*	[1.61]	[1.90]*	[0.67]
$\hat{\beta}^{A}$	1.200	1.204	1.089	1.308	1.864	1.704	2.687
	[1.10]	[1.04]	[1.09]	[0.36]	[0.55]	[0.55]	[0.79]
$\hat{\beta}^{B}$	6.882	6.427	4.234	17.677	18.636	13.765	11.327
	[2.03]**	[1.72]*	[1.21]	[1.39]	[1.43]	[1.07]	[1.11]
ROC Inter (p)	0.053	0.109	0.073	0.001	0.004	0.002	0.004
Controls: Change in Credit/GDP, Inflation, Openness and ACP movements							
$\hat{\beta}^{MG}$	0.192	-0.115	0.124	1.723	3.284	1.455	0.670
	[0.12]	[0.06]	[0.07]	[0.48]	[0.87]	[0.41]	[0.19]
ROC Comp (p)	0.197	0.264	0.076	0.148	0.033	0.062	0.138
$\hat{\beta}^{A}$	-1.230	-1.114	-0.278	3.076	3.398	4.407	3.449
	[0.52]	[0.50]	[0.13]	[0.80]	[0.85]	[0.93]	[0.95]
$\hat{\beta}^{B}$	10.841	7.502	9.452	9.685	8.286	6.972	11.857
	[1.90]*	[1.16]	[1.28]	[1.08]	[0.80]	[0.64]	[1.18]
ROC Comp (p)	0.035	0.111	0.018	0.099	0.131	0.076	0.078
ROC Inter (p)	0.015	0.031	0.006	0.048	0.012	0.023	0.029

(Continued Overleaf)

Table 2: 'Too Much Finance' and Banking Crises in LDCs (continued)

Treatment Range	**34-65% Credit/GDP** (60th-80th percentile)			**47-92% Credit/GDP** (70th-90th percentile)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Control: Above	0%	16%	20%	0%	16%	20%	26%
Percentile	0th	30th	40th	0th	30th	40th	50th
Panel C: Aggregate Commodity Price (ACP) Growth and Volatility							
Without additional controls							
ΔACP $\hat{\beta}^{MG}$	2.397	2.168	1.695	0.888	-0.091	2.057	0.168
	[1.31]	[1.14]	[0.94]	[0.41]	[0.04]	[0.94]	[0.07]
ACP Vol $\hat{\beta}^{MG}$	-2.675	-1.556	-4.264	-8.646	-12.273	-14.614	-9.545
	[0.71]	[0.52]	[2.07]**	[0.84]	[1.09]	[1.40]	[1.19]
ΔACP $\hat{\beta}^{A}$	2.904	2.928	3.035	2.686	3.824	2.201	2.331
	[1.77]*	[1.57]	[1.75]	[1.11]	[1.29]	[0.84]	[0.91]
ACP Vol $\hat{\beta}^{A}$	-1.128	-1.762	-2.723	4.227	8.226	0.551	2.919
	[0.19]	[0.32]	[0.58]	[0.43]	[1.60]	[0.06]	[0.54]
ΔACP $\hat{\beta}^{B}$	-6.144	-6.732	-6.317	-6.162	-5.656	-8.971	-9.728
	[1.54]	[1.86]*	[1.56]	[1.15]	[1.15]	[1.61]	[1.83]*
ACP Vol $\hat{\beta}^{B}$	-0.370	-1.029	-0.513	-5.040	-1.044	-3.051	-4.081
	[0.19]	[0.41]	[0.20]	[0.91]	[0.22]	[0.63]	[0.76]
ROC Inter (p)	0.000	0.001	0.000	0.001	0.000	0.002	0.004
Controls: Change in Capital Inflows/GDP, Inflation, Openness and Credit/GDP Growth							
ΔACP $\hat{\beta}^{MG}$	0.664	-0.189	0.933	1.649	2.066	1.363	1.682
	[0.31]	[0.09]	[0.44]	[0.66]	[0.16]	[0.57]	[0.34]
ACP Vol $\hat{\beta}^{MG}$	15.931	4.475	7.190	24.510	23.763	25.729	14.621
	[2.23]**	[0.82]	[1.02]	[1.83]*	[2.05]**	[1.50]	[1.17]
ROC Comp (p)	0.000	0.000	0.001	0.000	0.002	0.000	0.000
ΔACP $\hat{\beta}^{A}$	1.244	0.434	1.186	-0.412	-3.048	-0.032	-3.169
	[0.53]	[0.23]	[0.54]	[0.15]	[1.27]	[0.01]	[1.19]
ACP Vol $\hat{\beta}^{A}$	18.111	6.303	-0.225	25.984	27.541	27.002	18.722
	[1.54]	[0.71]	[0.02]	[1.59]	[2.37]**	[2.53]**	[2.00]**
ΔACP $\hat{\beta}^{B}$	-2.762	-7.282	-4.718	-4.895	-7.197	-9.922	-9.123
	[0.47]	[1.28]	[0.78]	[0.92]	[1.16]	[1.49]	[1.74]*
ACP Vol $\hat{\beta}^{B}$	6.836	3.876	5.761	1.350	2.468	0.142	-2.245
	[1.42]	[0.86]	[0.99]	[0.21]	[0.54]	[0.02]	[0.43]
ROC Comp (p)	0.003	0.001	0.000	0.001	0.001	0.000	0.000
ROC Inter (p)	0.093	0.037	0.020	0.048	0.053	0.034	0.063
Treated Crisis Prop.	0.058	0.058	0.058	0.060	0.060	0.060	0.060
Treated Crises<cutoff	31	31	31	34	34	34	34
Treated Crises>cutoff	16	16	16	16	16	16	16
Control Countries	24	19	16	34	29	26	20
Control Observations	710	599	492	1018	907	800	631
Control Crisis Prop.	0.051	0.052	0.055	0.051	0.052	0.054	0.049

Notes: We present robust means for country estimates (marginal effect of a 1sd increase in the variable, expressed in percent) of MA(3)-transformed Δcredit/GDP or ΔCap Flows/GDP or Aggregate Commodity Price Movements in the 'treated' sample of countries (N=27, n=810; N=30, n=839, respectively), where treatment is defined by having crossed a threshold of 34% or 47% of credit/GDP (but staying below 65% and 92%, respectively). Absolute t-ratios are reported in square brackets See also notes to Table 1.

periods above the cutoff, while the estimates for the lower regime are all negative, of small magnitude and statistically insignificant. While all estimates using the 47% threshold are insignificant, those for the higher regime are typically a multiple of those for the lower regime. Overall, the evidence, although weak, is suggestive of a systemic effect of capital inflows affecting countries *more* at high levels of finance.

Finally, the results for commodity prices in Panel (C) provide some evidence that this channel has a systematic bearing on banking crises: once controls are included the 47% threshold indicates strong volatility effects below the threshold but also, though just in one specification, evidence for ACP growth effects above the threshold. Although less robust, these results are in line with the findings for low-income countries (Eberhardt & Presbitero 2021).[36]

Taken together, our benchmark analysis confirms general narratives in the literature of credit boom cycles and ACP movements in their relevance for vulnerability to banking crises. Once we account for different financial development regimes we found some indicative evidence that capital inflows and commodity price movements affect financial vulnerability in the higher regime.

5 Concluding remarks

Until quite recently, there was little doubt in the literature about the economic benefits from financial development. The experience of the Global Financial Crisis then led to the suggestion that while financial development was generally good for growth, economies could experience 'too much of a good thing', and the work by Arcand et al. (2015) and others established the presence of such a 'non-linearity' in the finance-growth relationship. Our paper challenges this conclusion by analysing this relationship with (i) more flexible empirical specifications embedded in a causal treatment effects framework, (ii) a focus on country-specific effects, treatment length and the long-run equilibrium, and (iii) a methodological extension to study the impact of finance on the dominant banking crisis determinants in a factor-augmented EWS approach which focuses on the short-run and crisis 'triggers'.

Our analysis provides the following new insights into the implications of 'too much finance': there is no evidence that highly financially developed countries experience lower economic growth or

[36] All models presented in Table 2 indicate that the inclusion of the specific variable(s) of interest significantly add(s) to the predictive power of the model (ROC Comp p-values). The interaction terms for most samples of the 34% and 47% thresholds statistically significantly increase predictive power over the models not distinguishing financial development regimes (ROC Inter p-values). All models have better predictive power when factors are included (not presented).

are more susceptible to systemic banking crises above a certain threshold. In a moderate sample of advanced and emerging economies we are similarly unable to trace any detrimental growth effects when distinguishing whether financial development is driven by credit to households or to firms. Studying countries at intermediate levels of financial development we find that income per capita actually tends to *rise* with time spent in the 'high(er)' regime. Elevated levels of finance in this group of countries are however suggested to increase the risk of banking crises due to capital inflows and/or commodity price movements *in the short-run*. The empirical evidence is statistically weak, but the patterns are clearly more suggestive of a detrimental effect than in the advanced country sample. While some may disagree with this interpretation, it bears reminding that the *long-run* growth results suggest that however (in)substantial the increased vulnerability to banking crises in developing countries may be, these *short-run* implications of financial development do not hamper growth in the long-term. Hence, what remains of the 'too much finance' narrative? We would argue that for advanced and emerging economies on average there simply is no clear evidence for a large detrimental effect.

There are at least three important caveats for our analysis: first, we recognise that our proxy for financial deepening may not be *equally-suitable* at different points of the credit/GDP distribution (Popov 2018). We share this caveat with most of the empirical literature on the finance-growth nexus. However, if credit/GDP 'means different things' in different countries, then our heterogeneous model should go some way to weaken the bias relative to the pooled models studied in the existing literature.

Second, by moving away from pooled models with thousands of observations, our heterogeneous treatment effect analysis is *by construction* built on vastly fewer degrees of freedom. With this come imprecision, exaggerated idiosyncracies, and hence more uncertainty in the estimates we present. We have deliberately discussed and interpreted our results in broad brushes, trying to emphasise obvious commonalities across alternative specifications. We believe that the caution we employ in discussing our results and in drawing conclusions is reflected in the language we use, and that the patterns we detect stand out even to a more critical eye.

And third, although we have not ignored recent developments in unpacking private credit into more granular components (e.g. Beck et al. 2009, Mian et al. 2017, Müller & Verner 2021), our analysis of 'too much household credit' and 'too much corporate credit' could only rely on very modest 'treated' samples and did not unpack corporate credit into its sectoral components.

Future work could build on the data collection effort by Müller & Verner (2021) to arrive at robust results in the analysis of a significantly larger sample.

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Online Appendix

A Data: Sample Makeup and Descriptives

Table A-1: Sample Makeup

	ISO	Country	Start	End	Obs	Miss	GDP pc (2008 US$)			Private Credit/GDP					'Adv. Countries'				'Developing Countries'			
							Start	End	Δpa	Start	End	Δpa	Min	Max	92	C	119	C	34-47	34-65	47-65	47-92
1	AGO	Angola	2000	2016	17	0	2196	3530	78.5	1	22	1.25	1	25								
2	ALB	Albania	1994	2016	23	0	1494	4682	138.6	3	36	1.44	3	40					8	8		
3	ARE	UAE	2001	2016	16	0	60861	41045	-1238.5	33	83	3.16	33	84		×		×				11
4	ARG	Argentina	1960	2016	57	0	5643	10240	80.6	18	12	-0.10	8	25								
5	ARM	Armenia	1992	2016	25	0	948	3917	118.8	40	45	0.16	3	45					6			
6	AUS	Australia	1960	2016	57	0	19378	55729	637.7	18	142	2.18	17	142	13		9					
7	AUT	Austria	1970	2016	45	2	19574	48260	610.3	42	83	0.88	42	98	9							
8	AZE	Azerbaijan	1992	2016	25	0	2361	5813	138.1	4	31	1.09	1	36					1	1		
9	BDI	Burundi	1964	2016	53	0	205	220	0.3	3	17	0.27	2	22								
10	BEL	Belgium	1970	2016	45	2	19808	45943	556.1	17	62	0.97	17	77		×		×				23
11	BEN	Benin	1982	2016	35	0	864	1135	7.7	28	21	-0.20	6	31								
12	BFA	Burkina Faso	1979	2016	38	0	356	748	10.3	14	27	0.32	6	28								
13	BGD	Bangladesh	1980	2016	30	7	359	1062	19.0	4	39	0.95	4	39					6	6		
14	BGR	Bulgaria	1991	2016	26	0	4360	8009	140.4	61	52	-0.33	8	69		×		×				14
15	BHR	Bahrain	1980	2015	33	3	21185	22436	34.7	34	105	1.95	26	114	7			×				
16	BHS	Bahamas,	1977	2016	39	1	18600	27370	219.3	28	72	1.08	24	84		×		×				20
17	BIH	Bosnia & H	1997	2016	20	0	2267	5595	166.4	60	52	-0.41	27	60		×		×		17	12	12
18	BLR	Belarus	1994	2016	23	0	2252	6216	172.3	18	27	0.39	4	35					1	1		
19	BLZ	Belize	1980	2016	36	1	2269	4217	52.6	27	58	0.83	27	65		×		×	15	32	17	18
20	BOL	Bolivia	1970	2016	47	0	1400	2426	21.8	8	61	1.12	6	63		×		×		23	9	9
21	BRA	Brazil	1970	2016	47	0	4704	10966	133.2	20	68	1.01	10	70		×		×				8
22	BRB	Barbados	1975	2009	35	0	10881	16492	160.3	28	78	1.42	26	78		×		×				9
23	BRN	Brunei D.	1999	2016	18	0	35681	31685	-222.0	54	45	-0.50	28	54		×		×		11	3	3
24	BTN	Bhutan	1983	2016	34	0	473	2971	73.5	3	57	1.58	3	57		×		×		8	6	6
25	BWA	Botswana	1972	2016	45	0	1114	7797	148.5	9	30	0.47	6	33								
26	CAF	Central Af R	1977	2015	39	0	643	347	-7.6	10	13	0.08	4	16								
27	CAN	Canada	1970	2008	39	0	22844	48495	657.7	32	123	2.33	32	177	11		8					
28	CHE	Switzerland	1970	2016	47	0	49581	77026	583.9	103	172	1.48	86	172	45		32					
29	CHL	Chile	1960	2016	57	0	3612	14777	195.9	23	109	1.49	3	109	8			×				
30	CHN	China	1985	2016	32	0	538	6908	199.1	65	149	2.63	65	149	19		5					
31	CIV	Cote d'Ivoire	1965	2016	52	0	1475	1530	1.1	18	22	0.07	13	42					14	14		
32	CMR	Cameroon	1975	2016	42	0	1123	1469	8.2	15	16	0.03	7	25								
33	COD	Congo, DR	2000	2016	17	0	290	407	6.9	0	6	0.32	0	6								
34	COG	Congo, R	1974	2015	36	6	2040	3013	23.1	12	21	0.21	2	29								
35	COL	Colombia	1960	2016	55	2	2339	7634	92.9	20	46	0.46	12	50		×		×		8	3	3
36	COM	Comoros	1982	2016	35	0	1460	1367	-2.7	10	26	0.47	8	26								
37	CRI	Costa Rica	1960	2016	57	0	2911	9510	115.8	26	56	0.53	10	56		×		×		10	4	4
38	CYP	Cyprus	1975	2015	41	0	7360	27898	500.9	79	248	4.12	54	261	22		15					
39	CZE	Czech R	1993	2016	24	0	12313	21864	397.9	59	50	-0.40	27	62		×		×		20	14	14
40	DEU	Germany	1970	2016	47	0	19680	45960	559.2	57	76	0.41	57	116	17			×				
41	DNK	Denmark	1966	2016	51	0	26032	61878	702.9	27	169	2.78	21	212	16		16					
42	DOM	Dominican R	1960	2016	57	0	1324	7026	100.0	5	26	0.36	5	30								
43	DZA	Algeria	1973	2016	44	0	2925	4830	43.3	35	22	-0.28	4	68		×		×				13
44	ECU	Ecuador	1960	2016	57	0	2238	5176	51.5	20	29	0.16	11	34					2	2		
45	EGY	Egypt	1960	2016	57	0	578	2761	38.3	18	28	0.18	10	51		×		×	7	13	6	6
46	ERI	Eritrea	1995	2011	17	0	568	537	-1.8	15	13	-0.14	13	35					1	1		
47	ESP	Spain	1972	2016	45	0	15010	31449	365.3	65	112	1.03	61	173	16		11					
48	EST	Estonia	1993	2016	24	0	6743	18092	472.9	9	70	2.51	9	103	2			×				
49	FIN	Finland	1970	2016	47	0	18267	46750	606.0	37	93	1.19	37	93	4			×				
50	FRA	France	1960	2016	55	2	12744	42140	515.7	20	95	1.32	20	96	8			×				

(Continued overleaf)

Table A-1: Sample Makeup (continued)

	ISO	Country	Start	End	Obs	Miss	GDP pc (2008 US$)			Private Credit/GDP					'Adv. Countries'				'Developing Countries'			
							Start	End	∆pa	Start	End	∆pa	Min	Max	92	C	119	C	34-47	34-65	47-65	47-92
51	GAB	Gabon	1970	2016	47	0	7206	9429	47.3	5	14	0.19	5	28								
52	GBR	UK	1970	2016	47	0	17923	42500	522.9	19	130	2.38	19	196	28		15					
53	GEO	Georgia	1995	2016	22	0	1077	4305	146.7	5	56	2.33	3	56		×		×		5	2	2
54	GHA	Ghana	1967	2016	43	7	991	1645	13.1	8	18	0.20	1	18								
55	GIN	Guinea	1989	2016	28	0	535	810	9.8	3	10	0.25	2	10								
56	GMB	The Gambia	1981	2014	34	0	874	748	-3.7	15	13	-0.04	6	17								
57	GNB	Guinea-B.	1990	2016	27	0	637	595	-1.5	2	8	0.23	1	13								
58	GRC	Greece	1960	2016	57	0	6260	22666	287.8	10	110	1.75	10	121	7		3					
59	GTM	Guatemala	1960	2016	57	0	1491	3243	30.7	10	33	0.41	10	33								
60	GUY	Guyana	1960	2016	57	0	1699	3793	36.8	11	45	0.60	9	48		×		×		14	1	1
61	HKG	Hong Kong	1990	2016	27	0	18251	36819	687.7	153	202	1.79	124	219	27		27					
62	HND	Honduras	1960	2016	57	0	1096	2111	17.8	10	54	0.78	10	54		×		×		16	8	8
63	HRV	Croatia	1995	2016	22	0	8568	14706	279.0	24	61	1.70	24	71		×		×				12
64	HUN	Hungary	1991	2016	26	0	8858	15114	240.6	41	34	-0.25	20	66		×		×				8
65	IDN	Indonesia	1980	2016	37	0	1231	3968	74.0	6	38	0.84	6	44					10	10		
66	IND	India	1960	2016	57	0	330	1876	27.1	9	49	0.71	9	50		×		×		12	6	6
67	IRL	Ireland	1970	2016	47	0	12745	67078	1156.0	25	49	0.52	25	174	11		6					
68	IRN	Iran	1961	2016	53	3	3236	6791	63.5	14	61	0.83	14	61		×		×		14	7	7
69	ISL	Iceland	1970	2016	47	0	16240	49985	718.0	30	84	1.14	21	263	13		9					
70	ISR	Israel	1970	2016	47	0	13965	33721	420.3	24	64	0.87	23	90		×		×				26
71	ITA	Italy	1970	2016	47	0	17671	34459	357.2	62	85	0.50	45	96	3							
72	JAM	Jamaica	1966	2016	51	0	3796	4762	18.9	17	30	0.26	14	37					1	1		
73	JOR	Jordan	1976	2016	41	0	2037	3271	30.1	30	71	0.99	30	85		×		×				36
74	JPN	Japan	1970	2016	47	0	18700	47403	610.7	82	160	1.65	82	192	46		35					
75	KAZ	Kazakhstan	1993	2016	24	0	4513	10583	252.9	15	34	0.80	5	49		×		×		7	2	2
76	KEN	Kenya	1964	2016	53	0	545	1130	11.0	13	31	0.35	10	32								
77	KGZ	Kyrgyz Rep	1995	2016	22	0	535	1044	23.1	11	21	0.42	4	21								
78	KHM	Cambodia	1993	2016	24	0	510	1080	23.7	2	74	2.98	2	74		×		×				3
79	KOR	Korea	1960	2016	57	0	932	26726	452.5	11	139	2.23	11	139	6		3					
80	LBN	Lebanon	1990	2016	27	0	3006	6412	126.1	61	97	1.32	36	97	2			×				
81	LBR	Liberia	2000	2013	14	0	614	597	-1.2	113	17	-6.86	14	906	11		10					
82	LKA	Sri Lanka	1961	2016	56	0	586	3769	56.8	7	37	0.53	7	37					1	1		
83	LSO	Lesotho	1973	2016	19	25	432	1422	22.5	0	17	0.38	0	17								
84	LTU	Lithuania	1995	2016	21	1	5318	15944	483.0	14	41	1.25	10	58		×		×		10	4	4
85	LUX	Luxembourg	1970	2016	44	3	35457	110162	1589.5	41	98	1.21	41	108	8			×				
86	LVA	Latvia	1995	2016	21	1	5141	14736	436.1	11	47	1.66	7	95	1			×				
87	MAC	Macao	1984	2016	33	0	18134	52163	1031.2	53	112	1.80	39	112	2			×				
88	MAR	Morocco	1966	2016	51	0	815	3213	47.0	13	63	0.99	9	73		×		×				12
89	MDA	Moldova	1995	2016	22	0	1624	3120	68.0	4	31	1.19	4	39					6	6		
90	MDG	Madagascar	1970	2016	47	0	854	476	-8.0	13	13	-0.01	8	18								
91	MEX	Mexico	1960	2016	57	0	3907	10206	110.5	20	32	0.20	8	32								
92	MKD	N Macedonia	1993	2016	24	0	3146	5247	87.6	36	48	0.48	16	49		×		×		11	2	2
93	MLI	Mali	1967	2016	45	5	341	749	8.2	1	23	0.44	1	23								
94	MLT	Malta	1970	2016	47	0	3746	26788	490.2	43	83	0.86	21	120	16		1					
95	MNE	Montenegro	2002	2016	15	0	5059	7493	162.2	8	47	2.60	8	83		×		×				10
96	MNG	Mongolia	1991	2016	26	0	1584	3866	87.8	11	53	1.61	5	55		×		×		6	4	4
97	MOZ	Mozambique	1992	2016	25	0	200	584	15.4	13	32	0.76	8	32								
98	MRT	Mauritania	1961	2012	39	13	1382	1653	5.2	3	21	0.35	3	30								
99	MUS	Mauritius	1976	2016	41	0	2405	9834	181.2	22	98	1.85	21	103	5			×				
100	MWI	Malawi	1973	2016	44	0	342	506	3.7	6	10	0.10	2	13								
101	MYS	Malaysia	1960	2016	57	0	1354	11244	173.5	8	120	1.97	8	145	23		5					
102	NAM	Namibia	1990	2016	27	0	3501	6143	97.8	19	64	1.69	19	64		×		×		24	5	5
103	NER	Niger	1980	2016	37	0	695	527	-4.6	16	15	-0.02	4	18								
104	NGA	Nigeria	1981	2016	36	0	1742	2456	19.8	14	15	0.02	5	20								
105	NIC	Nicaragua	1960	2016	45	12	1506	1895	6.8	15	36	0.37	3	39					3	3		
106	NLD	Netherlands	1969	2016	46	2	23389	52727	611.2	30	113	1.72	29	125	18		1					
107	NOR	Norway	1970	2016	47	0	32245	90196	1233.0	50	143	1.97	48	143	10		8					
108	NPL	Nepal	1975	2016	42	0	280	730	10.7	4	71	1.59	4	71		×		×				7
109	NZL	New Zealand	1970	2010	41	0	19989	33700	334.4	11	146	3.29	10	146	15		6					
110	OMN	Oman	1972	2016	38	7	9286	16226	154.2	2	73	1.56	2	73		×		×				2

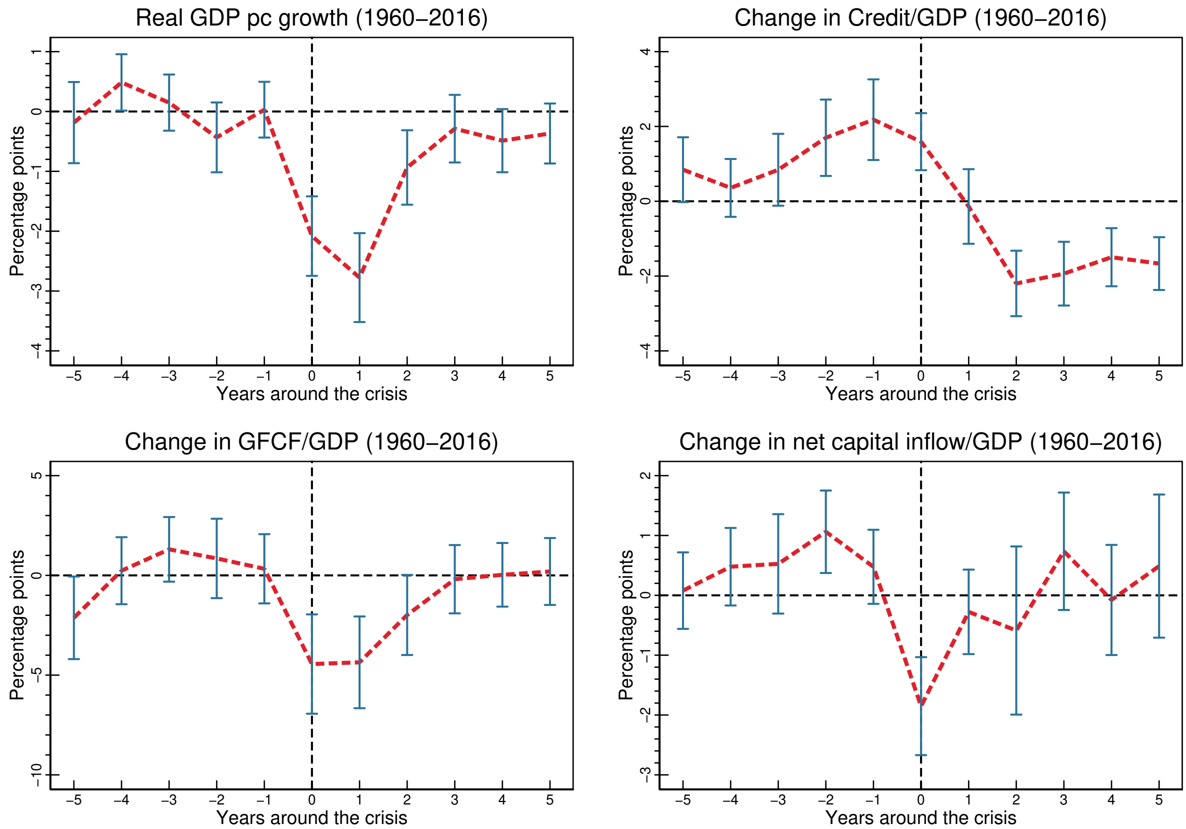
(Continued overleaf)

Table A-1: Sample Makeup (continued)

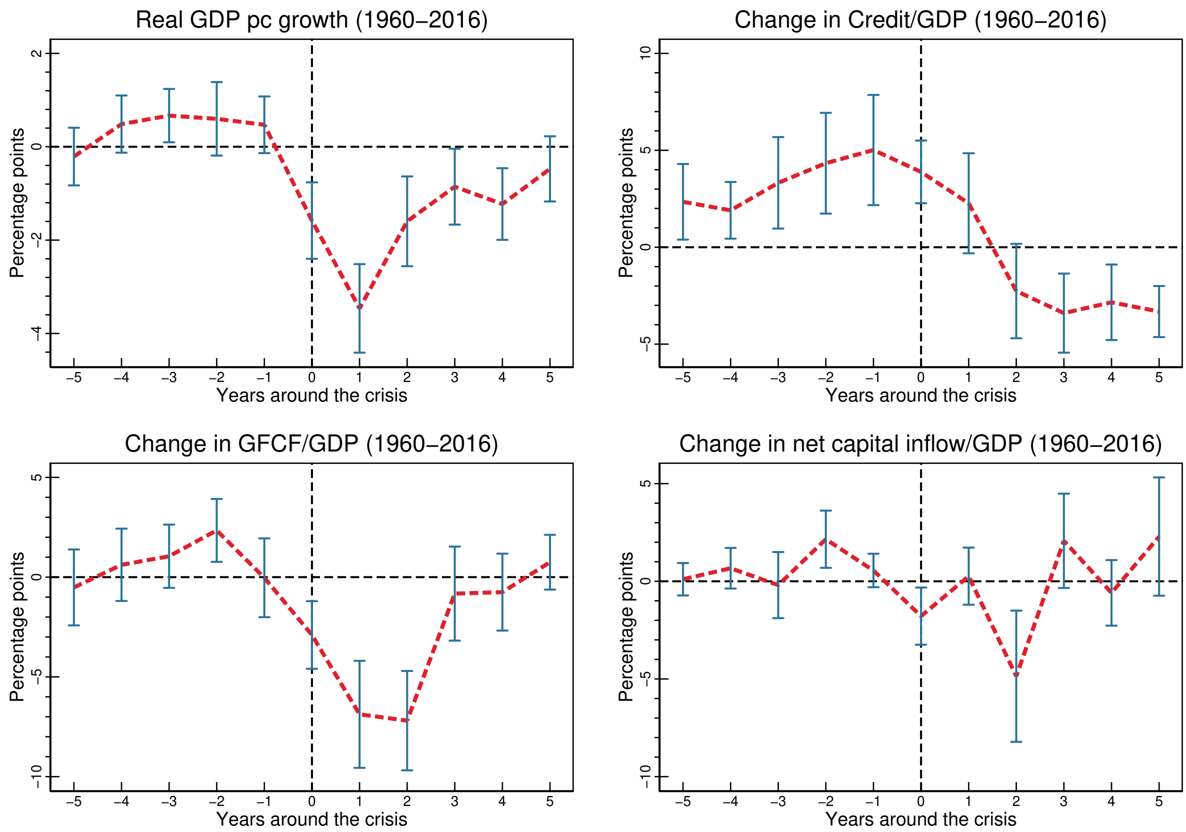
	ISO	Country	Start	End	Obs	Miss	GDP pc (2008 US$)			Private Credit/GDP					'Adv. Countries'				'Developing Countries'			
							Start	End	Δpa	Start	End	Δpa	Min	Max	92	C	119	C	34-47	34-65	47-65	47-92
111	PAK	Pakistan	1960	2016	57	0	302	1118	14.3	9	15	0.12	9	27								
112	PAN	Panama	1960	2016	57	0	2139	11107	157.3	12	81	1.23	11	92		×		×				30
113	PER	Peru	1960	2016	57	0	2660	6262	63.2	16	41	0.44	5	41					4	4		
114	PHL	Philippines	1960	2016	57	0	1100	2887	31.3	15	41	0.46	15	51		×		×	14	16	2	2
115	PNG	Papua NG	1973	2004	32	0	1774	1582	-6.0	11	8	-0.07	7	19								
116	POL	Poland	1995	2016	22	0	6540	15102	389.2	15	53	1.74	15	53		×		×		10	7	7
117	PRT	Portugal	1970	2016	47	0	8760	22534	293.1	46	114	1.45	42	159	18		11					
118	PRY	Paraguay	1962	2016	55	0	1430	5090	66.5	5	54	0.89	5	54		×		×		6	2	2
119	PSE	W Bank/Gaza	1996	2016	21	0	1879	2695	38.8	12	42	1.44	12	42					2	2		
120	ROU	Romania	1990	2016	23	4	5379	10237	179.9	70	34	-1.34	4	70		×		×				1
121	RUS	Russian Fed	1993	2016	24	0	7071	11356	178.6	6	56	2.10	6	56		×		×		9	3	3
122	RWA	Rwanda	1965	2016	51	1	288	793	9.7	0	20	0.37	0	20								
123	SAU	Saudi Arabia	1970	2016	47	0	22134	21271	-18.4	5	69	1.35	4	74		×		×				27
124	SDN	Sudan	1976	2015	40	0	946	1826	22.0	9	8	-0.02	2	15								
125	SEN	Senegal	1965	2016	52	0	1308	1432	2.4	17	32	0.29	13	35					3	3		
126	SGP	Singapore	1963	2016	54	0	4113	55043	943.2	33	132	1.84	33	132	22		4					
127	SLE	Sierra Leone	1980	2016	36	1	485	458	-0.7	4	5	0.02	1	7								
128	SLV	El Salvador	1965	2016	52	0	2358	3383	19.7	19	44	0.49	17	44					23	23		
129	SRB	Serbia	1997	2015	19	0	3504	6155	139.6	21	43	1.16	16	47		×		×	6	8	2	2
130	SVK	Slovak R	1993	2016	24	0	7821	19274	477.2	52	54	0.11	29	54		×		×		20	8	8
131	SVN	Slovenia	1991	2016	26	0	14135	24552	400.6	35	47	0.47	19	85		×		×				12
132	SWE	Sweden	1960	2016	57	0	18050	56789	679.6	40	125	1.49	39	129	22		10					
133	SWZ	Eswatini	1970	2016	47	0	1226	4663	73.1	8	20	0.26	7	21								
134	SYC	Sychelles	1976	2012	35	2	5078	12000	187.1	19	24	0.15	9	30								
135	TCD	Tchad	1982	2015	33	1	418	957	15.8	11	8	-0.06	2	18								
136	TGO	Togo	1980	2016	37	0	733	649	-2.3	27	36	0.25	13	36					1	1		
137	THA	Thailand	1964	2016	53	0	662	5916	99.1	14	145	2.47	14	163	19		11					
138	TJK	Tajikistan	1998	2016	19	0	381	976	31.3	11	19	0.40	10	24								
139	TLS	East Timor	2002	2016	15	0	667	923	17.1	1	8	0.42	1	8								
140	TON	Tonga	1981	2012	32	0	2206	3730	47.6	12	32	0.60	12	52		×		×		15	3	3
141	TUN	Tunisia	1965	2016	48	4	1113	4311	61.5	27	77	0.97	24	77		×		×				28
142	TUR	Turkey	1968	2016	49	0	4120	14063	202.9	17	65	0.97	11	65		×		×		8	5	5
143	TZA	Tanzania	1990	2016	27	0	516	904	14.4	15	14	-0.06	3	16								
144	UGA	Uganda	1982	2016	35	0	401	910	14.5	3	14	0.33	1	14								
145	UKR	Ukraine	1992	2016	25	0	3263	2904	-14.4	1	47	1.84	1	90		×		×				9
146	URY	Uruguay	1970	2016	47	0	5671	14124	179.9	7	29	0.46	6	61		×		×		8	4	4
147	USA	United States	1972	2016	45	0	24650	52556	620.1	89	179	2.00	85	196	33		22					
148	VEN	Venezuela	1960	2014	55	0	12457	14025	28.5	16	30	0.26	7	66		×		×				9
149	VNM	Vietnam	1995	2016	22	0	583	1753	53.1	18	114	4.36	17	114	5							
150	VUT	Vanuatu	1983	2014	32	0	2531	2853	10.1	29	69	1.24	26	69		×		×				6
151	ZAF	South Africa	1961	2016	56	0	4685	7477	49.8	19	143	2.22	18	147	24		14					
152	ZWE	Zimbabwe	1975	2016	39	3	1388	1224	-3.9	9	22	0.32	0	137	1		1					

Notes: We provide details on the 152 countries in the full sample of analysis, including Start and End Year of the country time series, the number of observations (Obs) and hence the number of missing observations (Miss). Real GDP pc is in US$ 2008 values for the first and final year of the country sample, Δpa refers to the average annual change in GDPpc over the country-specific sample period. We provide the same quantities for Credit/GDP, alongside with the minimum and maximum values. The final set of columns indicates a number of 'treated' samples: in the analysis 'Advanced Countries' we provide details on the number of observations in the 'higher' regime for the 92% and 119% cut-offs (the 'treated' relative to the 'untreated' observations in the 'treated countries' make up the first 'difference' of the Diff-in-Diff specification), alongside with the respective control samples ('C'), where we limit the presentation to the controls samples where credit/GDP peaks between 47 and 92% — all observations of a 'control' country enter the control sample (the second 'difference'), marked with ×. In the analysis of 'Developing Countries' we only present the number of observations in the treated sample for the four samples we analyse: 34-47% credit/GDP, 34-65%, 47-65% and 47-92%.

Figure A-1: Event Analysis — Banking Crises



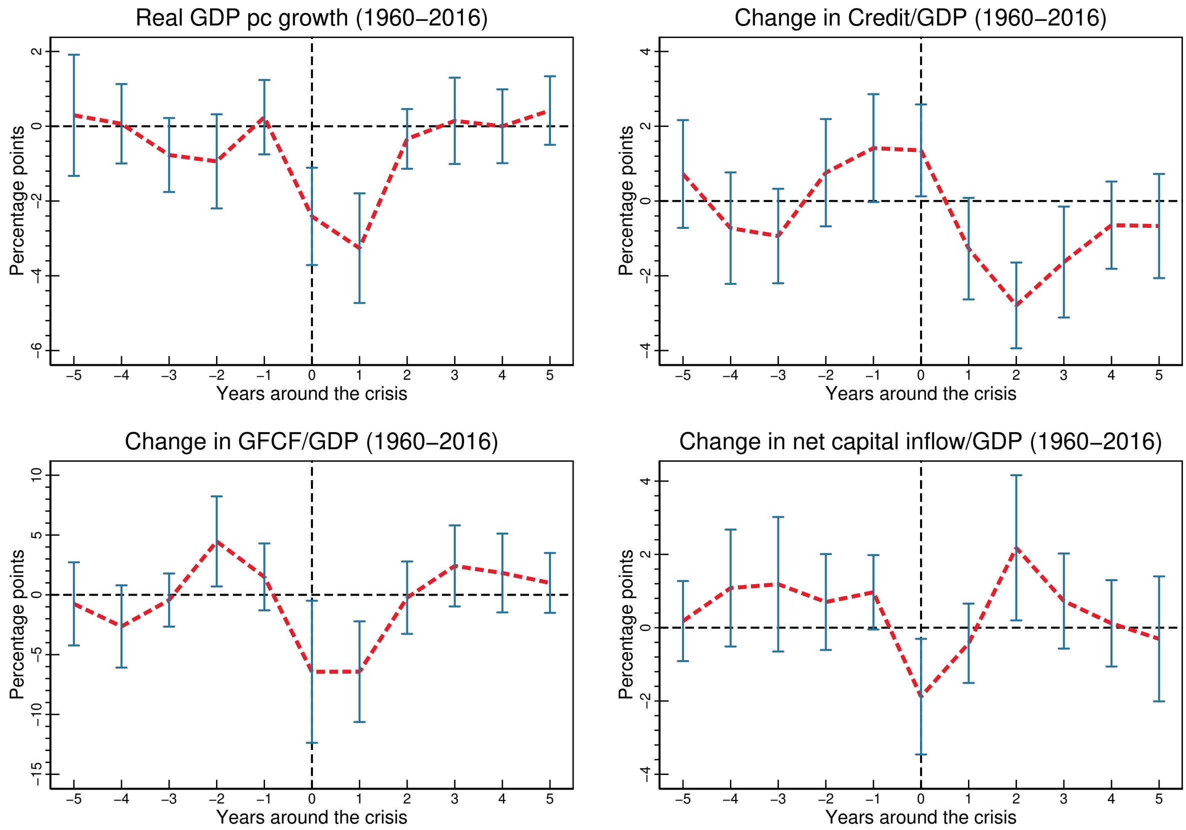
(a) 102 Countries which experienced a banking crisis



(b) 34 Highly financially developed countries (92% credit/GDP)

(continued overleaf)

Figure A-1: Event Analysis — Banking Crises (cont'd)

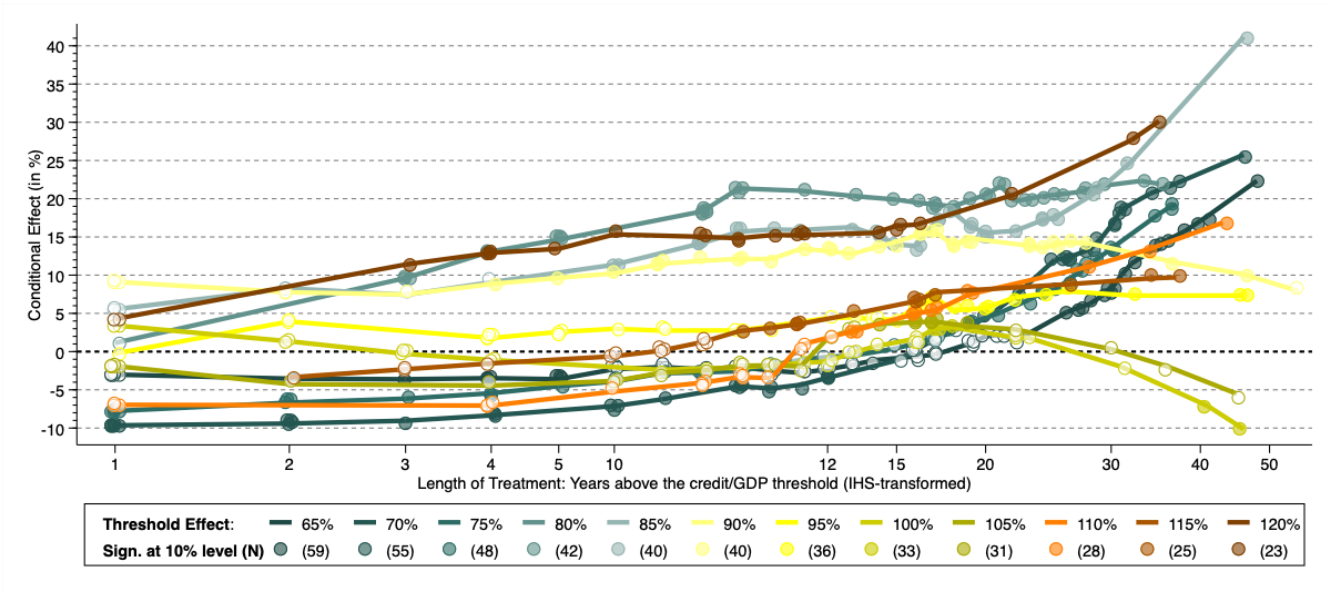


(c) 30 countries at intermediate levels of financial development (47% credit/GDP)

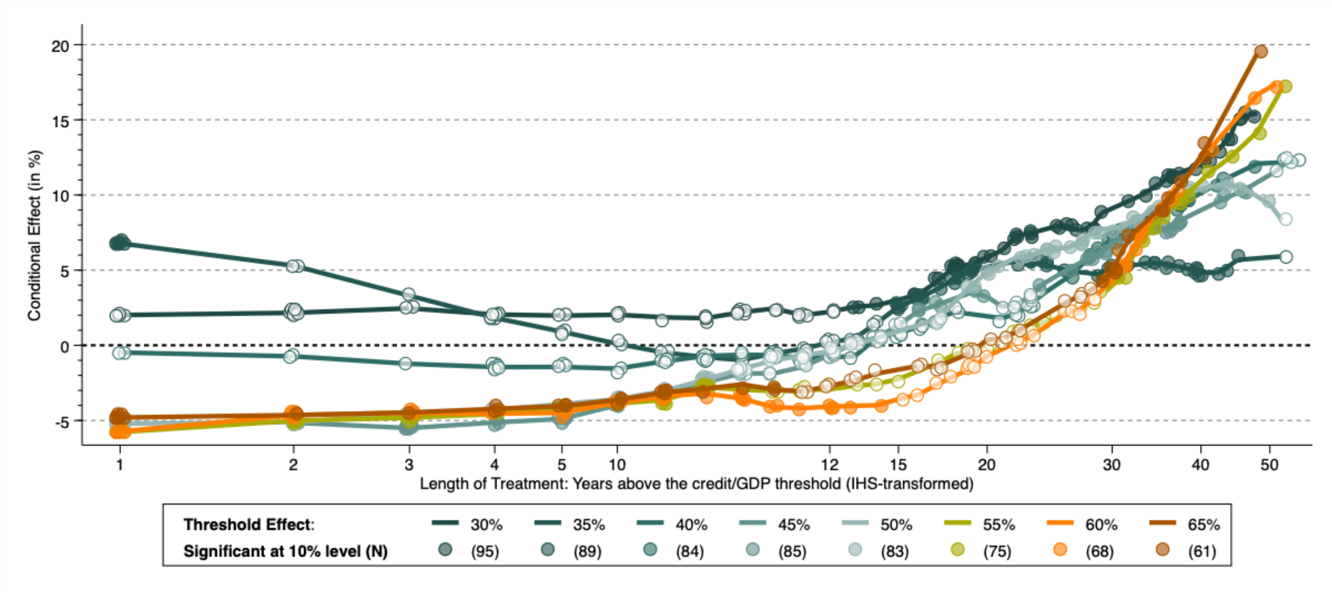
Notes: These plots present the results from event analyses in the eleven years surrounding banking crises, accounting for country fixed effects. The blue bars are the 90% confidence intervals, based on standard errors clustered at the country-level. Panel (a) is for all 102 countries (which experienced a banking crisis), panel (b) for countries which had credit/GDP in excess of 92% at one point in their sample period (dto.), panel (c) is for the 47% 'intermediate level' cut-off. Ongoing crisis years are omitted.

B Robustness Checks and Full Results

Figure B-1: Too much Finance — Alternative Cut-offs



(a) Threshold effects of 65% to 120% credit/GDP



(b) Threshold effects of 30% to 65% credit/GDP

Notes: Panel (a) is for the analysis of financial development at the top end of the distribution, broadly defined ($k =$ 65-120% credit/GDP), where the control sample is made up of all those countries which have reached at least $k-$25% (so as to omit countries with very low financial development). Panel (b) for the analysis of financial development at the intermediate level ($k =$ 35-65% credit/GDP), where the *treated* sample is curtailed to those countries which stayed below $k+$25%. The control sample is all countries which stayed below k. A filled (hollow) marker indicates statistical (in)significance at the 10% level. In the respective plot legend we report the number of countries in the treated sample in parentheses. All models presented include four estimated factors.

Table B-1: Too much Finance? PCDID Threshold regression ATET results (92% and 119% thresholds)

Higher Cutoff	92% Credit/GDP (90th pctile)					119% Credit/GDP (95th pctile)				
Lower cutoff	0	20	26	34	47	0	20	26	34	47
Percentile		40th	50th	60th	70th		40th	50th	60th	70th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Threshold Effect (ATET)	1.690	1.276	0.373	0.883	2.783	0.040	-0.084	-2.172	-2.387	0.496
	[1.514]	[1.592]	[1.754]	[1.906]	[2.005]	[2.031]	[2.064]	[1.692]	[1.872]	[1.857]
Inflation	0.390***	0.268*	0.190	0.238	0.152	0.455***	0.366**	0.530***	0.536***	0.241
	[0.141]	[0.138]	[0.176]	[0.193]	[0.192]	[0.148]	[0.164]	[0.178]	[0.201]	[0.252]
Trade Openness	22.491***	23.126***	31.875***	33.412***	42.447***	40.599***	40.487***	34.926***	40.454***	51.586***
	[6.901]	[6.754]	[7.254]	[7.567]	[8.691]	[10.385]	[9.721]	[8.606]	[9.612]	[10.387]
Treated Countries	38	38	38	38	38	24	24	24	24	24
Treated Observations	1678	1678	1678	1678	1678	1157	1157	1157	1157	1157
Share above threshold	0.34	0.34	0.34	0.34	0.34	0.23	0.23	0.23	0.23	0.23
Wald test controls (p)	0.27	0.31	0.22	0.28	0.32	0.08	0.33	0.13	0.06	0.21
Control Countries	101	89	77	65	48	115	103	91	79	62
Control Observations	3667	3279	2868	2327	1688	4188	3800	3389	2848	2209
Alternative Factor specifications: Coefficient for Threshold Effect										
1 Factor	2.621†	2.605†	2.624†	3.045†	4.496†	3.457	3.538	3.641	3.693	3.772
2 Factors	-0.426	-0.284	-0.454	0.018	2.726†	3.460	2.135	1.356	1.748	4.383
3 Factors	0.580	0.550	0.929	-0.290	3.388	1.486†	-0.115	-0.503	-0.125	3.282†
4 Factor	1.690	1.276	0.373	0.883	2.783	0.040†	-0.084	-2.172	-2.387†	0.496
5 Factors	0.287	0.345	0.236	1.858	3.919*	-1.591	-0.364	-2.818	-2.172	1.621†
6 Factors	1.035	1.578	-0.519	1.612	2.043	-0.401	-0.511	-2.192	0.343†	2.328*†

Notes: We present robust means (and absolute standard errors) for the PCDID country estimates in the 'treated' sample of countries, where treatment is defined by having overcome a threshold of 92% or 119% of credit/GDP, respectively. The estimates here are averages across heterogeneous treatments in terms of length of treatment and potential cross-country heterogeneity. Within each block of results we vary the control sample for this difference-in-difference estimator, by setting a second, lower, threshold for the 40th, 50th, 60th or 70th percentile of the credit/GDP distribution. The results use data for 1960 to 2016 and include four common factors estimated from the two control samples, in a lower panel of the table we present the threshold estimates for alternative factor specifications. † indicates where specifications fail a Wald test (10% level) that the additional controls are jointly statistically insignificant in a heterogeneous parameter linear probability model of the 'too much finance' dummy regressed on the controls and estimated factors from the control sample. For the model reported in detail the p-value for this test is provided in the table.

Table B-2: Finance for Development? PCDID Threshold regression ATET results (34% Credit/GDP)

	34-47% Credit/GDP (60th-70th pctile)				**34-65% Credit/GDP (60th-80th pctile)**			
Lower Cutoff	0	16	20	26	0	16	20	26
Percentile		30th	40th	50th		30th	40th	50th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Threshold Effect (ATET)	3.180	3.385	4.664*	3.041	2.107	2.710*	3.955**	3.104*
	[2.603]	[2.662]	[2.578]	[2.661]	[1.539]	[1.605]	[1.659]	[1.710]
Inflation	0.007	-0.050	-0.059*	0.016	-0.054	-0.108***	-0.112**	-0.133***
	[0.058]	[0.047]	[0.036]	[0.036]	[0.040]	[0.041]	[0.045]	[0.043]
Trade Openness	14.752**	16.097**	18.812**	20.098**	19.516***	22.052***	23.351***	25.949***
	[6.464]	[7.084]	[7.381]	[8.144]	[3.987]	[4.160]	[4.327]	[4.811]
Treated Countries	18	18	18	18	42	42	42	42
Treated Observations	661	661	661	661	1567	1567	1567	1567
Wald test controls (p)	0.25	0.47	0.50	0.67	0.20	0.42	0.39	0.53
Control Countries	36	28	24	12	36	28	24	12
Control Observations	1340	1124	952	541	1340	1124	952	541
Alternative Factor specifications: Coefficient for Threshold Effect								
1 Factor	2.713	3.129	3.435	3.711	2.919	3.572*	3.801**	3.704*
2 Factors	1.622	2.665	1.600	3.554	1.425	2.674	1.746	3.574*
3 Factors	1.518	2.259	2.855	4.560*	1.560	2.281	3.184*	3.439*
4 Factor	3.180	3.385	4.664*	3.041	2.107	2.710*	3.955**	3.104*
5 Factors	4.252*	2.953	4.000*	4.797**	2.542*	3.002**	3.903***	4.053**
6 Factors	4.477*	2.523	3.480	4.837*	2.814*	2.794**	3.642**	3.987**

Notes: We present robust means (and absolute standard errors) for the PCDID country estimates in the 'treated' sample of countries, where treatment is defined by having overcome a threshold of 34% of credit/GDP ('intermediate level of financial development'). Within each block of results we vary the control sample for this difference-in-difference estimator, by setting a second, lower, threshold for the 30th, 40th, or 50th percentile of the credit/GDP distribution. See Table B-1 for further details. Note that no specification rejected the Wald test.

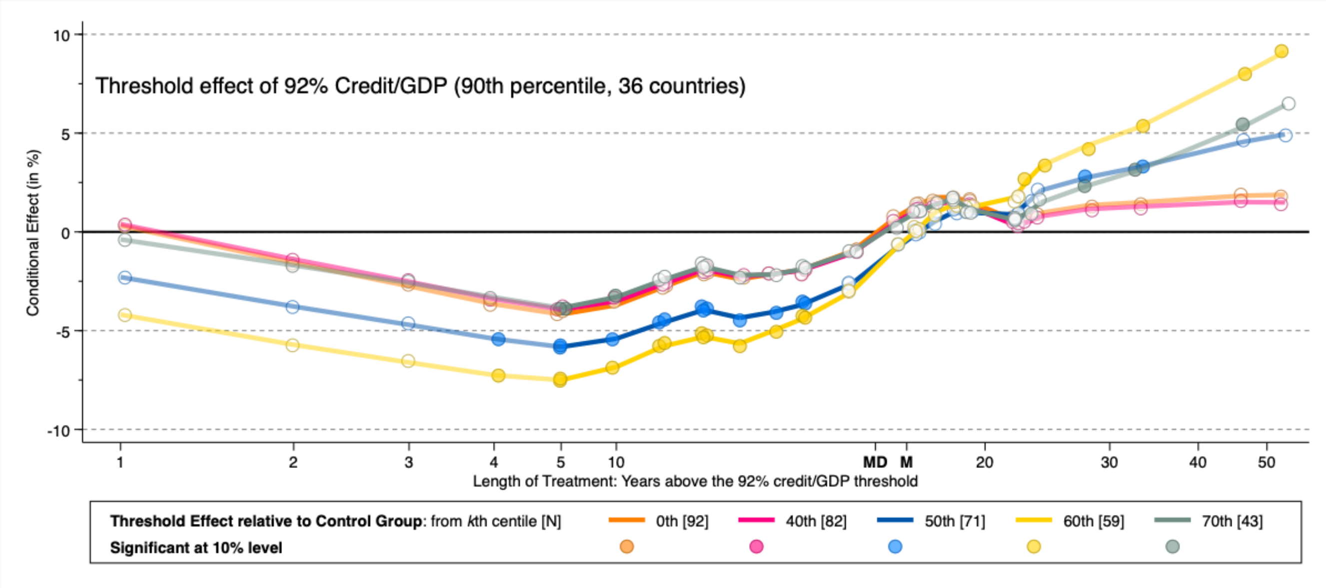
Table B-3: Finance for Development? PCDID Threshold regression ATET results (47% Credit/GDP)

Higher Cutoff	47-65% Credit/GDP (70th-80th pctile)					47-92% Credit/GDP (70th-90th pctile)				
Lower Cutoff	0	16	20	26	34	0	16	20	26	34
Percentile		30th	40th	50th	60th		30th	40th	50th	60th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Threshold Effect (ATET)	-0.849	-0.754	-0.772	0.069	-0.950	-0.865	-0.366	-0.477	0.767	-0.566
	[0.969]	[0.939]	[0.959]	[1.131]	[1.336]	[0.962]	[0.995]	[1.017]	[1.187]	[1.039]
Inflation	-0.009	-0.060	-0.065	-0.083	-0.098	-0.001	-0.044	-0.048	-0.059	0.009
	[0.050]	[0.060]	[0.062]	[0.063]	[0.089]	[0.048]	[0.051]	[0.046]	[0.042]	[0.078]
Trade Openness	21.394***	21.606***	20.781***	21.862***	24.998***	20.241***	20.903***	20.378***	22.180***	23.627***
	[4.083]	[4.021]	[4.193]	[3.991]	[5.484]	[2.975]	[2.774]	[2.873]	[3.046]	[3.958]
Treated Countries	26	26	26	26	26	47	47	47	47	47
Treated Observations	941	941	941	941	941	1666	1666	1666	1666	1666
Wald test controls (p)	0.01	0.00	0.00	0.01	0.07	0.14	0.22	0.21	0.17	0.15
Control Countries	101	89	77	65	48	115	103	91	79	62
Control Countries	54	46	42	30	18	54	46	42	30	18
Control Observations	2001	1785	1613	1202	661	2001	1785	1613	1202	661
Alternative Factor specifications: Coefficient for Threshold Effect										
1 Factor	1.757†	1.523†	1.758†	1.290†	3.354*†	2.172†	2.225†	2.382†	2.030†	3.317*†
2 Factors	1.231†	1.080†	0.898†	-0.301†	0.558†	1.037†	0.786†	0.695†	0.043†	0.704
3 Factors	-0.185†	0.075†	-0.009†	-0.590†	1.362†	-0.094	0.485	0.157	0.195	0.942
4 Factors	-0.849†	-0.754†	-0.772†	0.069†	-0.950†	-0.865	-0.366	-0.477	0.767	-0.566
5 Factors	-0.739†	-0.867†	-0.916†	0.365†	0.476	-0.237	0.069	-0.220	0.597	-0.046†
6 Factors	-0.065†	-0.274†	-0.122†	0.949†	-0.210	0.303	0.766	0.717	1.216	-0.133

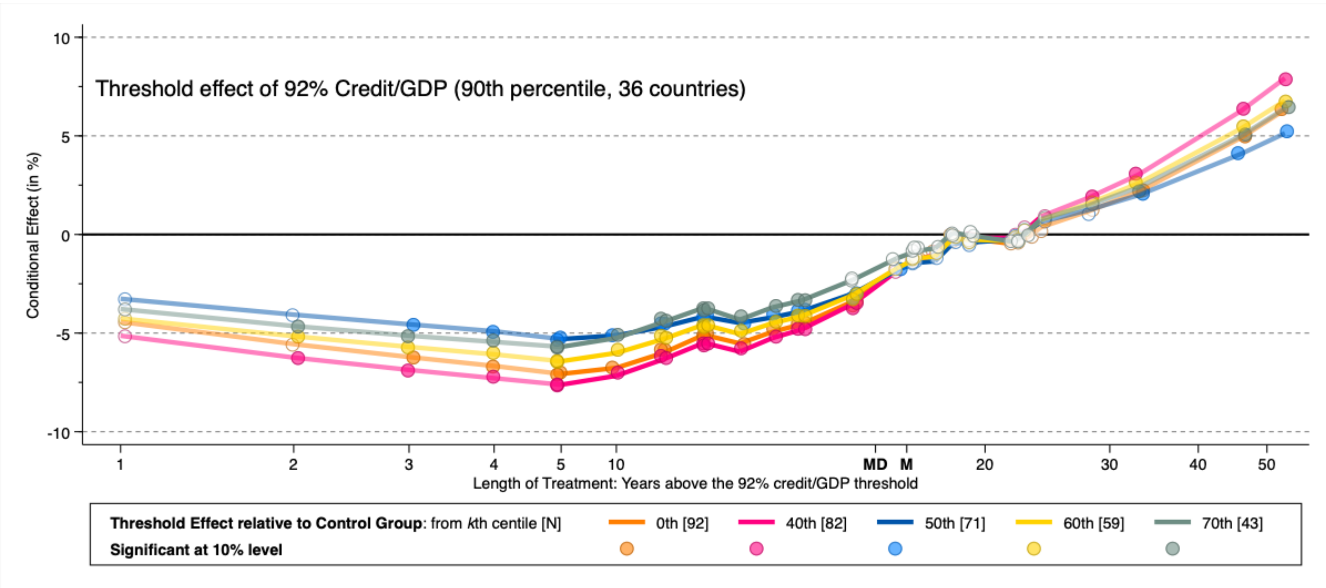
Notes: We present robust means (and absolute standard errors) for the PCDID country estimates in the 'treated' sample of countries, where treatment is defined by having overcome a threshold of 47% of credit/GDP ('intermediate level of financial development'). The estimates here are averages across heterogeneous treatments in terms of length of treatment and potential cross-country heterogeneity. Within each block of results we vary the control sample for this difference-in-difference estimator, by setting a second, lower, threshold for the 30th, 40th, 50th or 60th percentile of the credit/GDP distribution. The main results use data for 1960 to 2016 and include four common factors estimated from the two control samples, in a lower panel of the table we present the threshold estimates for alternative factor specifications (1-6 factors).

C PWT Production Function. . . or Not

Figure C-1: Too much Finance — Production Functions (or not) Using PWT Data



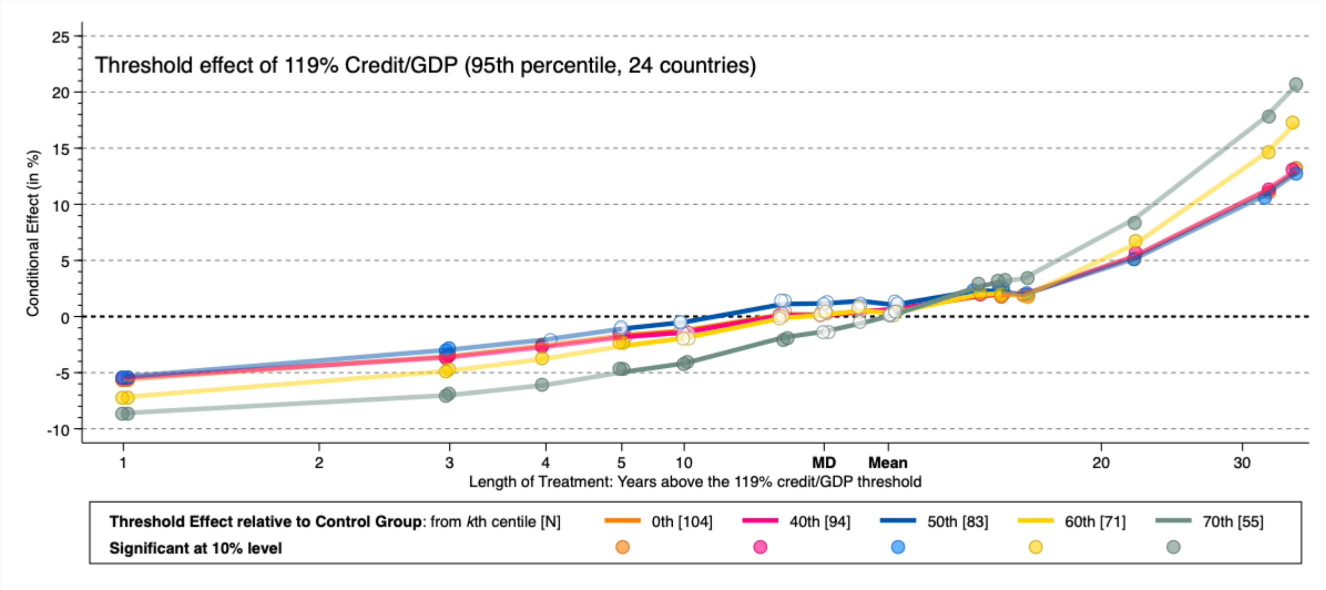
(a) Empirical Model without Capital Stock as Control — 92% Threshold



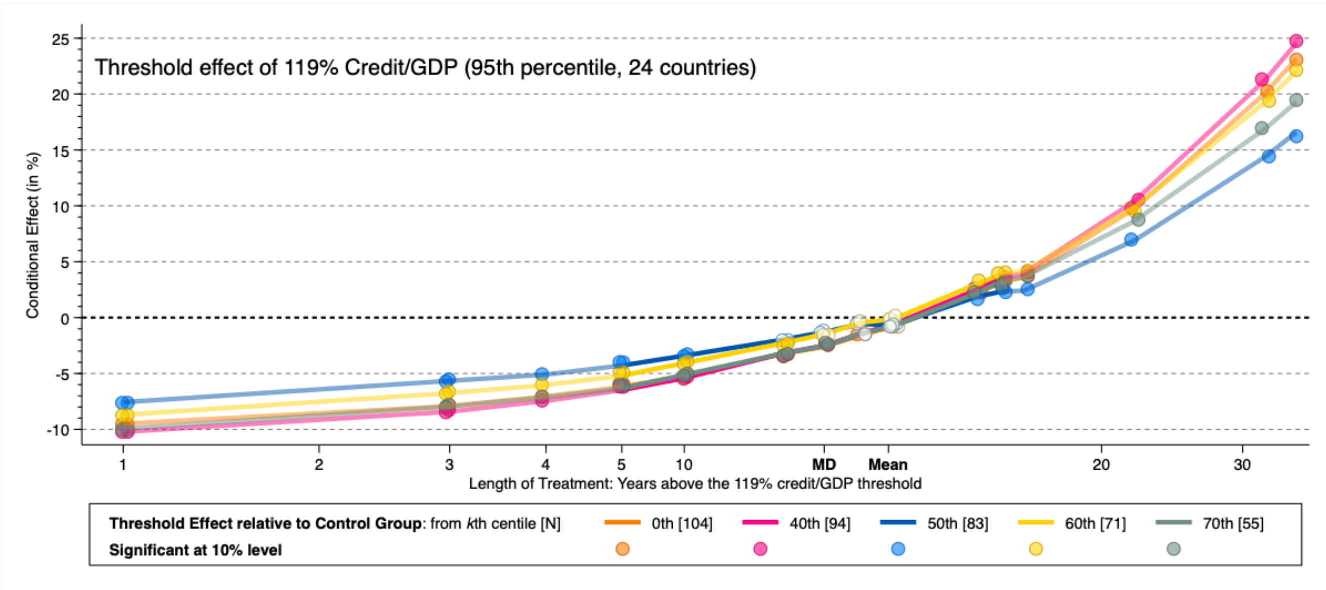
(b) Empirical Model with Capital Stock as Control (Production Function) — 92% Threshold

(Continued overleaf)

Figure C-1: Too much Finance — Production Functions (or not) Using PWT Data (cont'd)



(c) Empirical Model without Capital Stock as Control — 119% Threshold

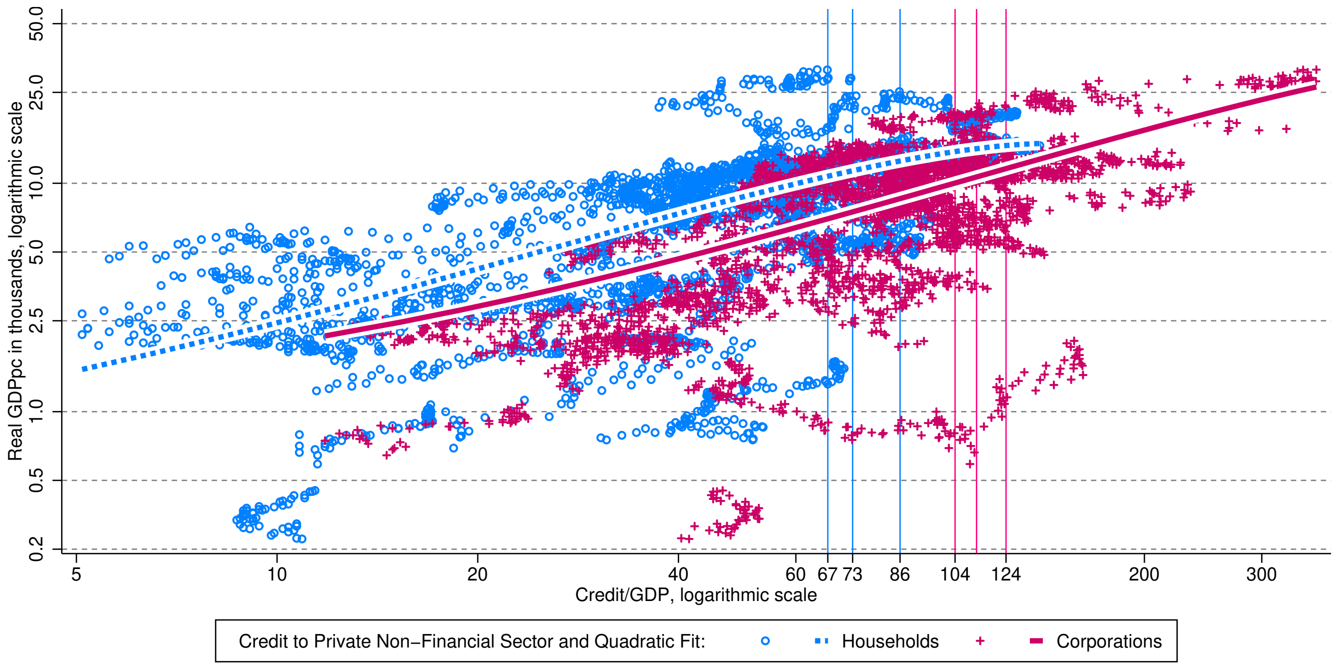


(d) Empirical Model with Capital Stock as Control (Production Function) — 119% Threshold

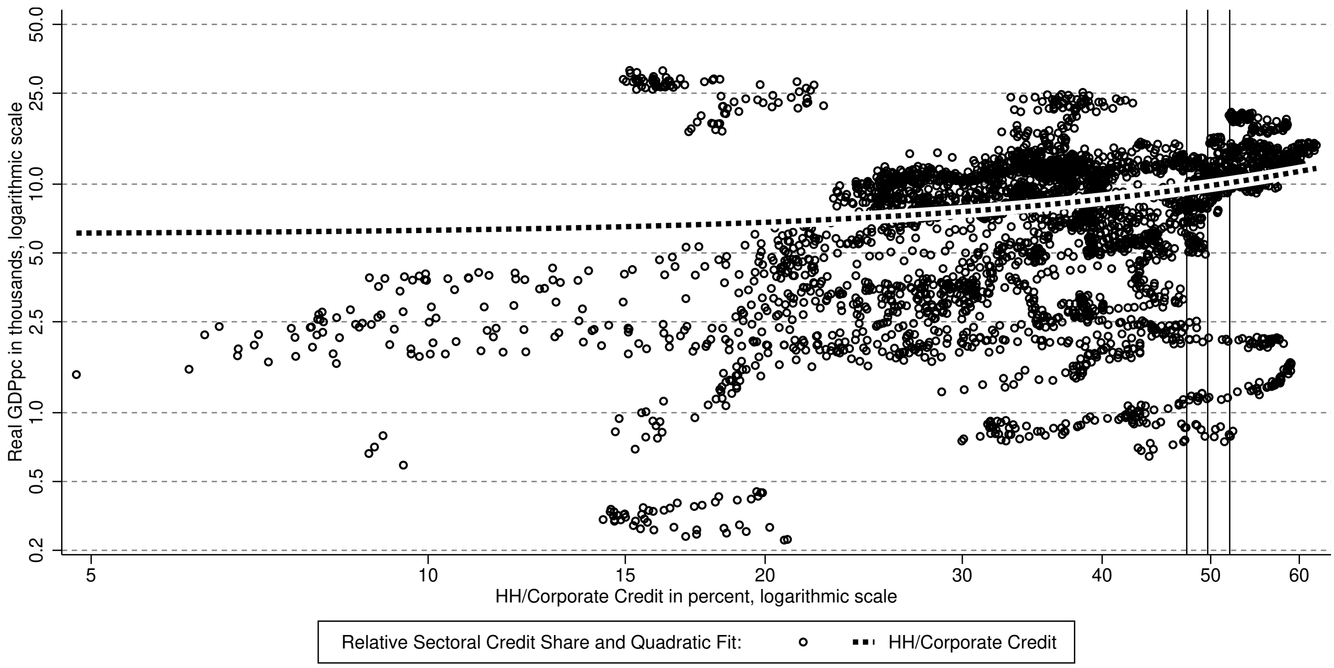
Notes: The figure presents mean estimates for a variety of Difference-in-Difference estimators; in contrast to the results in the maintext of the paper we here compare and contrast treatment effect results for a 'high financial development' dummy in a production function (Y/L regressed on K/L) using PWT data in (a) and (c) with an alternative specification without K/L as additional control in (b) and (d). Trade openness and inflation are included as controls in all models. In each plot we consider a number of alternative counterfactuals (control groups), by dropping countries with very low financial development (below 40th, 50th, 60th and 70th percentile of the credit/GDP distribution). The first plot, marked 0th percentile, is for a control group which includes all countries which stayed below the credit/GDP threshold. A filled (hollow) marker indicates statistical (in)significance at the 10% level. Mean and median length of treatment and treatment sample size are indicated in the graph.

D Distinguishing Household and Firm Credit

Figure D-1: Too much Finance? Quarterly Data for Household and Corporate Credit



(a) Income per capita and Sectoral Credit



(b) Income per capita and Relative Sectoral Credit Allocation

Notes: These are scatter plots for log real GDP pc (in thousands of US$ in 2010 values) and, in panel (a) the log of household credit/GDP (blue circles) and log of corporate (non-financial firm) credit/GDP (pink plus signs), as well as in panel (b) the log of household to corporate credit (in percent). The fitted lines are constructed using quadratic regression models, for the household credit data in panel (a) observations <5% credit/GDP are omitted to ease illustration.

Table D-1: Sample make-up — Quarterly Credit Data for HH and Corporations

					Household Credit/GDP			Firm Credit/GDP		
Country	ISO	Obs	Start	End	67%	73%	86%	104%	112%	124%
Australia	AUS	111	1991	2018	76	69	61	C	C	C
Austria	AUT	92	1995	2018	C	C	C	C	C	C
Belgium	BEL	87	1997	2018	C	C	C	72	20	43
Brazil	BRA	91	1996	2018	C	C	C	C	C	C
Canada	CAN	111	1991	2018	57	48	38	15	3	
Switzerland	CHE	76	1999	2018				22	28	
Chile	CHL	64	2002	2018	C	C	C	2	C	C
China	CHN	51	2006	2018	C	C	C	43	51	27
Colombia	COL	55	2005	2018	C	C	C	C	C	C
Czech Republic	CZE	92	1995	2018	C	C	C	C	C	C
Germany	DEU	111	1991	2018	30	C	C	C	C	C
Denmark	DNK	95	1995	2018		92	71	44	46	
Spain	ESP	95	1995	2018	43	34	C	42	25	20
Finland	FIN	111	1991	2018	2	C	C	47	68	3
France	FRA	111	1991	2018	C	C	C	72	44	28
United Kingdom	GBR	95	1995	2018	68	62	40	C	C	C
Greece	GRC	95	1995	2018	C	C	C	C	C	C
Hong Kong SAR	HKG	111	1991	2018	9	C	C	92	22	51
Hungary	HUN	95	1995	2018	C	C	C	C	C	C
Indonesia	IDN	43	2008	2018	C	C	C	C	C	C
India	IND	46	2007	2018	C	C	C	C	C	C
Ireland	IRL	67	2002	2018	43	39	33	50	44	46
Israel	ISR	95	1995	2018	C	C	C	C	C	C
Italy	ITA	95	1995	2018	C	C	C	C	C	C
Japan	JPN	99	1994	2018	41	C	C	53	36	25
Korea	KOR	111	1991	2018	50	42	13	16	2	
Luxembourg	LUX	67	2002	2018	4	C	C			
Mexico	MEX	96	1994	2018	C	C	C	C	C	C
Netherlands	NLD	95	1995	2018	87	85	73			68
Norway	NOR	111	1991	2018	61	41	18	80	64	44
New Zealand	NZL	82	1998	2018	62	57	49	5	C	C
Poland	POL	92	1995	2018	C	C	C	C	C	C
Portugal	PRT	95	1995	2018	64	50	25	52	37	22
Russia	RUS	63	2003	2018	C	C	C	C	C	C
Saudi Arabia	SAU	55	2005	2018	C	C	C	C	C	C
Singapore	SGP	111	1991	2018	C	C	C	17	6	
Sweden	SWE	103	1993	2018	42	37	8	68	47	44
Thailand	THA	103	1993	2018	17	C	C	5	1	
Turkey	TUR	83	1998	2018	C	C	C	C	C	C
United States	USA	111	1991	2018	79	69	32	C	C	C
South Africa	ZAF	43	2008	2018	C	C	C	C	C	C

Notes: The table indicates the full sample make-up for the 41 countries with quarterly data. The columns in the right part indicate the number of quarters a country was above the indicated thresholds ('in treatment'), with 'C' indicating that the country never breached the threshold and hence is part of the control sample.

Table D-2: Too much Finance? PCDID Threshold regression ATET results for Household and Firm Credit

	Household Credit/GDP			Firm Credit/GDP			Share of HH/Total Credit		
Cutoff	67%	73%	86%	104%	112%	124%	48%	50%	52%
Percentile	80th	85th	90th	80th	85th	90th	80th	85th	90th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Threshold Effect (ATET)	12.925***	13.748***	4.073	2.014	1.670	0.039	3.319**	2.904*	1.521
	[3.744]	[3.733]	[4.446]	[1.686]	[1.497]	[1.129]	[1.683]	[1.504]	[0.973]
Export/Trade	-22.055	-0.438	0.391	-1.418	-19.089	-30.026	-23.535	-16.017	-16.856
	[52.158]	[38.991]	[71.676]	[36.222]	[41.801]	[21.448]	[39.183]	[21.344]	[17.252]
Inflation	-1.210***	-1.065*	-1.595**	0.545*	0.523*	0.253	-0.642**	-1.479***	-0.775**
	[0.419]	[0.565]	[0.641]	[0.281]	[0.310]	[0.281]	[0.283]	[0.445]	[0.352]
Treated Countries	18	13	12	19	17	12	10	10	10
Treated Observations	1789	1282	1187	1794	1648	1136	890	905	870
Wald test controls (p)	0.53	0.03	0.05	0.29	0.03	0.11	0.60	0.23	0.00
Control Countries	21	27	28	20	22	28	27	30	31
Control Observations	1655	2257	2352	1659	1805	2412	2332	2634	2745
Alternative Factor specifications: Coefficient for Threshold Effect									
1 Factor	12.666***	13.067***†	7.352	0.288	-0.236†	0.298†	4.871	2.806*	1.903**
2 Factors	13.150***	9.891**†	5.347	-0.143	0.138†	1.743†	2.986	3.891*	2.320†
3 Factors	13.514***	14.903***†	4.656	1.584	0.699†	2.995***†	3.349	3.383**	1.695**†
4 Factors	12.925***	13.748***†	4.073†	2.014	1.670†	0.039	3.319**	2.904*	1.521†
5 Factors	11.058***	8.017***†	4.914*	2.692**†	1.424†	1.593†	4.432*	2.175	0.276†
6 Factors	10.915***	7.686***†	4.909**	2.732**†	2.249†	2.212	3.662**	1.279	0.294†

Notes: We present robust means (and absolute standard errors) for the PCDID country estimates in the 'treated' sample of countries, where treatment is defined by having overcome a threshold of the equivalent of the 80th, 85th and 90th percentile of the 'credit'/GDP, respectively — 'credit' here captures either 'household' or 'firm' credit (more formally: ' credit to households and non-profit institutions serving households' and 'credit to non-financial corporations'. Columns (7)-(9) use the share of Household to Total (Household and Firm) Credit as the threshold variable. The estimates are averages across heterogeneous treatments in terms of length of treatment and potential cross-country heterogeneity. The control sample for this difference-in-difference estimator is always the set of countries which stayed below the cut-off. The results use quarterly data for 1991Q1 to 2018Q3 and include four common factors estimated from the control samples, in a lower panel of the table we present the threshold estimates for alternative factor specifications. † indicates where specifications fail a Wald test (10% level) that the additional controls are jointly statistically insignificant in a heterogeneous parameter linear probability model of the 'too much finance' dummy regressed on the controls and estimated factors from the control sample. For the model reported in detail the p-value for this test is provided in the table.

Chapter 2: Cost of Collateral in a Firm Dynamics Model

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October 2022

Abstract

This paper investigates the effect of collateral backing as a prerequisite to obtain cheaper financing in a simple firm dynamics model. We adopt a reduced form structure for financing following Gomes (2001). In the baseline model, all firms face the same external financing cost regardless of their collateral backing. The model with collateral assumes that firms without sufficient collateral (bottom 40 percentile of firms) face a higher cost of financing. This structure is empirically supported by simple regressions on US firms (where firms are sorted according to their ownership of tangible assets – proxy for collateral (Ratio of PPE to Total Assets)). Empirically, firms with less tangible assets face higher cost of both debt and equity financing. The theoretical model is simulated based on these empirical findings. Overall, preliminary results show that the presence of collateral requirements lowers aggregate output by 8.2%, however, aggregate capital stock in the economy increases marginally by 0.5%. This follows from lower firm entry – entrants decline by 5.1% in the model.

Keywords: collateral, firm dynamics, entrants
JEL Codes: C63, G31

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1. Introduction

In imperfect financial markets, lenders often use collateral (usually a tangible asset) as a contracting/disciplining tool to incentivize borrowers to act in the interest of the lender. In the event a firm liquidates, the lender is able to seize control of these assets and resell them in the market. Usually, tangible assets (eg. real estate, equipment etc) are pledged as collateral, although more established firms can rely on intangible assets (eg. brand, reputation etc) as a substitute for tangible collateral (Almeida and Campello (2007)). The importance of collateralized loans in corporate finance is illustrated in Figure 1 and 2 - in the US, at least 40% of corporate loans are secured by collateral (Figure 1; Source: Federal Reserve). The proportion of corporate loans secured by collateral is even higher in developing countries - amounting to an average of 70-80% of total loans (Figure 2; Source: World Bank Enterprise Survey).

The willingness to pledge collateral by borrowers could be taken as a signal of borrower quality by an imperfectly informed lender (Bester, 1985). Therefore, even good and established firms sometimes pledge collateral when seeking external financing for a new project (Almeida and Campello (2007)). As collateral has to be pledged as a prerequisite to obtain external financing, collateral value has been found to affect firm investment (eg. Chaney et al (2012), Almeida and Campello (2007)). Firms with more valuable assets are less financially constrained.[1] They can obtain cheaper external financing for investment, which could lead to higher aggregate investment in the economy. In this paper, we show that larger firms (firms with more capital) are more likely to invest, as they hold more collateral. This contributes to higher aggregate investment in the model economy.

The need for tangible assets to be pledged as collateral signifies that smaller and younger firms (entrants) are more financially constrained. In general, younger firms do not have much tangible assets to rely on, neither have they build up sufficient retained earnings to fall back on. Therefore, external financing is the only option to finance productive investments (Bergin et al (2014)). Investors usually require higher returns[2] to compensate for the lack of collateral (Pozzolo, 2002). We con-

[1] We tie financial constraints to the cost of external financing in this framework

[2] Higher dividend payments for equity financing or higher interest payments for debt financing

firm this fact in Section 2 of this paper, where we show that US firms with less tangible assets face higher cost of equity and debt financing. We then incorporate the findings of these empirical results into a theoretical model. The findings of the quantitative theory model shows that more expensive external financing for smaller firms serves as a hindrance to firm entry, which depresses aggregate output.

The theoretical model we adopt for this exercise is an extension of Gomes (2001). In Gomes (2001), all firms seeking external financing face the same cost structure, regardless of their collateral backing. Our model adds an additional collateral requirement, such that external financing is more expensive for firms without sufficient collateral. In the following section, we will run an empirical exercise to calibrate the parameters for firms without sufficient collateral backing. We will then introduce the theoretical model in Section 3, which is largely based on Gomes (2001). The model is calibrated in Section 4, and Section 5 discusses the results from the simulation[3].

2. Empirical Exercise

In this section, we perform a simple empirical exercise to show that external financing is more expensive for firms with less tangible assets. Existing research (eg. Chaney et al (2012), Gelos and Werner (2002), Feder et al (1988)) has also highlighted the importance of the value of firm's tangible assets (due to their role as collateral) in driving firm's investment. Following existing literature, we utilize the ratio of the firm's tangible assets (Property, Plant and Equipment (PPE)) to total assets as a proxy for collateral[4].

The empirical analysis is conducted on listed US firms. Data for these firms were obtained from the COMPUSTAT database, a platform which stores financial data for listed US firms. A total of 968,223 firms were downloaded for the empirical analysis. The time period for the analysis was for over a period of 19 years, spanning from the year 2000 to 2019[5].

[3] Results from the model with the additional collateral requirements are compared with results from the benchmark model (without additional collateral requirements)

[4] We take the ratio to Total Assets to control for the size of the firm

[5] Data availability throughout this time span varies for each firm.

The empirical specification is given below:

$$Finance\ Cost_{it} = \beta_0 + \beta_1 \Delta Securities_{it}(t-1) + \varepsilon_{it}$$

where;

$Finance\ Cost_{it}$ - Ratio of interest payments (debt financing) or dividend payments (equity financing) to debt or shares outstanding

$Securities_{it}$ - Debt/Shares outstanding.

This regression is run for two subsets of firms - (i) Firms with sufficient collateral, and (ii) Firms without sufficient collateral. The regression aims to test if the cost of raising capital is more expensive for firms with less tangible assets. This hypothesis is tested for both debt and equity financing. The independent variable measures the change in securities outstanding in the previous period - this proxies securities issued/sold in the previous period. The dependent variable measures the increase/decline in payment to shareholders/debtors in the next period upon issuing/selling a security. The same regression is ran for firms with and without sufficient collateral. Details on how firms are sorted are explained in the paragraph below.

We start by running separate regressions based on the firm's PPE/Total Assets ratio. We start by first adopting a threshold at the 10th percentile of the PPE/Total Assets ratio, such that firms which fall below the 10th percentile will be categorized as 'firms with insufficient collateral', while firms above this percentile would be categorized as 'firms with sufficient collateral'. We then run debt/equity regressions based on the empirical specification above. We repeat this process by incrementally raising the PPE/Total Asset percentile by 10. Separate regressions were then run for these different group of firms: bottom(20th)/top(80th), bottom(30th)/top(70th), bottom(40th)/top(60th), bottom(50th)/top(50th), bottom(60th)/top(40th) and bottom(70th)/top(30th). The most significant regression results for both the debt/equity regressions[6] were obtained by dividing firms at the 40th percentile. Table 3 in the appendix reports the summary statistics for debt/equity financing costs for these firms.

[6] In fact, we got very insignificant regression results for these groups: bottom(10th)/top(90th), bottom(20th)/top(80th), bottom(60th)/top(40th) and bottom(70th)/top(30th)

The empirical results are published in Tables 1 and 2. We publish results when firms are divided at the 40th percentile of the PPE/Total Assets ratio:

1) Bottom 40% of firms: PPE/Total Assets ratio < 0.08; and

2) Top 60% of firms: PPE/Total Assets ratio > 0.08.

Table 1 – Dependent variable: Log(Interest Payments/Debt Outstanding)

	(1)	(2)
VARIABLES	PPE/Total Assets < 0.08	PPE/Total Assets > 0.08
Log(Debt Issued (t-1))	0.391***	0.269***
	(0.0257)	(0.0233)
Constant	3.674***	1.834***
	(0.295)	(0.0796)
Observations	10,156	18,529
R-squared	0.133	0.110
Time FE	Yes	Yes
Industry FE	Yes	Yes
Robust SE	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The empirical model is a simple Pooled OLS with time and industry fixed effects. Results from the regressions cannot reject the hypothesis that firms with less tangible assets (lower collateral value) face higher cost of debt and equity financing. These empirical findings will be used to support the numerical simulations of the theoretical model. The only difference is - the theoretical model in the next section assumes that external financing is provided only in the form of debt financing [7]. In the absence of financial frictions (taxes and bankruptcy costs), the Modigliani-Miller theorem is assumed to hold (Market value of firm is independent of it's capital structure). The next section describes the theoretical model in detail.

[7] As a result of the insignificance of the constant in the equity regression

Table 2 – Dependent variable: Log(Dividends Issued/Shares Outstanding)

	(1)	(2)
VARIABLES	PPE/Total Assets<0.08	PPE/Total Assets>0.08
Log(Equity Issued (t-1))	0.160***	0.0617**
	(0.0318)	(0.0264)
Constant	25.80	48.39***
	(50.95)	(3.314)
Observations	18,103	24,753
R-squared	0.015	0.031
Time FE	Yes	Yes
Industry FE	Yes	Yes
Robust SE	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

3. Model Environment

The model economy is an investment augmented version of a standard neoclassical model, similar to Gomes (2001). This is made up of firms, households and financial intermediaries. Firms are heterogeneous with respect to productivity, size, investment and financing patterns. Firms use a combination of labour and capital input to produce a single, homogeneous good[8]. Profits are either invested or distributed as dividends to the household, who are owners of firms. Firms seek external financing from the financial intermediary only if their accumulated profits are insufficient to cover the cost of investment.

Households are characterized by a single representative agent, whose goal is to maximise lifetime utility. Households earn labour income, and receive dividends from firms from their shareholdings in firms. As the owners of firms, households bear the cost of external financing.

Finally, financial intermediaries provide external financing to firms at a cost. Unlike firms and households, financial intermediaries are not modelled explicitly. Following Gomes (2001), the cost

[8]The price of the homogeneous good is set to 1 (Numeraire)

of external financing is summarized in a linear functional form. This aims to capture the notion that external funding is more costly compared to internal funding.

In addition to the external financing function introduced in Gomes (2001), we introduce an additional term to capture the positive risk premia for firms without sufficient collateral backing, defined as firms at the bottom 40% of the capital grid. On the other hand, external financing is cheaper for firms with sufficient collateral backing, defined as firms at the top 60% of the capital grid. The threshold of 40% is motivated by empirical findings in the previous section.

In the following sub-sections, we present the model in detail through the lens of the economic agents.

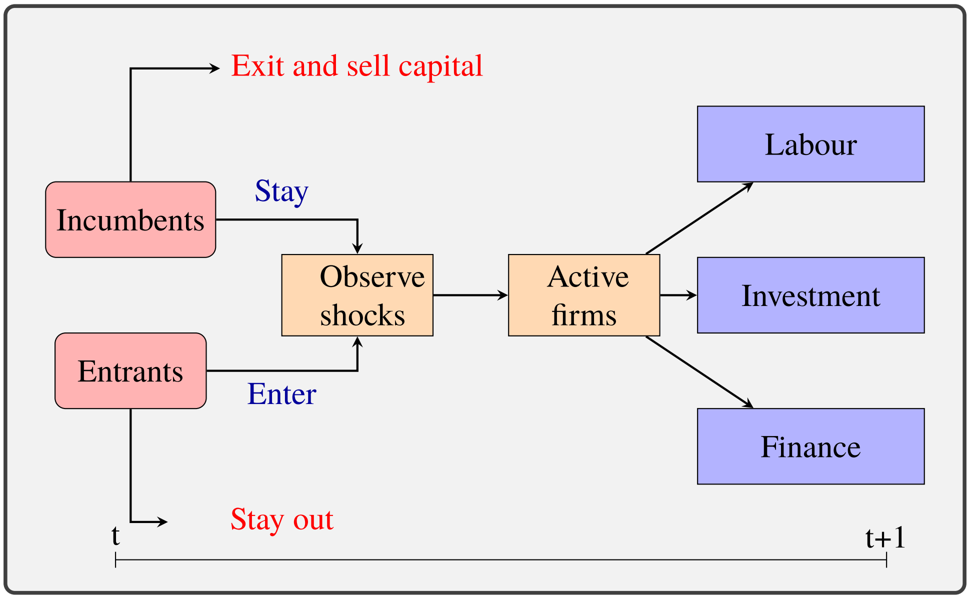
3.1 Firms

Production is carried out by a continuum of firms. At the start of the period, incumbents choose to stay in the market, or exit and sell their assets. Incumbents who choose to stay in the market and continue producing then face idiosyncratic productivity shocks, $Q(z_t|z_{t-1})$, which follow a common Markov process. They then make a number of decisions on (i) How much labour to hire; (ii) how much to invest; and (iii) how to finance their investment (internal or external financing). This process is illustrated in Figure 3.

Entrants also choose whether to enter or stay out at the beginning of period t. Entrants who choose to enter and produce draw their initial level of productivity from a common stationary Markov distribution, $\phi(z_t)$. Just like the incumbent, the entrant then makes decisions on; (i) How much labour to hire; (ii) how much to invest; and (iii) how to finance their investment. As an entrant would not have retained earnings to finance the investment internally, they would need to rely on external financing. Figure 3 summarises an entrant's decisions in a given time period.

Internal financing would only be a feasible option if a firm's retained earnings, $\pi(k, z; w)$ exceed the value of it's investment, $i(k, k')$. A firm would always opt for internal financing as the first option, as it's cheaper to finance investment. Firms would only opt for external financing iff retained earnings

Figure 3: Timing of Events



are insufficient to cover the value of investment $i(k, k') > \pi(k, z; w)$. This follows the pecking order hypothesis (Myers, 1984), in which firms prefer internal to external financing.

The cost of external financing, λ for a firm would depend on the amount of collateral the firm holds. External financing is cheaper for firms with a higher collateral value because in the event the firm liquidates, the creditor would able to sell the firm's assets at market value, $(1 - \delta)k'$, where δ is the rate of depreciation. The functional form of external financing is summarized in equations (5) and (6).

All firms (incumbents and entrants) aim to maximise profit every period. Firms use 2 inputs to production: capital, k and labour ℓ and are subject to individual productivity shocks, z. All firms hire labour in a given period at a market wage rate of $w_t > 0$ and discount future cash flows at a discount rate of $\beta \in [0, 1)$. Firms also incur a fix cost of production every period, given by $f \geqslant 0$. The presence of the fixed cost, f ensures that firms which are unable to cover the cost of production do not enter the market.

The static profit maximisation problem for firms is defined in equation (1):

Profits:

$$\pi(k, z; w) = \max_{\ell \geqslant 0} \{F(k, \ell; z) - w\ell - f\} \tag{1}$$

where $F(k, \ell; z)$, the technology, is (i) continuous, strictly increasing, and strictly concave in k and ℓ; (ii) continuous and strictly increasing in z; (iii) Strictly decreasing in w.

Firms choose to employ an optimal amount of labour to maximise profit. This is expressed in equation (2):

Labour Demand:

$$\ell(k, z; w) = \arg\max_{l \geqslant 0} \{F(k, \ell; z) - w\ell - f\} \tag{2}$$

Capital evolves through a standard law of motion investment equation. This is expressed in equation (3).

Investment:

$$i(k, k') = k' - (1 - \delta)k, \quad \delta \in [0, 1] \tag{3}$$

where k' represents the next period's capital stock. The simple model abstracts from any investment adjustment costs.

External financing is increasing and positive if $i(k, k') > \pi(k, z; w)$, and zero if $i(k, k') \leq \pi(k, z; w)$. This follows from the idea that firms would only go for external financing, if internal financing is insufficient to cover the cost of investment. The external financing function for firms with sufficient collateral[9] ($k > \bar{k}_{min}$) is expressed in equation (4):

External Finance (Sufficient Collateral):

$$\tilde{\lambda}(k, k', z; w) = \tilde{\lambda}\left(\tilde{i}(k, k') - \tilde{\pi}(k, z; w)\right) \tag{4}$$

$\bar{k}_{min}$ refers to minimum level of collateral the financial intermediary requires a firm to hold to qualify

[9]This is defined to be the top 60% of firms in the asset grid

for cheaper external financing. On the other hand, firms without sufficient collateral are charged a premium for external financing.

For firms without sufficient collateral[10] ($k \leq \bar{k}_{min}$), a risk premium (ξ) is charged to ($\tilde{\lambda}$). This risk premium is expected to cover the risk of liquidation following a productivity shock. Accounting for this premium, ξ, the external financing function for firms whose capital holdings $k \leq \bar{k}_{min}$ is given by equation (5):

External Financing (Insufficient Collateral):

$$\hat{\lambda}(k, k', z; w) = \tilde{\lambda}(k, k', z; w) + \xi(i(k, k') - \pi(k, z; w)) \tag{5}$$

The firm's value function, $V(k, z, ; w)$ is (i) continuous and increasing in (k,z), and (ii) continuous and strictly decreasing in w. The continuing firm solves the dynamic problem:

$$V(k, z; w) = \max_{k' \geqslant 0} \Bigg\{ \pi(k, z; w) - i(k, k') - \underset{i > \pi}{\lambda} (\tilde{\lambda}_{k > \bar{k}_{min}}(k, k', z; w), \hat{\lambda}_{k \leq \bar{k}_{min}}(k, k', z; w)) + \beta max\left((1-\delta)k', \int V(k', z'; w) \times Q(dz'|z)\right) \Bigg\}$$

The first 3 terms reflect the current dividends: Profits minus investment spending and external financing (modeled as a cost which reduces the firm's value). External financing, λ is positive if and only if $i(k, k') > \pi(k, z, ; w)$, and zero otherwise. Suppose λ>0, λ would then take the value of $\tilde{\lambda}$ if $k > \bar{k}_{min}$, and $\hat{\lambda}$ if $k \leq \bar{k}_{min}$. The last term is the expected continuation value, including the exit decision. Firms will exit at the start of the next period when the discounted expected profitability is below the market value of its' assets. This is expressed by Equation (6).

[10] Defined to be the bottom 40% of firms in the asset grid

Exit condition:

$$\int V(k', z'; w)Q(dz'|z) < (1 - \delta)k' \tag{6}$$

The exit decision is determined by a threshold productivity level, z^*. Firms will exit if their productivity level falls below the threshold productivity level, and vice versa. This is expressed in equation (7).

Exit decision:

$$x(k, z; w) = \begin{cases} 1, & \text{if} \quad z > z^* \quad \text{(stay)} \\ 0, & \text{if} \quad z \leqslant z^* \quad \text{(exit)} \end{cases} \tag{7}$$

where z^* represents the productivity of the marginal firm, and is expressed in equation (8):

$$z^* = \min\left\{\inf\left\{z : \int V(k', z'; w) \ \times \ Q(dz'|z) \geqslant (1 - \delta)k'\right\}, \bar{z}\right\} \tag{8}$$

Firms choose to stay and produce only if the expected present discounted value of their revenue is enough to cover their costs. This happens only when the level productivity of a firm is above a threshold of the marginal firm, z^*.

The equilibrium wage rate, w is determined such that the free entry condition (Equation (8)) is satisfied: Free entry condition:

$$\int p(0, z; w)\psi(dz) - f_e \leqslant 0 \tag{9}$$

where f_e represents the fixed entry cost/sunk cost the firm incurs upon deciding to enter the market.

3.2 Market Clearing/Aggregation

The exact level of entry, B is obtained such that the labour market clears. The distribution of firms, $\mu(k,z)$ evolve over the state (k,z). For any set $\theta = (k \times z)$, μ evolves according to equation (10):

The law of motion for surviving firms (μ):

$$\mu'(\theta) = \sum_k \sum_z T(\theta,(k',z'))\mu(k,z) + B\sum_z T((0,z);(k',z')))\phi(z) \tag{10}$$

where $\phi(z)$ is the ergodic Markov distribution, the distribution drawn by entrants when they first enter.

$T(\theta,(k',z'))$ is the transition probability, which is equal to: $T(\theta,(k',z')) \equiv \mathbb{1}\{k(k,z) = k'\}x(k,z)Q(dz'|z)$. $T(\theta,(k',z'))$ reflects the transition probability from (k,z) to (k',z')

In equilibrium, the law of motion converges to a stationary distribution, such that: $\mu' = \mu = \mu^*$. The level of entry, B, should satisfy the labour market clearing condition, expressed in equation (11):

Labour market clearing:

$$L^d \equiv \sum_k \sum_z \ell(k,z;w)x(k,z)Q(dz'|z) + B\sum_z \ell(0,z;w)\phi(z) = L^s \tag{11}$$

Optimal labour supply is obtained from the household's optimisation problem (Section 3.2)

Similar to Gomes(2001), we assume that all aggregate quantities are jointly homogeneous of degree one in B and μ.

Aggregate quantities are defined as:

Aggregate final goods:

$$Y(\mu, B; w) = \int \{(y(k, z; w) - f)) \times x(k, z; w)\mu(dk, dz) - Bf\}\,; \tag{12}$$

Total profits:

$$\pi(\mu, B; w) = \int \pi(k, z; w)x(k, z; w)\mu(dk, dz) \quad + \quad B \int \pi(0, z; w)\phi(dz) \tag{13}$$

Aggregate labour demand:

$$L(\mu, B; w) = \int \ell(k, z; w)x(k, z; w)\mu(dk, dz) \quad + \quad B \int \ell(0, z; w)\phi(dz) \tag{14}$$

Aggregate investment:

$$I(\mu, B; w) = \int \{i(k(k, z; w), k)x(k, z; w)\mu(dk, dz) \quad + \quad B \int k(0, z; w)\phi(dz) \tag{15}$$

For external financing, let λ_{tot} be the sum of external financing taken by firms, where; $\lambda_{tot}(k, k(k, z; w), z; w) = \int \tilde{\lambda}(k, k(k, z; w), z; w) \times \tilde{x}(k, z; w)\mu(dk, dz) + \int \hat{\lambda}(k, k(k, z; w), z; w) \times \hat{x}(k, z; w)\mu(dk, dz)$. Then, total external financing for this economy is given by:

External financing:

$$\Lambda(\mu, B; w) = \int \lambda_{tot}(k, k(k,z;w), z; w)x(k,z;w)\mu(dk,dz) \quad + \quad B\int \lambda_{tot}(0, k(0,z;w), z; w)\phi(dz) \tag{16}$$

This concludes the firm's optmisation problem

3.3 Households

Households are homogeneous in this model. The representative household chooses consumption and labour supply to maximize lifetime utility. Households derive their wage income from supplying labour to firms, and from firm dividend payments - the amount depends on the number of shares they own in firms. This is illustrated in the household's budget constraint. The household's problem can be summarized as follows:

$$\max_{c,\ell,s_t(k_t,z_t)\geqslant 0} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \tilde{\beta}^t U(c_t, 1-l_t)\right]$$

subject to

$$c_t \quad + \quad \int (\tilde{V}_t(k,z) - d_t(k,z))s_t(k,z)\mu(dk,dz) = \int max\{\tilde{V}_t(k,z), \phi k\} s_{t-1}(k,z)\,\mu(dk,dz) \quad + \quad w_t\ell_t$$

where c_t is household consumption at time t, $\tilde{V}_t(k,z)$, $d_t(k,z)$ and $s_t(k,z)$ denote the price, dividends received from the firm and the shares owned by households at any time t. The preference relation is assumed to satisfy $0 < \tilde{\beta} < 1$ and the utility function, $U(c_t, 1-l_t)$ is strictly increasing, strictly concave and twice continuously differentiable. $\mu(k,z)$ denote the mass of firms in the state (k,z).

In a stationary equilibrium, the discount rates of the firm equals the discount rates for the consumers; $\beta = \tilde{\beta}$ and the value of the firm would equal the price of the firm's shares, $\tilde{V}(k,z) = V(k,z)$. Given this information, the consumer problem can be simplified into a static problem (Gomes, 2001) where in every period, a consumer chooses consumption and labour supply to maximise utility:

The static problem of the household:

$$\max_{c,\ell \geqslant 0} U(c, 1-\ell)$$

s.t. $c = w\ell + \pi(\mu, B; w)$

3.4 Stationary Competitive Equilibrium

A stationary competitive equilibrium is a set of:

1) Quantities $(L^s, C, k(k, z; w), \ell(k, z; w), x(k, z; w))$ and prices, w such that:

(i) Given wage rate, w, the representative household chooses consumption, $C(w, \pi(\mu, B; w))$ and labour supply $L^s(w, \pi(\mu, B; w))$ to maximise the static consumption problem

(ii) Given wage rate w, a firm chooses capital, $k(k, z; w)$, labour, $\ell(k, z; w)$ and whether to enter/exit, $x(k, z; w)$ to maximise their value, $V(k, z; w)$

2) Aggregate quantities, $Y(\mu, B; w)$, $L(\mu, B; w), I(\mu, B; w)$ and $\Lambda(\mu, B; w)$ such that the labour and goods market clears

3) A stationary measure, μ of firms and a level of entry, B such that the firm decision rules and the free-entry condition is satisfied

4) Markets clear:

(i) Market for labour clears: $L^s(w, \pi(\mu, B; w)) = L^d(\mu, B; w)$

(ii) Economy's resource constraint: $C(w, \pi(\mu, B; w)) = Y(\mu, B; w) - I(\mu, B; w) - \Lambda(\mu, B; w)$

4. Calibration

We calibrate the model by first assuming functional forms for variables described in Section 3, after which we will specify values for parameters used for the numerical exercise.

4.1 Functional Forms

To model household preferences, we follow Gomes (2001) and adopt a simple logarithmic utility function (Hansen, 1984):

1) Preferences: $U(c, \ell) = log(c) + H(1 - \ell)$

where H refers to the share of workers in the population. This is set to 0.6 - the fraction of employed workers in the labour force, following Gomes (2001).

2) Production function: $y = A\varepsilon^z k^{\alpha_k} \ell^{\alpha_\ell}$, where $0 < \alpha_\ell + \alpha_k < 1$

The production technology is assumed to take a Cobb-Douglas form. The inputs to production, capital k and labour ℓ are assumed to feature decreasing returns to scale properties (Burnside, 1996). Aggregate productivity, A is set to 1.

3) Stochastic process of productivity: $z' = \rho z + \varepsilon'$

Idiosyncratic productivity, z is assumed to follow an AR(1) process. z is discretized using the Tauchen and Hussey (1991) procedure to a 11 state Markov chain ($n_z = 11$). The initial distribution of entrants is assumed to be uniform, $\phi(z) = 1/n_z$.

4) External Financing: $\lambda = \lambda_0 + \lambda_1 \times EI$

where EI refers to the cost of issuing external finance. The external financing function is assumed to increase linearly with the issued amount. λ_0 and λ_1 reflect fixed and variable cost of external financing. Following from this, the external financing functions for firms with sufficient collateral and without sufficient collateral take the form:

4.1) External Financing (Sufficient Collateral): $\tilde{\lambda} = \tilde{\lambda_0} + \tilde{\lambda_1} \times EI$

4.2) External Financing (Insufficient Collateral): $\hat{\lambda} = \hat{\lambda_0} + \hat{\lambda_1} \times EI$

The risk premium is expected to be embedded in $\hat{\lambda_0}$ and $\hat{\lambda_1}$, where these parameters are expected to take on larger values compared to $\tilde{\lambda_0}$ and $\tilde{\lambda_1}$. To calibrate $\tilde{\lambda_0}$ and $\tilde{\lambda_1}$, we follow values reported in Gomes (2001) [11]. $\hat{\lambda_0}$ and $\hat{\lambda_1}$ are obtained by regressing interest payments on a one-period change

[11] We compared the results with Gomes (2001), with our empirical results in Section 2. The parameters are adjusted

in debt issued (t-1) for the bottom 40% percentile of firms (sorted by PPE to Total Assets) in COMPUSTAT (details provided in Section 2).

4.2 Parameters

Table 3 reports the parameter values for the general parameters used in this numerical analysis:

Table 3 – Parameter Values

Parameters		
Technology		
α_k	0.3	Degree of returns to scale in capital
α_l	0.65	Labour share
δ	0.145	Investment to capital ratio
Preferences (Hansen, 1985)		
β	1/1.065	Interest rate
H	0.6	Employment share
Productivity shock process (Gomes, 2001)		
ρ	0.762	Persistence in investment
σ	0.0352	Cross sectional variance in investment
Financing Costs		
Firms with sufficient collateral (Gomes, 2001)		
$\tilde{\lambda}_0$	0.08	Fixed financing cost
$\tilde{\lambda}_1$	0.28	Variable financing cost
Firms without sufficient collateral (Calibrated)		
$\hat{\lambda}_0$	0.16	Fixed financing cost
$\hat{\lambda}_1$	0.41	Variable financing cost
$\bar{k}_{min}$	$0.4 * k_{grid}$	Bottom 40% of firms on the capital grid

5. Results and Discussion

Results from the numerical analysis are presented in Table 2. Two models are simulated: One with collateral requirements and a benchmark, where collateral constraints do not bind. The results for

according to the difference in scale. As an example, in the debt regression, the constant term was double for the bottom 40% of firms, while the intercept value was 1.45 times larger for the bottom 40% of firms the model with collateral requirements are analysed against the benchmark model. The benchmark model assumes that all firms are charged the same external financing cost, $\tilde{\lambda}$ (the lower value), irrespective of their collateral backing.

Table 4 – Model Results

Model Output		
Variable	Benchmark (No Collateral)	Collateral Requirements
Aggregates		
Output (Y)	0.6510	0.5977
Investment (I)	0.1254	0.1260
Capital (K)	0.8648	0.8690
Total Finance (Λ)	0.0017	0.0145
Cutoff Productivity (z^*)	0.8614	0.8991
Entrants (B)	6.1506	5.9006
Ratios		
Investment share (I/Y)	0.1926	0.2108
Share of Financing Cost (Λ/Y)	0.0026	0.0242

Collateral requirements are shown to have an adverse effect on aggregate output (Output declines by 8.2% relative to the baseline). On the contrary, investment increases in the economy - probably reflecting an increase in aggregate capital stock (Firms with more collateral invest more: Gan (2007); Chaney et al (2012)). This mirrors the conclusions obtained by Huang et al (2017) whereby; adding a formal collateral constraint on debt financing reduced aggregate output by 11%. This can be explained by the misallocation of resources, where a tighter collateral constraint reallocates resources towards firms with higher collateral (higher capital stock). Reduction in firm entry in the model (level of entrants decline by 4.1%) implies that smaller and younger firms are priced out of the market, due to the higher cost of external financing. The fact that these firms are most affected by financing constraints is supported by existing research (eg. Gertler and Gilchrist (1994), Guariglia (2008), Bottazzi et al (2014)). The lowering of aggregate output as a result - implying that the entrants that were excluded from the market are generally more productive. This is supported by the literature, where high growth young firms (also known as gazelles), contribute to output growth and job creation (Lopez-Garcia and Puente, 2012). This explains the overall reduction in output following the entrant's decision to stay out of the market as a result of a higher cost of external financing.

6. Conclusion

In this chapter, we have shown empirically that US firms with insufficient collateral backing face higher cost of debt and equity financing. The results from the empirical section was used to motivate the theoretical model, which was an extension of Gomes (2001), such that firms without sufficient collateral backing are charged a higher cost of external financing.

Introducing higher costs of external financing for firms without sufficient collateral backing is shown to depress aggregate output. This is due to lower firm entry, as the higher cost of external financing priced out high productivity, potential entrants in the model. This result is similar to what was found in Huang et al (2017).

In the next chapter, we aim to explore further how financial constraints affect entrepreneurship decisions. This will be done through simulating a model with households as the main decision maker (as opposed to firms in this chapter).

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Appendix

Figure 1: US: Bank Loans Secured by Collateral

(% all loans)

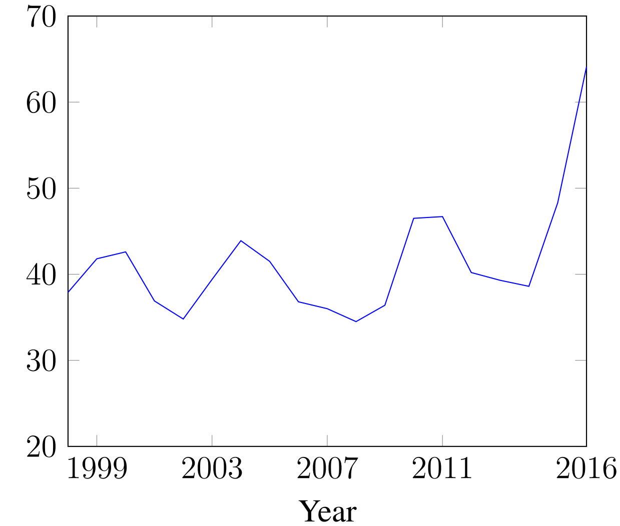

Figure 2: Developing Countries: Corporate Loans Requiring Collateral

(% all loans)

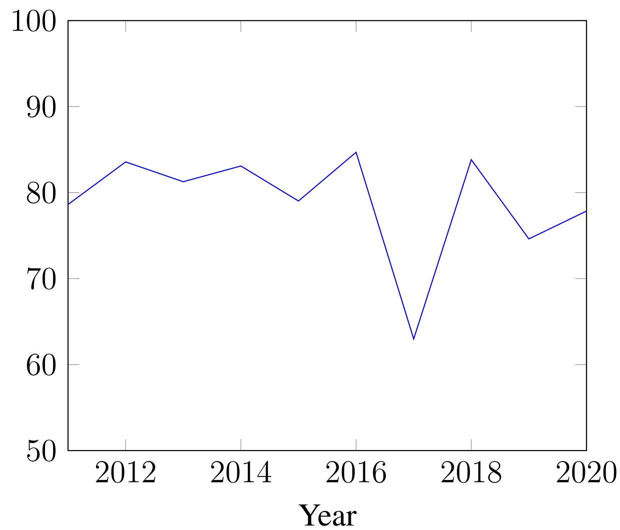

Table 3 - Summary Statistics for Debt/Equity Finance Cost

Equity financing			
Variable (Dividend payments/Shares outstanding)	**Mean**	**Std Dev**	**Observations**
Bottom 40th percentile (PPE/Total Assets <0.08)	0.4326	12.73	21,314
Top 60th percentile (PPE/Total Assets >0.08)	0.1395	17.26	32,258
Debt financing			
Variable (Interest payments/Debt Outstanding)	**Mean**	**Std Dev**	**Observations**
Bottom 40th percentile (PPE/Total Assets <0.08)	1.107	40.14	10,507
Top 60th percentile (PPE/Total Assets >0.08)	0.3903	8.469	26,852

Chapter 3: Corporate Tax, Entrepreneurship and Financial Frictions

Rachel Cho *

VERY PRELIMINARY, PLEASE DO NOT CITE

October 2022

Abstract

An economic environment which encourages entrepreneurial activity among high ability individuals is crucial for economic prosperity. Prospective asset poor entrepreneurs face two main barriers to entry: (i) Wealth barrier and (ii) Distortionary government policies - this is modelled as corporate taxes in this paper. This paper simulates a model with occupational choices, calibrated to the UK economy to analyse the effect of a rise in corporate taxation. We show that the UK government's plans to raise corporate tax by 6% by April 2023 lowers the prospective profits of the entrepreneur which discourages high ability, asset poor individuals from entering into entrepreneurship. These displaced individuals join the labour force, exerting downward pressure on wage rates as a result of higher labour supply. Lower incomes in the economy affects economic activity, decreasing aggregate consumption and output. However, policies aimed at improving access to finance could potentially enable high ability, asset poor individuals transition into entrepreneurship which reverses the adverse effects of higher corporate taxes.

Keywords: corporate tax, financial constraints, financial economics

JEL Codes: C63, G30, H25

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1. Introduction

Entrepreneurial activity has been recognized as a crucial engine to economic performance (Audretsch (1995); Caves (1998); Davidsson et al., (2006); Sutton, (1997)). The main driving force linking entrepreneurship to sustained economic growth is the process of *creative destruction* (Schumpeter, (1934, 1950)). The Schumpeterian process of creative destruction emphasizes the role of the entrepreneur as the primary driver of economic development. The innovating entrepreneur challenges incumbent firms by introducing new inventions that make current technologies obsolete. Subsequent theoretical and empirical literature has further built on Schumpeter's model of creative destruction to entangle the process of innovation and economic development (Aghion and Howitt (1992); Klette and Kortum (2004); Lentz and Mortensen (2008); Akcigit and Kerr (2010)).

While Schumpeter (1950) generally focuses on the innovative activity of large firms, attention has shifted mainly to the role of smaller firms. In recent decades, a combination of technological change and deregulation reduced entry costs, allowing the industry structure to shift towards a greater role for small firms (Thurik, 2009). In 2021, Small and Medium Enterprises[1] (SMEs) accounted for 99% of total businesses in both US and UK. The high concentration of small firms in the economy implies that small firms are the source of considerable innovative activity, stimulating industry evolution and creating new jobs (Acs and Audretsch (1990) and Audretsch (1995)).

This paper evaluates the contribution of small firms on economic activity. We refer to small firms as low wealth entrepreneurs in this paper. Our contribution to the wider literature on small firms and innovative activity is twofold: Firstly, we abstract from a 'Schumpeter' kind of model which focuses on creating more product varieties - also known as Product R&D in the literature. Our model focuses more on Process R&D, where entrepreneurs with higher ability/productivity are more efficient in producing output. We achieve this by embedding entrepreneurial ability into a Cobb-Douglas production function with a span of control (Buera and Shin, 2013). Secondly, we perform a numerical analysis to study the effects of a recent policy change on low wealth entrepreneurs in

[1] Defined as firms having fewer than 500 employees

the UK economy. In order to perform this counterfactual, we utilize a dynamic general equilibrium model with financial frictions and corporate taxation.

There are two major constraints facing a prospective entrepreneur. Low wealth entrepreneurs, especially, are confronted with a wealth barrier. Empirical literature has found a significant, positive relationship between a potential entrepreneur's initial wealth and entry into entrepreneurship (Evans and Jovanovic (1989), Hurst and Lusardi (2004)). The decision to become an entrepreneur therefore relies heavily on a prospective entrepreneur's access to external financing.

Financing barriers to entrepreneurship could have major implications on the macroeconomy. Theoretically, the role of financial intermediaries in pooling excess savings from savers to borrowers could be beneficial to long term economic prosperity by efficiently reallocating capital to it's most productive uses (King and Levine, 1993). Financial systems are crucial in channeling savings to the most productive activities and are therefore, crucial engines to economic growth. On the contrary, financial constraints, in the form of any exogenous shock or institutional deficiencies, would be damaging to economic activity. This would result in a misallocation of capital, which could lead to a slowdown in growth.

Another barrier confronting a prospective entrepreneur are government policies, which could either encourage or discourage entrepreneurship activity. In this paper, we look especially at corporate tax policy - which could depress earnings of a prospective entrepreneur. While taxes are undoubtedly a key government instrument to finance public goods and services to achieve greater equality in the economy (Chen et al, 2002), the burden of taxation (particularly corporate taxes) can also affect economic growth by discouraging investment and entrepreneurial incentives (Engen and Skinner, 1996). In UK, the government has announced an increase in corporate tax rates from 19% to 25% by April 2023. In this paper, we show that the increased tax rates can have an adverse effect on entrepreneurial incentives, which leads to a slowdown in economic activity.

We study the interaction of these two constraints in the context of the UK economy and it's effects on entrepreneurship decisions in a dynamic general equilibrium model with occupational choice and financial frictions. We find that in this model setup, higher corporate taxes discourage high ability, low wealth entrepreneurs from entering into entrepreneurship. This leads to an overall decline in aggregate output in the model. However, improving access to finance for high ability, low wealth entrepreneurs can more than offset these adverse effects.

The next section will briefly introduce some facts to highlight the importance of small firms in UK and highlight current challenges they face in the context of the corporate tax and financing environment, before delving into the model environment and calibrations.

2. Background

In the recent decades, small firms in UK have been key players in driving innovation, wealth creation and economic growth (Matlay, 2004).

2.1. Development of Small Firms in UK

A thriving ecosystem is essential to enable the growth of small firms in any economy. Given the importance of SMEs, the UK government has been actively involved in initiating a vast array of support policies aimed at encouraging the creation of small businesses (Hussain et al, 2006). In 1971, the Small Firms Division was established within the Department of Trade and Industry, which is responsible for the implementation of policy towards the development of small firms in the UK economy. The Small Firms Division has been working closely with the research community to analyse the needs of small businesses. In 2004, the Small Firms Division identified 7 strategic key themes[2] to encourage the growth and development of small firms. Among the 7 key themes highlighted in the document includes, creating a dynamic and enabling environment for small, start up firms, as well as improving access to finance for small entrepreneurs.

The enabling government policies created an environment which allowed entry and development of small firms in UK. By 2014, SMEs accounted for 99.9% of all private businesses in UK and 59.3%

[2]Environment and Planning C: Government and Policy 2004, volume 22, pages 775-777

of private sector employment[3]. Small businesses in UK continue to face significant challenges on access to external finance (Owen et al, 2022). This was especially difficult during the Covid pandemic, where a third of SMEs in UK reported that they were unable to obtain financing, or were offered less than the amount they requested (SME Finance Survey, 2021). As a result of the pandemic and inability of obtain financing, 80% of SMEs in UK reported to have contracted in 2020.

As the UK economy recovers from the pandemic, it's important for government policies to facilitate small businesses in remaining competitive in the market, to prevent further business contractions. However, the government recently announced a sharp increase in corporate taxation, which may further impact the profitability of SMEs in UK.

The next subsection discusses the evolution of UK's corporate tax and financing environment over the past decade. We briefly discuss the implications of a 6% in corporate taxation on small businesses.

2.2. UK's Corporate Tax and Financing Environment

UK's corporate tax rates have recorded steady declines since the Global Financial Crisis in 2008 (Figure 1) in an attempt to boost private investment. It was further reduced in 2018 to 19% - the lowest rate in 10 years, to encourage firms to invest post-Brexit. The Covid pandemic in 2020 further accentuated business uncertainty, where 6.5% of small businesses were recorded to permanently close[4] during the lockdown. As a result, the UK government continued to keep corporate tax rates at 19%, as Covid restrictions were eased in 2021 to prevent further business shutdowns. Corporate tax rates were kept at 19% until 2022. Corporate tax rates are set to rise for the first time in more than 10 years in 2023, to 25%.[5] This 6% increase in corporate tax rates would reduce the profits of a prospective entrepreneur in the UK. This would affect the going concern of small businesses,

[3] BSI (UK's UK's National Standards Body) UK SME Landscape and Standardization Research

[4] UK Federation of Small Businesses, 2021

[5] The UK government announced on 14th October 2022 that all business with operating profits higher than £250,000. Firms with operating profits less than £50,000 will continue paying 19%.

especially (e.g. low wealth entrepreneurs).

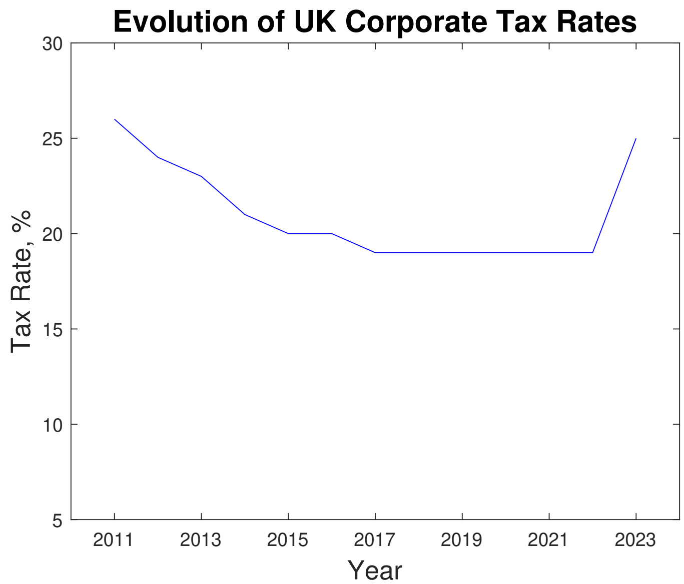

Figure 1 – Time Series of UK Corporate Tax Rates (2011-2023)

It's crucial to ensure that the contractionary fiscal policy is offset/balanced out by another enabling policy to prevent further shutdowns of small businesses. As an example, UK policymakers could experiment with policies to improve low wealth entrepreneurs access to finance to counteract the effect of higher taxes. Low wealth entrepreneurs especially, would require access to external financing to overcome the wealth barrier. However, some lenders require the prospective entrepreneur to put up collateral (Figure 2), as an insurance against business failure. The need for collateral implies that high productivity but asset poor individuals may struggle to get access to external financing. The financing environment seems to be improving for small businesses in UK - Figure 2 illustrates that fewer lenders are requiring collateral for loans extended to small businesses in recent years.

As the prospective low wealth entrepreneur faces higher tax rates by 2023, a more enabling financial environment is crucial to ensure that low wealth, highly productive individuals continue to obtain the capital they need to continue in/or start a business. In this paper, we show that high ability, low wealth entrepreneurs would be most affected by the hike in the corporate tax rates. However, alleviating financial constraints could help to mitigate the adverse effect from higher tax rates.

The next section will introduce the theoretical framework used to study the effect of financial con-

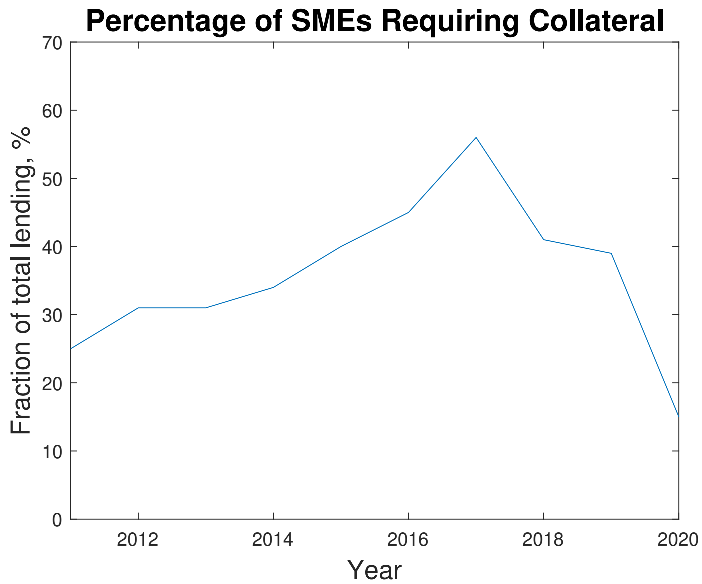

Figure 2 – Fraction of UK SMEs Requiring Collateral for Financing (2011-2020)

straints and higher tax rates on entrepreneurial decisions and macroeconomic variables.

3. Model Environment

The theoretical model, similar to Buera and Shin (2013), is one which encompasses individual-specific technologies with imperfect financial markets. We do not consider taxation in this section, but would be introduced in later sections (in the form of a tax on entrepreneur profits). Individuals endogenously choose to be either (i) Workers or (ii) Entrepreneurs. Individuals live indefinitely, and choose consumption and asset holdings to maximise lifetime utility, based on the equation below:

$$\max_{\{c_s,a_{s+1}\}} \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{c_s^{1-\sigma}-1}{1-\sigma}$$

subject to

$$c_s + a_{s+1} \leq \max\{w_s e_s^{\theta}, \pi(a_s, e_s; r_s, w_s)\} + (1+r_s)a_s$$

Individuals discount their future utility using the same discount factor, β. They are heterogeneous with respect to their wealth, a and their ability, e, the former being chosen endogenously by forward looking saving decisions. Each individual possesses a predetermined level of ability, e, which then evolves according to a Markov process. It is assumed that the individual's ability level, e is known to the respective individuals.

Given their ability level, e, individuals endogenously decide to be workers or entrepreneurs. Workers earn a wage which depends on their ability[6] - we^{θ}, where $\theta \geq 0$. A more productive worker is paid more, compared to a less productive worker. Entrepreneurs keep their profits, π, and decide to consume, save or reinvest their earnings. Individuals endogenously decide to be entrepreneurs, if: (i) The profits they earn as entrepreneurs exceed the wages they earn as workers, $\pi > we^{\theta}$, for a given level of e; and (ii) They are wealthy enough to overcome the wealth constraint. The 2nd condition implies that without the aid of financial intermediaries, only wealthy individuals can afford to become entrepreneurs. Low wealth entrepreneurs can possibly overcome these wealth constraints by borrowing from a financial intermediary.

Entrepreneurs produce using the following Cobb-Douglas technology:

$$f(e_s, k_s, \ell_s) = A_{\psi} e_s (k_s^{\alpha} \ell_s^{1-\alpha})^{(1-\nu)}$$

where ν is the span of control parameter - $(1-\nu)$ represents the share of output that goes to variable factors.

A_{ψ}, is determined endogenously. This represents the knowledge spillovers from entrepreneurial ability, and depends on the distribution of ability within the population. We strictly follow the functional form introduced in Buera and Shin (2013). This is defined to be:

[6] In Buera and Shin (2013), workers earned a fixed wage equal to w, regardless of their productivity

$$A_\psi = \max_{e_m, 0<\iota\leq 1} \left[\sum_{e>e_m} \psi(e)e^{1/\nu} + \iota\psi(e_m)e_m^{1/\nu} \right]^\nu \times \left[\sum_{e<e_m} \psi(e) + (1-\iota)\psi(e_m) \right]^{(1-\nu)(1-\alpha)}$$

where e_m is the ability of the marginal entrepreneur

$\psi(e)$ is the ergodic Markov distribution of ability, ι refers to the selected fraction of marginal ability types who choose to be entrepreneurs.

Financial Intermediation - Productive capital is the only asset used for production in this economy. There is a perfectly competitive financial intermediary that receives deposits, a from the individuals and rents out capital k to the entrepreneur. The amount an entrepreneur is able to borrow for capital rental is limited by a collateral constraint, $k \leq \lambda a$. λ measures the degree of financial frictions - $\lambda = \infty$ - perfect financial markets and $\lambda = 1$ signals financial autarky - all capital is self-financed by entrepreneurs.

The amount of credit an individual can get is limited by the individual's financial wealth, a. The focus is on within period credit - capital rental for production purposes. We impose a constraint which does not allow households to borrow for intertemporal consumption smoothing purposes, that is, $a \geq 0$.

The collateral constraint can be derived from the following limited enforcement problem. An individual with a wealth of $a \geq 0$ is able to rent k units of capital, and can abscond with a fraction $1/\lambda$ of the rented capital. The only cost of default, is that the entrepreneur loses the amount, a, deposited into the intermediary. We assume no 'reputational cost' of default in this model, such that the 'defaulter' will be able to continue as an entrepreneur or change occupations to a worker.

In equilibrium, the financial intermediary will rent out capital only to the extent that no individual will have an incentive to default, such that $k/\lambda \leq a$.

3.1. The Individual's Problem

The individual's problem is dynamic and recursive. This can be summarised in the Bellman equation below:

$$V(e_s, a_s; w_s, r_s) = \max_{a_{s+1}} \{U\left(M(e_s, a_s; w_s, r_s) + (1 + r_s)a_s - a_{s+1}\right) + \beta \mathbb{E}_{a_{s+1}} V(e_{s+1}, a_{s+1})\}$$

where $V(e_s, a_s; w_s, r_s)$ refers to the value function. Solving the value function gives the policy function for the asset control, $a_{s+1} = g(e_s, a_s)$.

The function $M(e_s, a_s; w_s, r_s)$ represents the choice function in the individual's budget constraint, $\max\{we_s^\theta, \pi(a_s, e_s; r_s, w_s)\}$. Individuals endogenously decide to be workers or entrepreneurs, contingent on their ability and asset levels, e_s and a_s, for a given level of wage, w and interest rate, r.

Individuals choose to become entrepreneurs only if their ability, $e_s(a)$ is high enough. There is a lower bound of $\underline{e_s}(a)$, such that individuals with $e_s(a) > \underline{e_s}(a)$ start transitioning into entrepreneurship, provided a is large enough.

Type $e_s(a)$, where $e_s(a) > \underline{e_s}(a)$ decide to be entrepreneurs if they are able to overcome the wealth barrier. Technically, type $e_s(a)$ individuals will become entrepreneurs so long as $\pi(a_s(e_s), e_s; r_s, w_s) > we_s^\theta$. For a given level of ability, $e_s(a)$, there is a lower bound level of wealth, $\underline{a_s}(e_s)$, where an individual is indifferent between being an entrepreneur and a worker. This lower bound wealth level, $\underline{a_s}(e_s)$ solves:

$$\pi(\underline{a_s}(e_s), e_s; w_s, r_s) = we_s^\theta$$

An individual's productivity may be so low, $e_s < \underline{e_s}$, that he never chooses to become an entrepreneur. In this case, $\underline{a_s}(e_s) = \infty$.

3.2. The Entrepreneur/Firm's Problem

The firm maximises profit every period. The profit function is given below:

$$\pi(a_s, e_s; r_s, w_s) = \max_{\ell_s, k_s \leq \lambda a_s} \{A_\psi e(k_s^\alpha \ell_s^{1-\alpha})^{(1-\nu)} - w_s e_s^\theta \ell_s - (r_s + \delta)k_s\}$$

The entrepreneur chooses 2 variable inputs to production, capital, k and labour, ℓ, such that profits, π are maximised. The entrepreneur has a choice of self-financing his/her investment, k, or borrowing from the financial intermediary, λa.

Optimal capital, k and labour, ℓ choices for the individual entrepreneur correspond to:

$$k_{i,opt} = \left[\frac{\alpha(1-\nu)e}{r+\delta} \ell_{i,opt}^{(1-\alpha)(1-\nu)} \right]^{\frac{1}{1-\alpha(1-\nu)}}$$

$$\ell_{i,opt} = \left[\frac{e(1-\alpha)(1-\nu)}{we^\theta} \right]^{\frac{1-\alpha(1-\nu)}{\nu}} \left[\frac{\alpha(1-\nu)e}{r+\delta} \right]^{\frac{\alpha(1-\nu)}{\nu}}$$

The optimal wage rate, w, is chosen such that the labour market clears. Equilibrium r is determined by bisection - this clears the asset markets.

3.3. Equilibrium Conditions

Each individual can be described by it's current state (e_s, a_s). We denote the measure over ability and assets at time, t by $\mu_t(\mathcal{E}, \mathcal{A})$, where $\mathcal{E}$ and $\mathcal{A}$ are the state spaces for ability and assets, respectively. More formally, we define the measure μ, such that for $\forall(\mathcal{E}_t, \mathcal{A}_t) \in E \times A$, $\mu(e, a)$ denotes the mass of individuals in the state (e, a). In the following equations, we will replace the subscript $t+1$ with $'$, eg. $\mu_{t+1} = \mu'$.

Law of Motion: To solve for the stationary distribution, we first discretize the state spaces over ability and assets, where, $|\mathcal{E}| = n_E$ and $|\mathcal{A}| = n_A$. The initial distribution over the states of assets and ability, $\mu_0(e, a)$, is assumed to follow a uniform distribution:

$$\mu_0(e,a) = \frac{1}{n_E n_A}$$

$\forall e \in \{1, ...n_E\}$ and $\forall a \in \{1, ...n_A\}$

Given the initial distribution, $\mu_0(e,a)$, the equation for the law of motion takes as inputs: $a' = g(e,a)$ - the policy function (solution to the value function iteration for the individual's problem), $\mu(e,a)$ - the current distribution and $p(e'|e)$ - the Markov transition probability. The exact law of motion is then defined as:

$$\mu'(e',a') = \int_0^{\bar{a}} \int_0^{\bar{e}} \mathbb{1}_{a'=g(e,a)} p(e'|e)\mu(e,a) deda$$

$\bar{e}$ and $\bar{a}$ refers to the respective upper bounds of e and a. The equation above is iterated on to find a steady state measure of individuals. In a stationary equilibrium, $\mu' = \mu = \mu^*$. The invariant distribution, μ^* summarizes the distribution of individuals in a stationary equilibrium.

Aggregates: The aggregates for the model are defined in the equations below:

Labour Demand:

$$L_d(\mu; w, r) = \int_{\underline{a}(e;w,r)}^{\bar{a}} \int_{\underline{\mathrm{e}}(a;w,r)}^{\bar{e}} \mathbb{1}_{\pi > we^{\theta}} \ell_{i,opt}(g(e,a), e; w, r) d\mu(e,a)$$

Labour Supply:

$$L_s(\mu; w, r) = \int_0^{\underline{a}(e;w,r)} \int_0^{\underline{\mathrm{e}}(a;w,r)} \mathbb{1}_{\pi < we^{\theta}} we(\bar{a}(g(e,a); w, r), e_t; w, r)^{\theta} d\mu(e,a)$$

Aggregate Entrepreneurs:

$$Ent(\mu; w, r) = \int_{\underline{a}(e;w,r)}^{\bar{a}} \int_{\underline{\mathrm{e}}(a;w,r)}^{\bar{e}} \mathbb{1}_{\pi > we^{\theta}} \mu(\bar{a}(g(e,a)); w, r) d\mu(e,a)$$

Aggregate Assets:

$$A(\mu; w, r) = \int_0^{\bar{a}} \int_0^{\bar{e}} a'(g(e, a); w, r) d\mu(e, a)$$

Aggregate Capital Stock:

$$K(\mu; w, r) = \int_0^{\bar{a}} \int_0^{\bar{e}} k_{i,opt}(g(e, a), e; w, r) d\mu(e, a)$$

Aggregate Profits:

$$\Pi(\mu; w, r) = \int_0^{\bar{a}} \int_0^{\bar{e}} \pi(g(e, a), e; w, r) d\mu(e, a)$$

Aggregate Consumption:

$$C(\mu; w, r) = \int_0^{\bar{a}} \int_0^{\bar{e}} c(g(e, a), e; w, r) d\mu(e, a)$$

Aggregate Output:

$$Y(\mu; w, r) = \int_0^{\bar{a}} \int_0^{\bar{e}} \mathbb{1}_{\pi > we^{\theta}} f(e(g(a, e)), k_{i,opt}, \ell_{i,opt}); w, r) d\mu(e, a)$$

The equilibrium conditions of the model are defined below.

Competitive Equilibrium: Denote $\mu_t(a, e)$ as the cumulative distribution function (cdf) for the joint distribution of wealth and ability at time t. Given $\mu_0(a, e)$, a competitive equilibrium consists of allocations:

$\{c_s(a_t, e_t), a_{s+1}(a_t, e_t), \ell_s(a_t, e_t), k_s(a_t, e_t)\}_{s=t}^{\infty}$ for all $t \geq 0$, sequences of joint distribution of ability and wealth, $\{\mu_t(a, e)\}_{t=1}^{\infty}$, and prices $\{w_t, r_t\}_{t=1}^{\infty}$ such that:

1) Given $\{w_t, r_t\}_{t=1}^{\infty}$, e_t and a_t, $\{c_s(a_t, e_t), a_{s+1}(a_t, e_t), \ell_s(a_t, e_t), k_s(a_t, e_t)\}_{s=t}^{\infty}$ solves the individual and firm's problem for all $t \geq 0$

2) Labour and capital markets clear:

Labour market clearing (Labour supply = Labour demand)

$$\int_0^{\underline{a}(e;w,r)} \int_0^{\underline{\mathrm{e}}(a;w,r)} \mathbb{1}_{\pi < we^{\theta}} we(\bar{a}(g(e,a);w,r), e_t; w, r)^{\theta} d\mu(e,a)$$
$$= \int_{\underline{a}(e;w,r)}^{\bar{a}} \int_{\underline{\mathrm{e}}(a;w,r)}^{\bar{e}} \mathbb{1}_{\pi > we^{\theta}} \ell_{i,opt}(g(e,a), e; w, r) d\mu(e,a)$$

Capital market clearing (Individual asset holdings = Capital ownership[7])

$$\int_0^{\bar{a}} \int_0^{\bar{e}} a'(g(e,a);w,r) d\mu(e,a) = \int_0^{\bar{a}} \int_0^{\bar{e}} k_{i,opt}(g(e,a), e; w, r) d\mu(e,a)$$

4. Calibration

We first introduce the benchmark model, where nine parameters need to be calibrated. In the next subsection, an additional distortion is introduced, τ in the form of a tax on entrepreneur profits. We then calibrate four out of the nine parameters to match moments in the UK economy.

4.1. Parameters for Benchmark Model

The parameters for the benchmark model are listed in Table 1. Of the benchmark parameters, the values of σ, the CRRA coefficient and α, the share of capital in individual firms follows the seminal work of Buera and Shin (2013). The rest of the parameters listed in Table 1 are calibrated either exogenously (δ, ψ and ω) or endogenously (β, ν, θ, λ). We will go through details of exogenously calibrated variables in this sub-section, while endogenously calibrated variables will be elaborated further in the following sub-section.

The rate of capital stock depreciation, δ was estimated using UK's chained volume measure of capital stocks. Depreciation rate is then estimated by taking the fraction of consumption of fixed

[7]Both entrepreneurs and workers can own capital, some workers rent capital to entrepreneurs

Table 1 – Parameter Values

Parameters			
Parameter		**Value**	**Source(s)**
Preferences			
β	Discount factor for households	0.97	*Calibrated (Section 4.2)*
σ	Intertemporal elasticity of substitution (CRRA coefficient)	1.5	Buera and Shin (2013)
Production			
α	Share of capital in individual firms	0.3	Buera and Shin (2013)
δ	1 year capital depreciation rate	0.04	UK Office for National Statistics (ONS)
ν	Span of control	0.18	*Calibrated (Section 4.2)*
θ	Sensitivity of wages to productivity	0.25	*Calibrated (Section 4.2)*
Others			
λ	Ease of financing	3.6	*Calibrated (Section 4.2)*
ρ	Persistence of ability in population	0.85	*Estimated using UK ONS productivity data (see text)*
ω	Dispersion of ability in population	0.11	*Estimated using UK ONS productivity data (see text)*

capital to gross capital stock, averaged over a period of 10 years (from 2011-2021). The calibrated value of 0.04 reflects the 10 year average of UK's depreciation rate.

Productivity was used as a proxy for ability. In the model, ability is assumed to follow an AR(1) Markov process. Ability is then discretised using the Tauchen-Hussey (1991) procedure. Labour productivity of UK's workforce was used to estimate the persistence and dispersion of ability of UK's population. Estimates of ρ and ω are obtained from an AR(1) regression of UK's labour productivity. The regression is run following the equation below: [8]

$$e_t = \rho\, e_{t-1} + \gamma\, trend_t + \varepsilon_t$$

ρ reports the coefficient from the AR(1) regression, and ω reports the standard deviation of the AR(1) coefficient.

The remaining four parameters (β, ν, θ, λ) were calibrated to match UK moments. A simple distortion was introduced to calibrate these moments, in the form of a tax on entrepreneur profits, τ.

4.2. Introducing Distortions (Tax on Entrepreneur Profits, τ)

We first introduce a tax on entrepreneur profits in the model. This changes the profit function in Section 3.2. The after-tax profit function, would be:

$$\pi(a_s, e_s; r_s, w_s) = \max_{\ell_s, k_s \leq \lambda a_s} \{(1-\tau)(f(e_s, k_s, \ell_s) - w_s e_s^{\theta} \ell_s - (r_s + \delta)k_s)\}$$

where τ denotes the corporate tax rate.

We calibrate τ using UK's baseline corporate tax rate. In the baseline model, τ is calibrated to take the value of 0.21, which reflects the average of UK's baseline corporate tax rate from 2011-2021. Given the value of τ, we calibrate the remaining four parameters to match four moments in the UK economy. This is summarised in Table 2.

4 parameters (β, ν, θ and λ) were computed to minimise the distance between model moments and UK data moments.[9] The program was able to fit 3 out of 4 moments in Table 2 perfectly.

The first moment, after tax corporate profits to output ratio is estimated by taking the fraction of after

[8] An AR(1) model with a linear trend was run using annual UK productivity data from 1971-2020.

[9] This was computed with the help of MATLAB's fminsearch command, such that the values of the four parameters (β, ν, θ and λ) were chosen to minimize the distance between the data and model moments.

Table 2 – Calibration to UK Data

Moments	UK Data	Model
Corporate Profits After Tax to Output ratio	0.67	0.67
Capital to Labour ratio	4.1	4.1
Household Assets to Labour Income ratio	6.2	6.2
Labour Income Share	0.59	0.44

tax UK corporate profits to UK's nominal GDP. In order to be consistent with the other estimated moments (δ and τ), we take the 10 year average (2011-2021) of this moment, which resulted in a value of 0.67. Data for both after tax corporate profits was proxied using UK's Gross Operating Surplus and UK's nominal GDP was obtained from ONS.

The second moment in Table 2, capital to labour ratio is estimated by taking the fraction of UK's net capital stock data to compensation of employees. Similarly, we take the 10 year average of this moment (2011-2021), which amounts to 0.41. Data for both net capital stock and compensation of employees were taken from ONS.

The third moment, household assets to labour income ratio is estimated using the fraction of UK's household financial assets to compensation of employees. Taking the 10 year average (2011-2021) of this fraction amounted to 6.2. The data for UK household's financial assets was obtained from UK's wealth and assets survey.

The fourth moment, UK's labour income share is estimated using the fraction of compensation of employees to total income. The 10 year average (2011-2021) of this fraction amounted to 0.59. Unfortunately, the relevant model moment could not fit this value very well, resulting in a value of 0.44 instead, a deviation of 0.15 from the actual moment.

In the following section, we present results for the model, utilising these calibrated parameters. We also hope to compute some comparative statics to study the model's sensitivity to the tax rate, τ.

4.3. Numerical Strategy

Before proceeding to the results, we briefly outline the numerical strategy adopted to compute the equilibrium of the model.

The model is simulated using the following algorithm. A bisection algorithm was employed for a fixed for a range of r. Given an initial guess for r_0, and subsequently for any value of r_i given i=0,1,2,...15 (max iteration) do the following:

- Given r_i, find w_i - wage is found using a Newtonian gradient method (fsolve in MATLAB), such that $L_d = L_s$ (labour markets cleared)
- Given w_i and r_i, solve the individual firm's problem to obtain entrepreneur profits. Then, solve the individual's problem using Value Function Iteration (VFI), and obtain the policy function (a, e) that maximizes the value function.
- Aggregate the variables - find aggregates for K and L specifically
- Compute excess demand for K, if K is different from A - update the interest rate accordingly (Increase r if $K > A$, decrease r if $A > K$)
- Model is solved when an equilibrium interest rate, r^* is found. This interest rate roughly clears the asset market[10] , such that $K = A$ (Firm's capital = Household Asset Holdings)

5. Results

In this section, we first present results from the baseline model. After which, we perform a comparative statics exercise to observe changes in entrepreneurship decisions, following an increase in UK's corporate taxes from 19% to 25%.

[10] A larger convergence criterion was used to clear the asset market in the calibrated model, the convergence criterion used was 1 - the model couldn't clear using a smaller convergence criterion to match the moments. Utilizing this convergence criterion, A was larger than K by about 0.9.

5.1. Benchmark Model

We present results of the theoretical model outlined in Section 3, utilizing benchmark parameters in Section 4. Our focus is mainly to study variables affecting decisions into entrepreneurship. Enabling productive individuals select into entrepreneurship is crucial for the macroeconomy as it enables output to be produced in a more efficient way and aids with job creation (Meh, 2005). In addition, efficient use of resources (capital and labour) by productive entrepreneurs also help drive economic growth (King and Levine (1993), Levine (1997)). In the model environment (described in the previous section), a prospective entrepreneur faces two barriers to entrepreneurship:
(i) Wealth Barrier, which could be overcome through self financing using the individual's initial wealth, a or by borrowing from the financial intermediary (the amount that can be borrowed depends on, λ, the parameter measuring the degree of financial frictions)
(ii) Government Policies - This is modelled as corporate taxation, τ, which depresses entrepreneur profits. This is calibrated to 21% in the baseline model.

As corporate taxes functions to depress profits of a prospective entrepreneur, this would affect occupational choice in the model. All things constant, this wedge created by taxing entrepreneur profits would discourage highly productive, but low wealth individuals from entering the market for entrepreneurship (Chen et al, 2002). These highly productive individuals would choose to join the labour market instead if they could earn a higher income there, as wages are scaled to productivity - we^{θ}. Figure 3 illustrates the relationship between prospective profits and labour income (wages) by productivity.

In the model, θ was calibrated to be 0.25, which is less than 1. Income derived from labour increases in a concave fashion, relative to productivity (Figure 3). This imperfect relationship between wages and productivity matches recent research which posits the decoupling of wages and productivity in UK (Teichgräbber and Reenen, 2021). In contrast, the relationship between average entrepreneur profits[11] and productivity increases in a convex manner. This matches the findings of existing literature that it's only profitable for highly productive individuals to select into entrepreneurship (Evans

[11] Profits were averaged across the asset grids

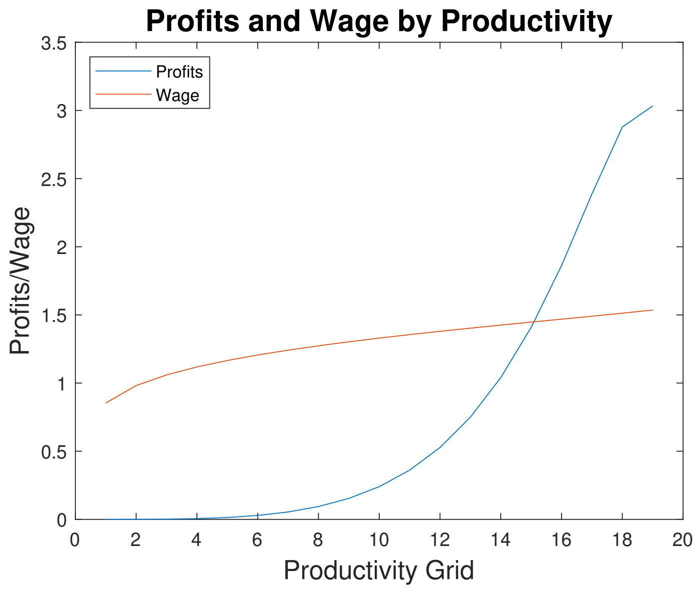

Figure 3 – Average Entrepreneur Profits vs Wage

and Jovanovic (1989); Hurst and Lusardi (2004)). In the simulated model, the productivity of the marginal entrepreneur was recorded at the 15th productivity grid. This implies that individuals from the 15th to 20th productivity grid can transition into entrepreneurship, provided that they can overcome the wealth barrier. Figure 4 confirms that entrepreneurs are mostly made up from the highest two productivity quantiles.

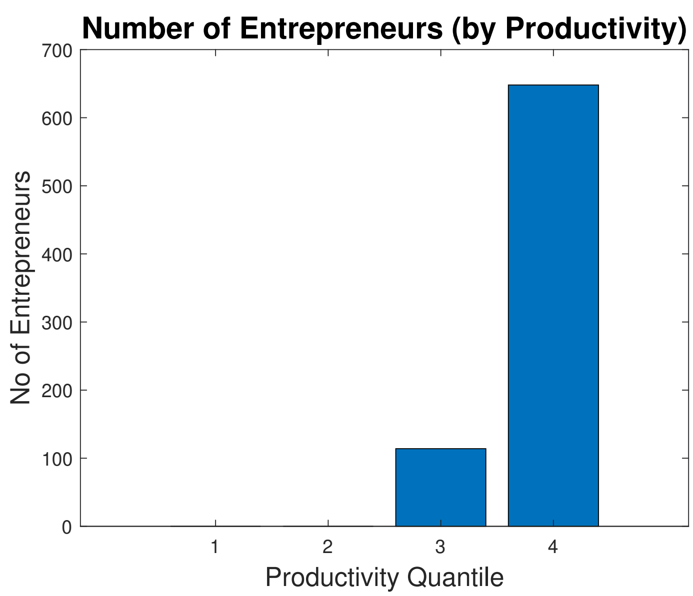

Figure 4 – No of Entrepreneurs by Productivity

Figure 5 displays the asset holdings of these high productivity entrepreneurs in the model. The first asset quantile has the lowest number of entrepreneurs, implying that some high productivity individuals are unable to overcome the wealth barrier. This finding corroborates existing literature which posits that capital constraints are one of the biggest factors impacting potential entrepreneurs globally (Kerr and Nanda, 2009). Overcoming the wealth barrier is therefore crucial to enable high productivity, asset poor individuals select into entrepreneurship. A well-functioning financial system would help prospective entrepreneurs to access the required capital needed to finance their business. The parameter measuring ease of access to capital is λ. A higher value of λ implies reduced financing constraints, enabling low wealth, high productivity individuals access the capital they need for production.

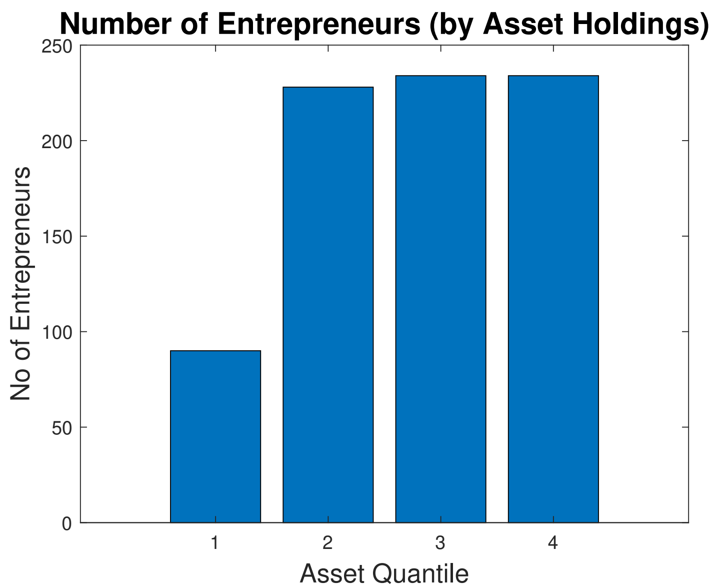

Figure 5 – No of Entrepreneurs by Asset

If the prospective entrepreneur can sufficiently overcome the wealth barrier, either through self-financing, or borrowing from the financial intermediary, the entrepreneur then rents capital and hires labour and translates these into output. Figure 6 shows that more productive individuals can transform these capital into output more efficiently, and this process, in turn, drives economic growth. Simulations from the model shows that individuals in the higher productivity grid (`prod_17` to `prod_19`) are better able to overcome the wealth barrier - they can select into entrepreneurship at lower asset levels, and cumulatively hold more capital at equilibrium.

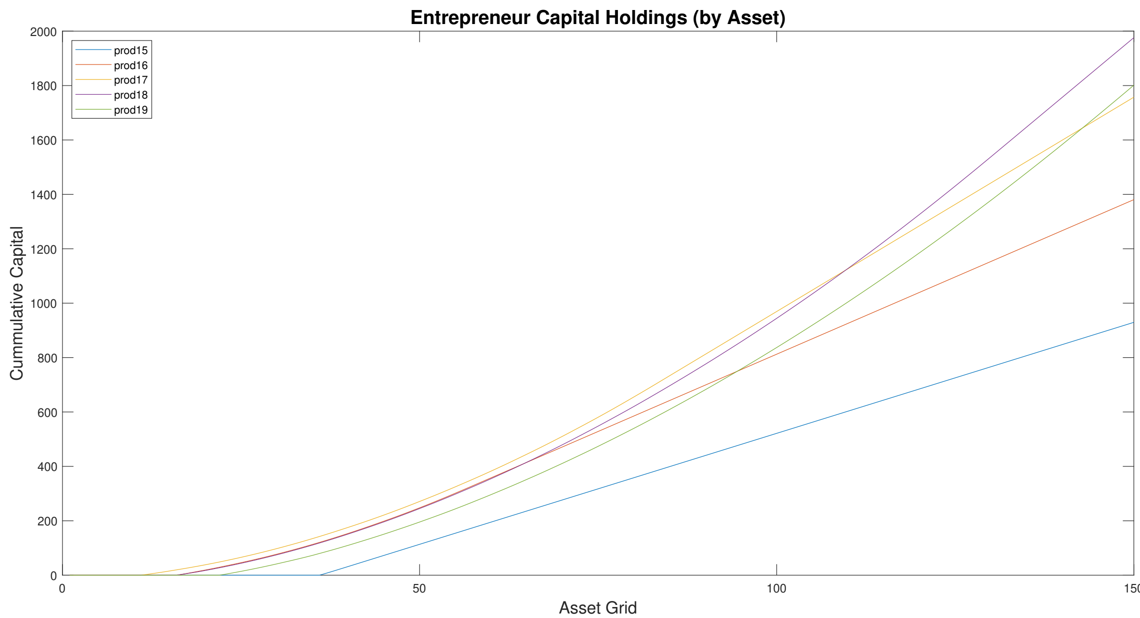

Figure 6 – Cummulative Capital Stock by Productivity

Table 3 reports the aggregates. A higher capital stock implies higher output in the economy. The next section will present results from a comparative statics exercise, studying the effect of an increase in UK's corporate tax rates from 19% to 25%.

Table 3 – Model Output: Aggregates

Aggregates		
Capital, K	Consumption, C	Output, Y
3.96	2.49	2.61

5.2. Comparative Statics: Effect of a Corporate Tax Increase

The UK government announced that the main corporate tax rate will be increased in April 2023 from 19% to 25%. Given the recent increase in energy cost, this 6% increase in taxes would be an added cost burden, especially for smaller entrepreneurs. In this model, increasing corporate tax rates have 2 opposing effects on capital stock: (i) Discourages incorporation of small firms - this decreases capital stock in the economy (Chen et al, 2002); (ii) Redistributes capital to higher productivity entrepreneurs - which could potentially increase capital stock (Meh et al, 2005). The net effect on aggregate capital stock in the economy would depend on whether effect (i) or (ii) dominates.

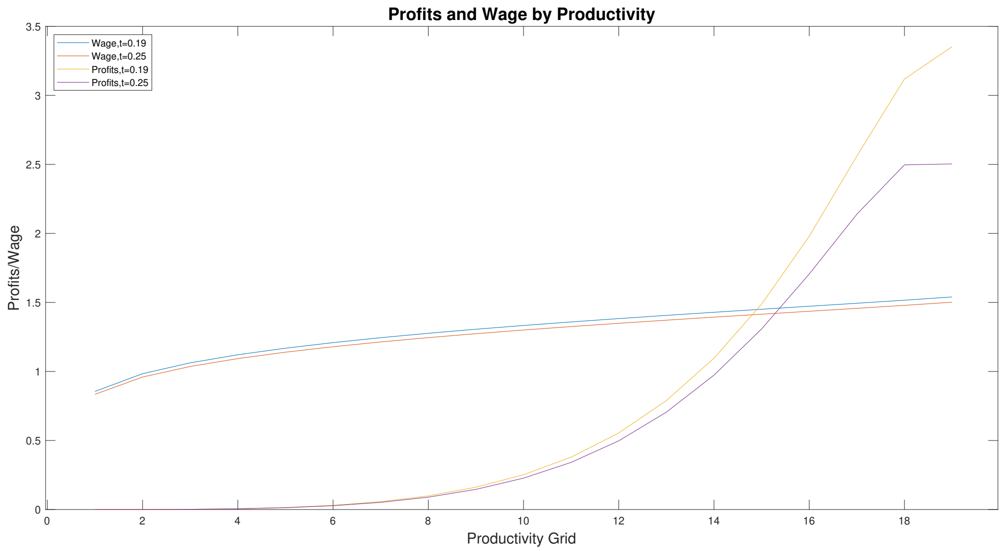

Figure 7 – Average Entrepreneur Profits vs Wage

Figure 7 illustrates the simulated wages and profits from the model for the different tax rates. Raising τ from 0.19 to 0.25 shifts both the wages and profits curve downward, such that both wages and profits are lower for every level of productivity. Lower profits would discourage low wealth prospective entrepreneurs from producing, who would choose to join the labour market instead. Increased labour supply (Appendix Figure 1) as a result of the occupational shift puts a downward pressure on labour income, depressing wages. On the other hand, the 6% tax increase raises the barrier to entry, sieving out entrepreneurs of lower productivity[12] (Figure 8). Figure 8 shows that entrepreneurs in the higher tax regime are therefore, more productive on average. However, the higher tax regime has also induced a few entrepreneurs in the highest productivity quantile to exit the market.

The majority of prospective entrepreneurs forced to exit as a result of higher taxes are possibly from the lowest wealth quantile. This is illustrated in Figure 9, where the number of entrepreneurs in the lowest asset quantile was more than halved in the higher tax regime (tax25). This finding was

[12]The higher tax regime excludes entrepreneurs in the 15th productivity grid altogether, raising the productivity of the marginal entrepreneur in the model to the 16th productivity grid.

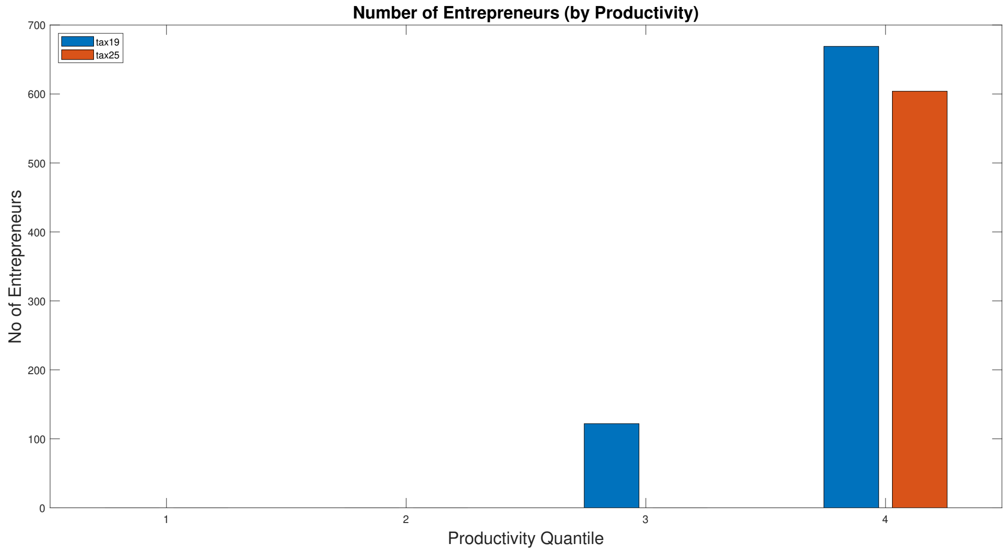

Figure 8 – No of Entrepreneurs by Productivity

corroborated by Chen et al (2002), who found that taxation on corporate profits are more likely to discourage the incorporation of small firms. Larger firms are also affected by the higher tax rate in the model, but are less likely to exit. We therefore recorded exits of a smaller magnitude in the higher asset quantiles (Figure 9).

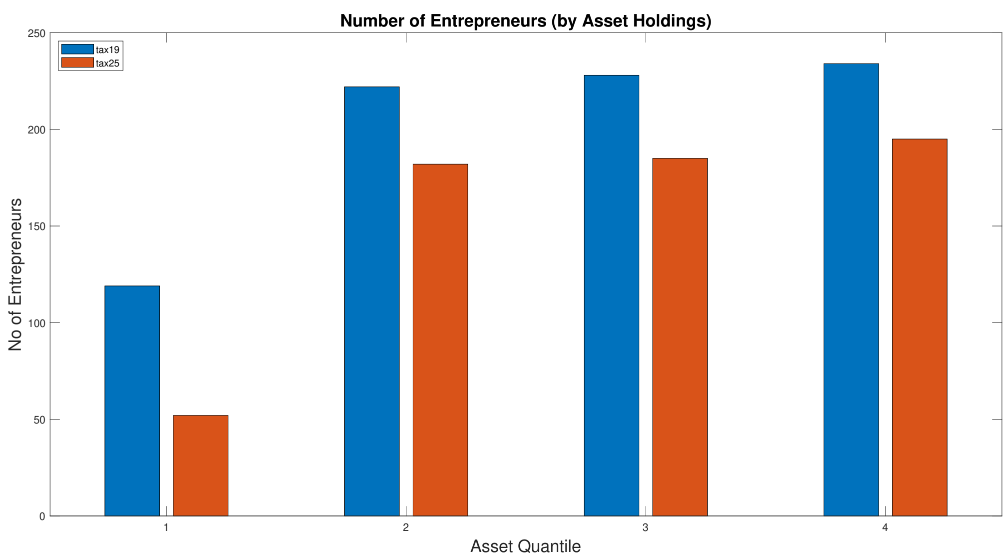

Figure 9 – No of Entrepreneurs by Assets

Consequently, lower number of entrepreneurs in the higher tax regime implies a lower equilibrium capital stock (Figure 10). Higher corporate taxes also lowers returns to capital, which discourages entrepreneurs from utilizing capital for production purposes - the equilibrium interest rate declines from 1.57% (τ = 0.19) to 1.41% (τ = 0.25).

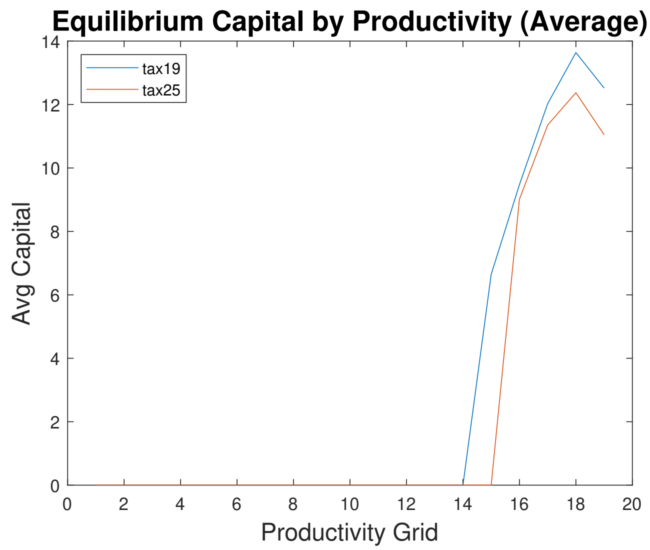

Figure 10 – Average Capital Holdings by Productivity

As a result of lower capital stock, aggregate consumption and output also declines with a 6% increase in the corporate tax rate. Although a higher tax rate results in (i) higher average productivity among the remaining entrepreneurs, at the same time, (ii) it precludes wealth constrained, higher quality entrepreneurs from entering the market. In this model, the second (ii) effect dominates, leading to lower aggregate consumption and lower output in general.

Table 4 – Comparing Aggregates for both Tax Regimes

Aggregates			
τ = 0.19			
Capital, K	Labour, L	Consumption, C	Output, Y
4.06	0.86	2.56	2.69
τ = 0.25			
Capital, K	Labour, L	Consumption, C	Output, Y
3.44	0.92	2.38	2.53

Without any additional policies counteracting the increase in corporate tax rates[13], consumption

[13] Taxes are not redistributed in the model

and output contracts. However, easing financing conditions for entrepreneurs (higher λ) could help raise aggregate consumption - back to the levels prior to the increase in tax rates. In the following section, we compute value of λ needed to counteract the increase in corporate tax rates.

5.3. Improving Access to Finance to Offset Increases in Corporate Tax

In this section, we solve for the value of λ which will allow economic agents to consume the same amount prior to the rise in corporate taxes. This is computed via *fsolve* in MATLAB, where the program finds the optimal value of λ under the new tax regime (τ = 0.25) needed to achieve consumption levels in the old tax regime (τ = 0.19; C = 2.56), holding everything else constant[14]. This results in a value of λ = 14.7, a fourfold increase from the calibrated baseline parameter of λ = 3.6.

Changes to other aggregate variables are reported in Table 5. Improving access to finance (by increasing λ) increases aggregate capital stock in the model, and consequently leads to higher aggregate output.

Table 5 – Sensitivity Analysis: Aggregates

Aggregates			
τ = 0.25, λ = 3.6			
Capital, K	Labour, L	Consumption, C	Output, Y
3.44	0.92	2.38	2.53
τ = 0.25, λ = 14.7			
Capital, K	Labour, L	Consumption, C	Output, Y
5.25	0.85	2.56	2.84

Removing credit frictions has been theorized to encourage the flow of capital towards asset poor individuals with high return investments (Aghion and Bolton (1997); Galor and Moav (2004)). This is also observed in the model, where removing financial frictions (higher λ) enables low wealth, high productivity individuals select into entrepreneurship. Figures 11 and 12 illustrates this, where a fourfold increase in λ encourages the entry of high productivity entrepreneurs (Figure 11).

[14]With the exception of equilibrium prices (w and r), which needs to change to clear the labour and asset markets

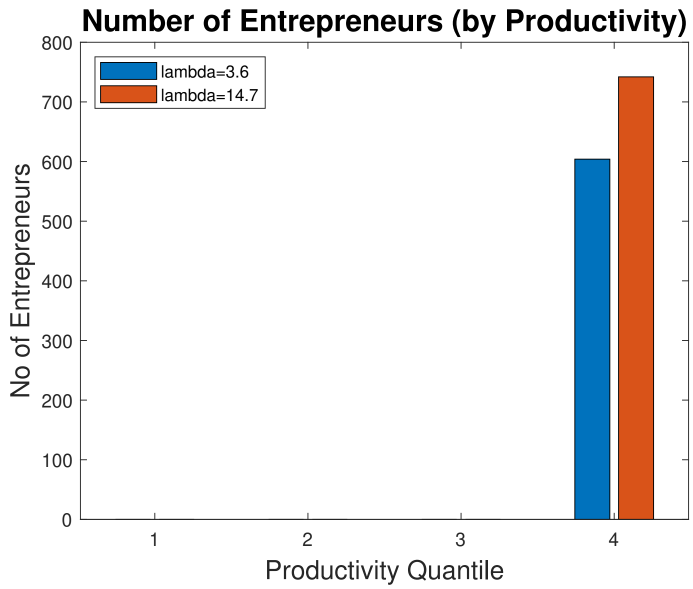

Figure 11 – No of Entrepreneurs by Productivity

The new entrants are made up mainly of low wealth individuals (Figure 12). By allowing productive but asset poor individuals borrow up to λ times their asset holdings for entrepreneurial purposes, this boost their income levels, and leads to higher output. This hypothesis was also supported by Beck et al (2007), where they postulate that removing financial frictions allows poor households to engage in productive activities, which consequently lift incomes of households in the poorest quantile. This in turn, boosts economic growth.

The above exercise shows that by improving access to finance, policymakers may be able to cushion the impact of a corporate tax hike. Policies could be geared towards encouraging specialized non-bank financial institutions (NBFIs) to help fund highly productive, but asset poor entrepreneurs. NBFIs such as venture capitalists, angel investors etc are designed to screen new ideas and continuously monitor it's development. This may help mitigate the issue of information asymmetry - which prevents traditional financial institutions (eg. banks) from investing in start up firms (Laeven et al, 2015). This could allow start ups to obtain the funds they need for investment, without requiring the entrepreneurs to put up collateral. This enables prospective entrepreneurs to obtain the capital they need for investment purposes, regardless of their asset ownership (initial capital).

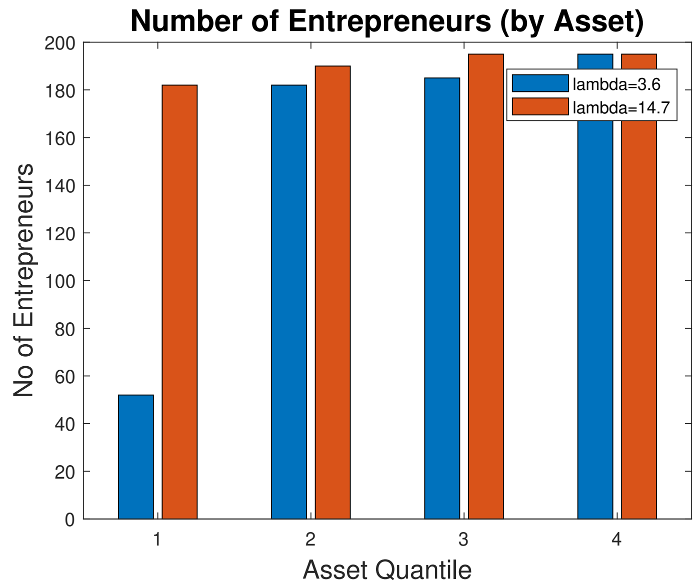

Figure 12 – No of Entrepreneurs by Assets

6. Concluding Remarks and Policy Implications

Taxation is a potent policy instrument which allows governments to achieve the equality and to overcome market failure in the economy (Chen et al, 2002). While taxes allows the creation of public goods that are needed to create economic opportunities for economic agents, it can also distort incentives to work or invest. In the context of corporate taxation, the simulated model shows that an increase in corporate tax rates affects entrepreneurship decisions. A 6% hike in UK's corporate tax rates discourages entry into entrepreneurship among the high productivity, asset poor individuals - lowers capital stock and aggregate output. However, increasing corporate tax rates also increases the productivity of the marginal entrepreneur. Increasing average productivity of the entrepreneurs has the opposing effect of possibly increasing capital stock and aggregate output. In the simulations, the first effect dominated - a 6% increase in corporate tax rates dampened aggregate consumption and output.

Alleviating financial constraints - increasing λ by fourfold could more than offset the adverse effects of higher tax rates. Allowing highly productive, low wealth individuals borrow up to 14 times their asset holdings enabled them to enter into/continue in entrepreneurship, which raised aggregate output. While the 6% increase in corporate tax rates is inevitable to improve government finances, policy could be geared towards encouraging alternative financing. This can incentivize entrepreneurship among asset poor individuals.

In conclusion, without additional policy support, increasing corporate tax rates dampens the economy as a whole. It is therefore essential to ensure that highly productive individuals are able to enter into entrepreneurship, innovate and transmit knowledge spillovers on the economy in an environment with higher tax rates - high growth young firms are crucial engines to sustainable, long term growth after all.

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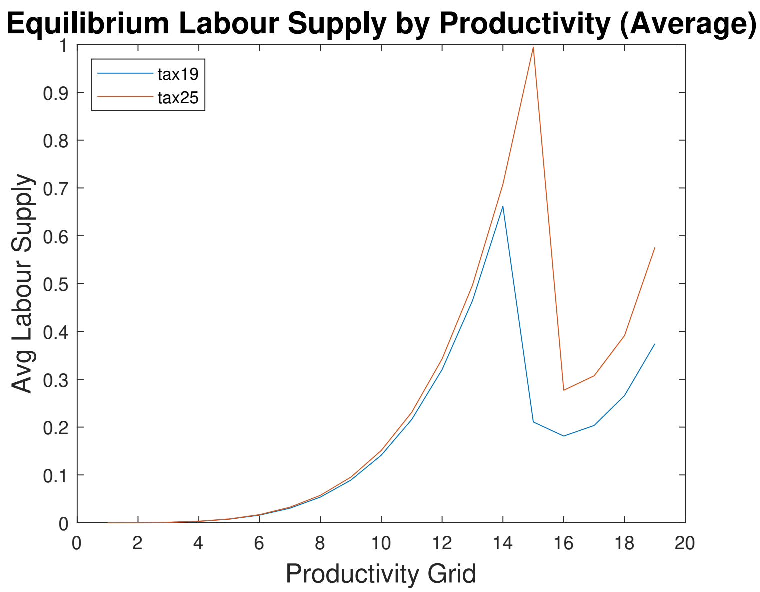
Appendix



Appendix Figure 1: Equilibrium Labour Supply by Productivity