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Essays on Financial Shocks and External Debt

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Abstract

My thesis consists of three chapters: two chapters on the effects of financial shocks, and one on the relationship between external debt and economic growth in low- and middle-income countries.

Chapter 1, “Financial Shocks, Interbank Rates and Corporate Rates”, introduces financial shocks that change interbank and corporate debt rates and their spread and shows how these shocks affect economic fluctuations.

Chapter 2, “Tighter Debt Limits, Default, and Labour Supply”, shows that the effect of tighter debt limits on households' labour supply decisions depends on whether default is allowed or not.

Chapter 3, “External Debt, Initial Conditions, and Economic Growth in Low- and Middle-Income Countries”, looks at the external debt-growth relationship from a new angle and shows that where an economy starts relative to its long-run average output per capita affects the direction of this relationship.

Keywords

Financial Shocks, Economic Fluctuations, Hours Worked, Bankruptcy Filings,
External Debt, Economic Growth.

Summary for Lay Audience

Companies rely on debt as a source to fund their operations. Consequently, it is expected that the cost of debt affects firms' decisions, like hiring and production. The rates paid on many corporate debt instruments are based on benchmark rates like interbank rates. Interbank rates are interest rates paid by financial institutions (banks) when borrowing from each other. This suggests that the interplay between corporate debt and interbank rates may have wider implications on the economy by affecting firms' decisions and activities.

Therefore, in Chapter 1, I study the movement of interbank and corporate debt rates, then I ask how do changes in these rates and their spread (the difference between them) affect economic fluctuations? I find that changes in these rates and their spread can generate economic fluctuations like what is observed in the United States (US) in the past few decades. This highlights the importance of fluctuations in the financial sector as a source of wider economic fluctuations.

Further, changes in the financial sector can affect households' decisions by affecting their ability to borrow. During the financial crisis that started in 2007, it became more difficult to borrow from banks in the US and elsewhere. Meanwhile, there was an increase in bankruptcy filings and a decrease in hours worked in the US.

Therefore, in Chapter 2, I ask how does tightening debt limits affect households' labour supply decisions when they are allowed to file for bankruptcy? I find that following a decrease in debt limits, households who file for bankruptcy decrease their hours worked. If they were not allowed to file for bankruptcy, they increase their hours worked.

Like firms and households, countries require funds. In low- and middle-income countries, external debt is an important source of funding. World Bank data show that external debt increased significantly in this group of countries since 1970.

In Chapter 3, I ask about the relationship between external debt and economic growth in low- and middle-income countries and look at this relationship from a new angle. I find that when an economy starts with income per person lower than its long-run average, external debt is more likely to be positively related with economic growth.

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Preface

My thesis consists of three chapters: two chapters on the effects of financial shocks, and one on the relationship between external debt and economic growth in low- and middle-income countries. Chapter 1, "Financial Shocks, Interbank Rates and Corporate Rates", introduces financial shocks that change interbank and corporate debt rates and their spread and shows how these shocks affect economic fluctuations. Chapter 2, "Tighter Debt Limits, Default, and Labour Supply", shows that the effect of tighter debt limits on households' labour supply decisions depends on whether default is allowed or not. Chapter 3, "External Debt, Initial Conditions, and Economic Growth in Low- and Middle-Income Countries", looks at the external debt-growth relationship from a new angle and shows that where an economy starts relative to its long-run average output per capita affects the direction of this relationship.

In Chapter 1, I first study the movement of interbank rates and corporate debt rates relative to GDP. I find that while interbank rates are procylical, corporate debt rates are countercyclical. The spread between them is also countercyclical.

Debt instruments represent a significant source of funding for firms in the US. The rates on many corporate debt instruments are based on a benchmark rate like an interbank rate. This suggests that the interplay between corporate debt and interbank rates may have wider macroeconomic implications.

Hence, in Chapter 1 I ask, how do shocks to the financial sector that change the spread between corporate debt and interbank rates contribute to economic fluctuations? To answer this question, I build on the model of Boissay et al. (2016) by adding shocks to the financial sector (financial shocks) and a working capital loan required by a representative firm. I use the model's equilibrium equations along with data on the interbank and corporate debt rates to estimate financial shocks.

Then, I simulate the model with productivity shocks only, financial shocks only, and both types of shocks. Simulating the model with only productivity shocks fails to capture the cyclicality of the interbank and corporate debt rates and their spread. In contrast, after adding financial shocks, model simulation generates a procylical interbank rate, a countercyclical corporate debt rate, and a countercyclical spread, in line with data.

In addition, simulating the model with financial shocks generates the right sign of the correlation between the spread and other macroeconomic variables (hours worked, consumption, investment). Model simulation with only productivity shocks fails on that aspect as well. Also, simulating the model with financial shocks generates volatility in hours worked relative to GDP closer to data than simulating the model with only productivity shocks. This highlights the importance of fluctuations in the financial sector as a source of wider economic fluctuations.

Debt is also used by households to smooth consumption. During the financial crisis that started in 2007, banks in the US and around the world tightened lending standards (Quadrini, 2011; Puri, et al.2011). Meanwhile, non-business bankruptcy filings almost doubled, and hours worked decreased in the US.

Therefore, in Chapter 2, I ask how does tightening debt limits affect households' labour supply decisions when they are allowed to default versus when they are not allowed to default? To answer the question, I build on the models from Guerrieri and Lorenzoni (2017) and Fieldhouse et al. (2018). I find that following a decrease in debt limits, households who find it optimal to default decrease their labour supply. If not allowed to default, they increase their labour supply.

Like firms and households, countries require funds. In low- and middle-income countries, external debt is an important source of funding. World Bank data show that the average external debt to gross national income almost tripled since 1970 in this group of countries.

Empirical studies report mixed results on the relationship between external debt and economic growth in this group of countries. In Chapter 3, I look at this relationship from a new angle. I find that when a low- or middle-income economy starts with income per capita lower than its long-run average, external debt is more likely to be positively related with economic growth.

Then, I test whether a standard stochastic growth model with external borrowing can account for this observation. I simulate the model with different levels of initial external debt, initial output per capita and different productivity shock parameters. This is to reflect the differences between low- and middle-income countries in their initial conditions. Simulated data produce results in line with the observation that the lower the starting income per capita relative to the long-run average, the more likely that external debt is positively related to growth and vice versa.

Chapter 1

1 Financial Shocks, Interbank Rates and Corporate Rates

1.1 Introduction

Corporate debt is an important source of finance for firms in the US. For example, Liu and Magnan (2014) mention that US firms issued $13.5 trillion debt instruments compared to less than $2 trillion equity instruments between 2003 and 2009. The rates that firms pay on their debt is therefore expected to affect their economic decisions and activities and as a result, aggregate economic activity.

Interbank market rates, like the London Inter-Bank Offered Rate (Libor), have been used as a benchmark to price corporate debt with floating rates. Mollenkamp and Whitehouse (2008) mention that trillions of dollars of corporate debt and other financial instruments have their rates “reset according to Libor” (p.2).

US data from Q1:1986 to Q4:2019 show that while interbank rates are procyclical, corporate bond rates are countercyclical. The spread between the two is also countercyclical. What does this imply for the overall economic fluctuations? In particular, how do shocks to the financial sector that change the spread between corporate and interbank rates affect economic fluctuations?

To answer this question, I build on the model of Boissay et al. (2016). The model has a financial sector composed of heterogenous intermediaries. Intermediaries can borrow and lend from each other, as well as provide loans to a representative firm. Intermediaries vary in their intermediation efficiency, that is, the cost of providing a loan to the representative firm. They also have an outside option in which they can invest and divert funds. The latter gives rise to moral hazard. In addition, intermediaries do not know each other’s types when lending to each other. Hence, the financial sector has two frictions: moral hazard and asymmetric information. Moral hazard results in intermediaries putting a limit (constraint) on how much they are willing to lend other intermediaries, in order to eliminate the incentive to divert funds. Asymmetric information results in having one constraint in the interbank market, regardless of types since they are private information.

The model also has a representative profit-maximizing firm. It has been reported that on average, firms in the US borrow 50% of their capital input costs and 43% of their labour input costs (Phaneuf & Victor, 2017). I incorporate this to the model by assuming that the representative firm needs to borrow different fractions of its input costs (capital and labour) in advance before production takes place. Loans are provided by intermediaries from the financial sector.

Finally, the model has a utility-maximizing representative household with an infinite horizon. The representative household values consumption and leisure. It supplies labour to the representative firm, supplies funds to intermediaries in the financial sector, and accumulates capital.

There are two sources of disturbance to the economy. The first source is productivity shocks. These shocks change the efficiency of the representative firm in converting inputs to output, which is a standard assumption in the macroeconomic literature. The second source is financial shocks. These shocks change the overall intermediation efficiency of the financial sector. A negative financial shock makes it more costly to provide a loan to the representative firm while a positive financial shock does the opposite. Both types of shocks change the interbank borrowing limit, interbank rate, the firm's cost of borrowing, and the spread. Since the firm needs to borrow part of its inputs' cost each period, then these changes affect the firm's optimal decisions and therefore the aggregate economic activity.

My estimation of financial shocks is based on the model's equilibrium equations. I use the model's equilibrium equations and data on 3-month Libor (3m Libor) and the average of AAA and BAA corporate bond rates to construct a time series for a measure of the financial sector's overall intermediation efficiency. Then, I use the constructed time series to estimate shocks to the efficiency of the financial sector (i.e. financial shocks). I repeat the estimation using 12-month Libor (12m Libor) and the effective federal funds rate (FF). Results do not significantly change.

The model in this chapter aims to simultaneously capture the procyclicality of interbank rates and the countercyclicality of corporate bond rates. It also aims to capture the countercyclicality of the spread between corporate debt and interbank rates. I show that simulating the model with financial shocks (as an only source of disturbance or combined with productivity shocks) captures the cyclicality of interbank and corporate rates, their spread, and the right sign of the correlation between the spread and other macroeconomic variables. It also generates business cycle statistics in line with US data since 1986. In contrast, simulating the model with productivity shocks only produces procyclical corporate debt rate and spread, which contradicts data. It also fails in terms of the correlation between the spread and other macroeconomic variables. In addition, adding financial shocks to the model generates volatility in hours worked relative to GDP that is closer to data.

The link between the financial sector and aggregate economic activity has long been a subject of interest and ongoing research for macroeconomists. Bernanke (1993) provides a literature survey (at the time) on the role of credit and credit crises in the economy. More recent surveys on the effects of financial frictions and shocks on aggregate economic activity are provided by Quadrini (2011) and Claessens and Kose (2018).

The theoretical literature on the link between financial intermediation and economic fluctuations can be divided into two broad categories. In the first strand of literature, financial frictions have been modelled as "amplifiers" of the effects of other shocks, like productivity shocks for example. Examples of seminal papers in this strand include Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and Bernanke et al. (1999) with the financial accelerator mechanism. A more recent example is Boissay et al. (2016) in which interbank market mechanisms amplify the effects of productivity shocks and can lead to financial crises.

The second strand of literature has financial shocks as a source of economic fluctuations rather than having financial frictions being just an amplifier of other shocks (see, e.g.; Gilchrist and Zakrajsek, 2011; Jermann & Quadrini, 2012; Gertler et al., 2020). This is not surprising since a period of "Great Moderation" ended with a "Great Recession" that was preceded by a financial crisis. This sparked interest in studying the direct effects of shocks that originate in the financial sector on aggregate economic activity.

Many papers in either strand abstract from having an interbank market (see, e.g.; Bernanke et al., 1999; Jermann & Quadrini, 2012). Therefore, these papers cannot capture the interplay between interbank and corporate debt rates and how this relates to aggregate economic activity. This chapter aims to contribute to filling this gap.

Other papers present models that imply or predict that interbank and corporate rates move in the same direction relative to GDP (see, e.g.; Gertler & Kiyotaki, 2010; Boissay et al., 2016). To the best of my knowledge, this is the first study that can simultaneously account for the procyclicality of interbank rates, countercyclicality of corporate bond rates, and countercyclicality of the spreads while generating economic fluctuations in line with what we observe in the US data since 1986. The choice of the period is due to data on (US dollar) Libor being available since 1986 only.

The rest of the chapter is organized as follows: Section 1.2 presents data on the interbank rates and corporate debt rates and spreads in the US since 1986. The benchmark model is presented in Section 1.3. Estimation and results are reported in Section 1.4. Sensitivity analysis and alternative specifications with the related results are presented in Section 1.5. Finally, a conclusion is provided in Section 1.6.

1.2 Interbank Rates and Corporate Bond Rates[1]

US quarterly data between 1986:Q1 and 2019:Q4 show that real interbank rates are positively correlated to GDP. This applies to 3m Libor and 12m Libor, based on US dollar. The correlations between deviations from trend of these rates and deviations from trend in (log) real GDP are 0.497 and 0.462 respectively. Similar observation applies to the real effective federal funds rate. The correlation between deviations from trend of that rate and deviations from trend in (log) real GDP is 0.485. In addition, real interbank rates are positively correlated to consumption, investment, and hours worked. Table 1-1 below

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[1] Data retrieved from: https://fred.stlouisfed.org and https://apps.bea.gov. FRED removed US Dollar Libor data on January 31, 2022.

shows the correlations between interbank rates and macroeconomic variables. Variables are detrended using the Hodrick-Prescott filter, with a smoothing parameter of 1,600 usually used for quarterly data.

Table 1-1: Correlations Between Interbank Rates and Macroeconomic Variables

	Effective Federal Funds Rate	3m Libor	12m Libor
GDP	0.485	0.497	0.462
Consumption	0.439	0.446	0.422
Investment	0.352	0.362	0.316
Hours Worked	0.605	0.639	0.592

In contrast, US data over the same period show that corporate debt rates are countercyclical. Table 1-2 below shows correlations between deviations from trend of Moody's Seasoned AAA and BAA Corporate Bond Rates and GDP, consumption, investment, and hours worked.

Table 1-2: Correlations Between Corporate Rates and Macroeconomic Variables

	Moody’s AAA Corporate Bond Rate	Moody’s BAA Corporate Bond Rate
GDP	-0.202	-0.277
Consumption	-0.153	-0.207
Investment	-0.337	-0.412
Hours Worked	-0.096	-0.120

Finally, the spreads between corporate bond rates and different interbank rates are strongly countercyclical. Table 1-3 below shows correlations between deviations from trend of spreads and GDP, consumption, investment, and hours worked. Table 1-3 uses Moody's Seasoned AAA Corporate Bond Rate to calculate spreads.

Table 1-3: Correlations Between Spreads (Using AAA) and Macroeconomic Variables

	AAA - Effective Federal Funds Rate	AAA - 3m Libor	AAA - 12m Libor
GDP	-0.675	-0.714	-0.710
Consumption	-0.588	-0.618	-0.620
Investment	-0.638	-0.676	-0.663
Hours Worked	-0.726	-0.790	-0.770

In addition, Figures 1-1 to 1-3 show the deviations from trend in GDP and in the spread between Moody’s AAA Corporate Bond Rate and 3m Libor, 12m Libor, and the effective federal funds rate respectively. Variables are detrended using the Hodrick-Prescott filter, with a smoothing parameter of 1,600 usually used for quarterly data.

Table 1-4 also shows correlations between deviations from trend of spreads and GDP, consumption, investment, and hours worked. Table 1-4 uses Moody's Seasoned BAA Corporate Bond Rate to calculate the spread. In addition, Figures 1-4 to 1-6 show the deviations from trend in GDP and in the spread between Moody’s BAA Corporate Bond Rate and 3m Libor, 12m Libor, and the effective federal funds rate respectively. Again, variables are detrended using the Hodrick-Prescott filter, with a smoothing parameter of 1,600 usually used for quarterly data.

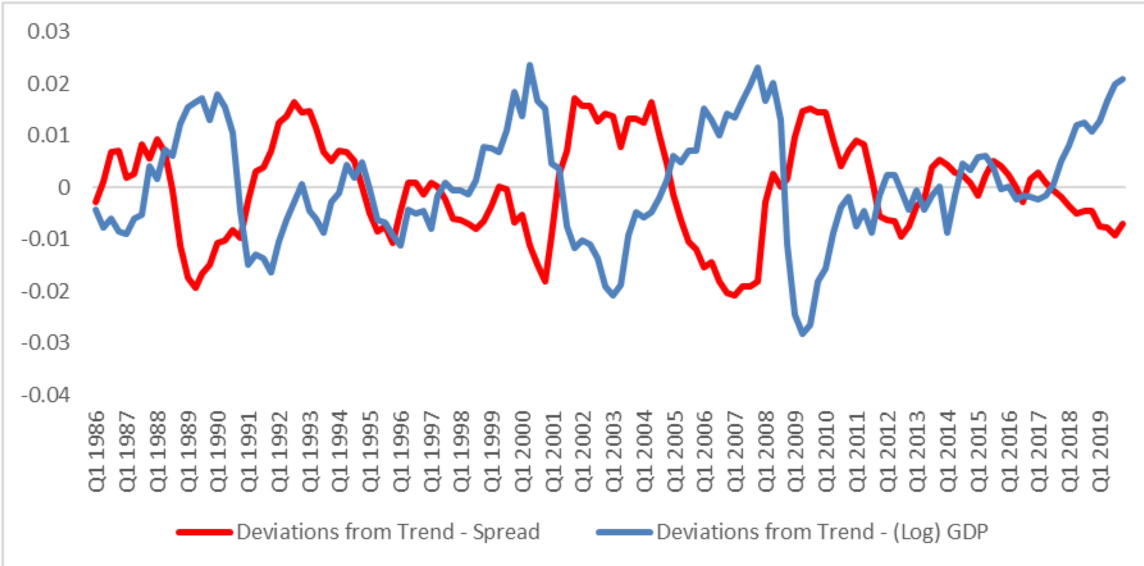

Figure 1-1: (AAA Corporate Bond Rate - 3m Libor) Spread and GDP - Deviations From Trend

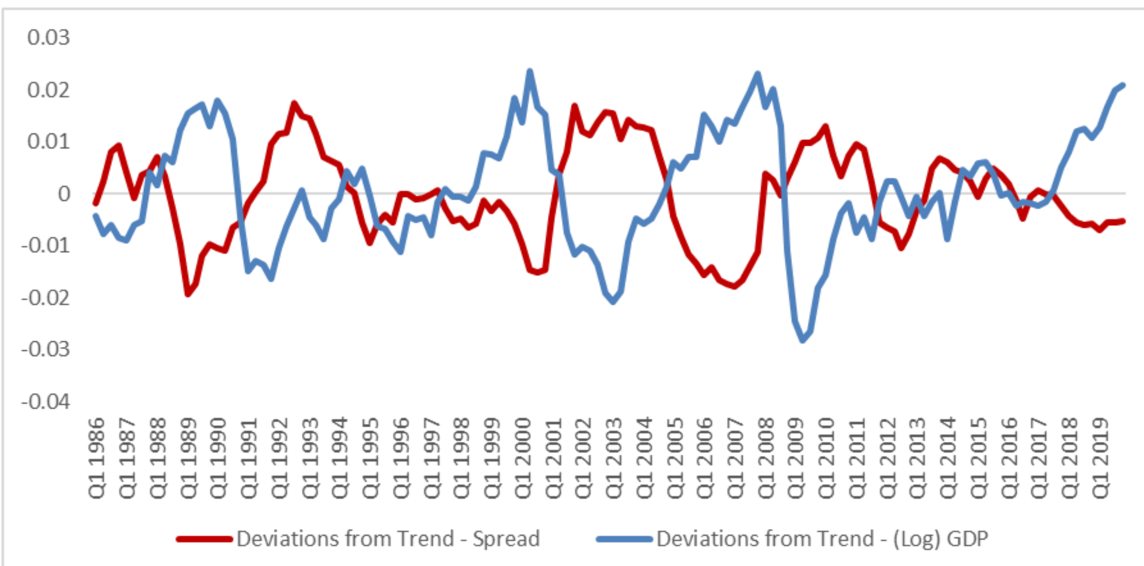

Figure 1-2: (AAA Corporate Bond Rate - 12m Libor) Spread and GDP - Deviations From Trend

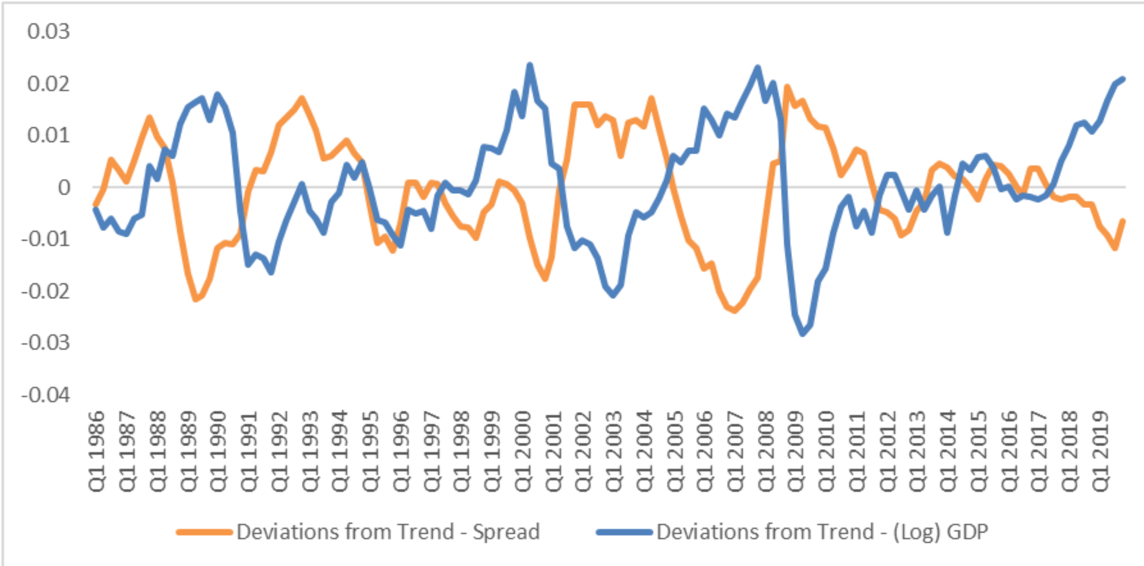

Figure 1-3: (AAA Corporate Bond Rate – Effective Federal Funds Rate) Spread and GDP - Deviations From Trend

Table 1-4: Correlations Between Spreads (Using BAA) and Macroeconomic Variables

	BAA - Effective Federal Funds Rate	BAA - 3m Libor	BAA - 12m Libor
GDP	-0.659	-0.711	-0.708
Consumption	-0.551	-0.590	-0.591
Investment	-0.674	-0.728	-0.721
Hours Worked	-0.648	-0.719	-0.695

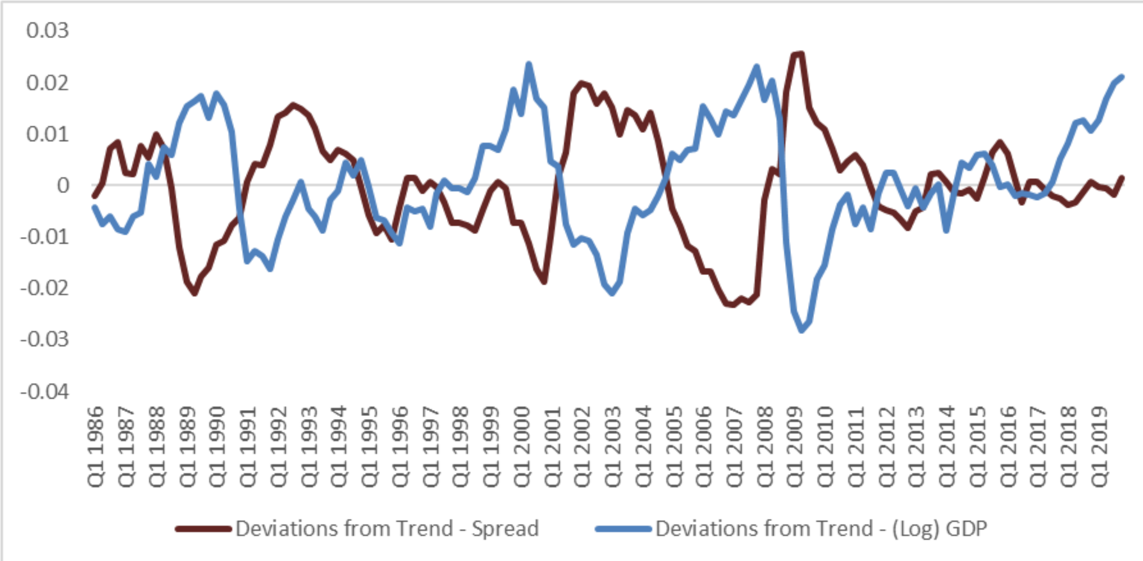

Figure 1-4: (BAA Corporate Bond Rate - 3m Libor) Spread and GDP - Deviations From Trend

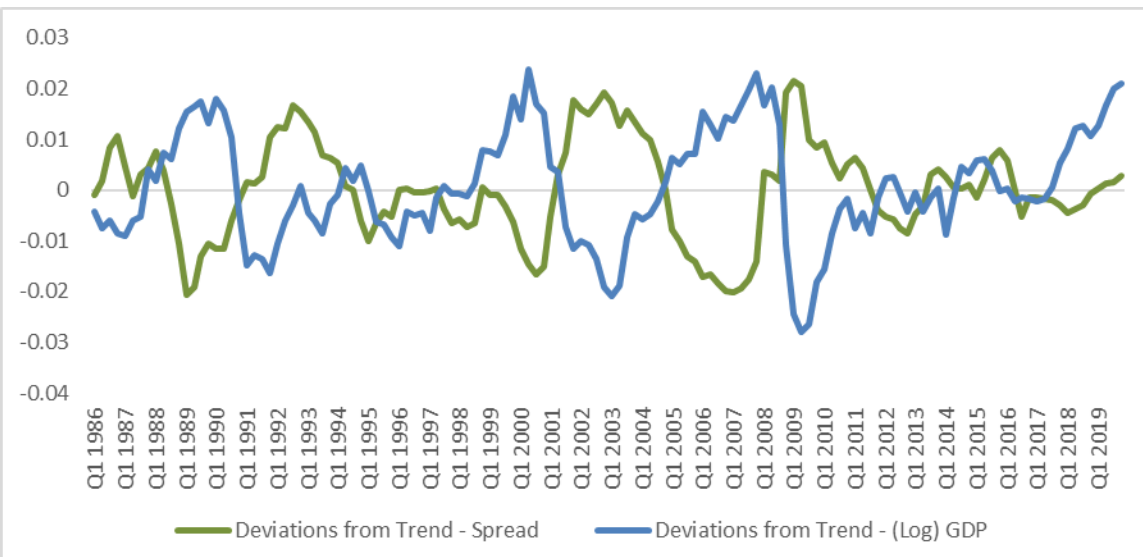

Figure 1-5: (BAA Corporate Bond Rate - 12m Libor) Spread and GDP - Deviations From Trend

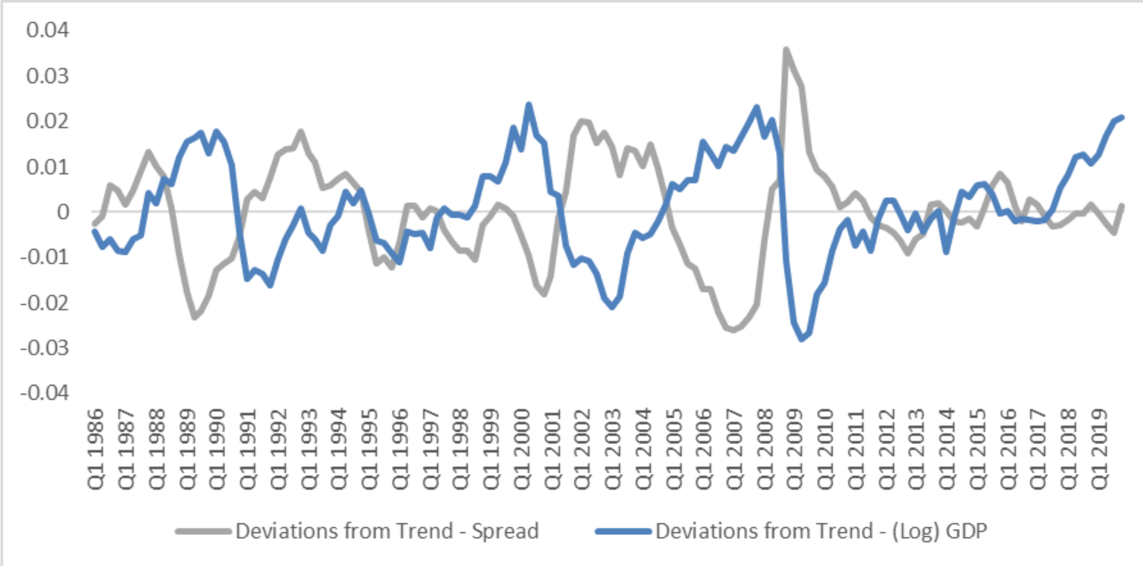

Figure 1-6: (BAA Corporate Bond Rate – Effective Federal Funds Rate) Spread and GDP - Deviations From Trend

The statistics reported in this section show that interbank rates are usually above trend whenever GDP is above trend. Given that interbank rates are the benchmark for the rates on trillions of dollars debt instruments as mentioned, one would predict that debt rates must show a similar kind of movement.

However, this section shows that deviations from trend in corporate debt rates are negatively correlated to deviations from trend in GDP. An increase (decrease) in corporate bond rates implies an increase (decrease) in firms' cost of borrowing. This may affect firms' decisions such as demand for factors of production and the level of operations and production.

Moreover, the difference between corporate debt rates and interbank bank rates usually shrinks when GDP is above trend. This is shown by the negative correlation between deviations from trend in spreads and GDP. Given the relatively high negative correlation between spreads and GDP (and other macroeconomic variables) shown in this section, the relationship between these variables warrants further investigation.

In the next section, I present a model that can account for these observations. In this model, financial shocks that increase the interbank borrowing rate and limit result in a decrease in the spread between the firm's cost of borrowing and the interbank rate, in line with data. A decrease in the firm's cost of borrowing increases the firm's demand for factors of production and consequently GDP.

1.3 Model

In this section, I present the details of the model. The model is based on Boissay et al. (2016). The economy is composed of a representative firm, a financial sector, and a representative household.

Each period, a profit-maximizing representative firm needs a working capital loan. This is used to pay part of its input costs before production takes place. This loan is obtained from the financial sector.

The financial sector is composed of intermediaries that differ in their intermediation efficiency. They collect funds from the household and may supply loans to the firm. They can borrow from/lend to each other in an interbank market. They can also invest in an "outside option" and divert funds. Each period, the sector is subject to a shock that affects its overall intermediation efficiency (financial shock).

The utility-maximizing representative household has an infinite horizon and values consumption and leisure. Each period, it supplies labour to the firm and funds to the financial sector. It also accumulates capital.

1.3.1 Firm

Each period, a profit-maximizing representative firm with a standard Cobb-Douglas production function chooses how much capital to rent and labour to hire and therefore how much output to produce in order to maximize profit. As mentioned, the firm needs an intra-period working capital loan to pay part of its input costs before any production takes place each period. The loan is repaid within the period after production takes place. The firm faces an aggregate productivity shock that occurs at the beginning of each period.

The firm's objective function, in any period $t \geq 0$, is as follows:

$$max_{\{k_t,\ h_t\}}\ y_t - (1+\eta_k i_t)R_t k_t - (1+\eta_h i_t)w_t h_t\ ,$$
$$s.t.\quad y_t = A_t {k_t}^{\alpha} {h_t}^{1-\alpha},$$

y_t is output, A_t is aggregate productivity, k_t is capital input, h_t is labour input, and α is the capital share in the production function, with $0 < \alpha < 1$. Further, R_t is the rental rate of capital, w_t is the wage of labour, η_k is the share of the capital input cost that the firm needs to borrow, η_h is the share of the labour input cost that the firm needs to borrow, with $\eta_k, \eta_h \in [0,1]$, and i_t is the firm's borrowing cost (that is, the net interest rate charged by financial intermediaries on the firm's working capital loan).

The firm's need for a working capital loan creates a wedge between capital rent and the marginal product of capital (capital wedge) and a wedge between labour wage and the marginal product of labour (labour wedge), as shown by the firm's first order conditions:

$$(1+\eta_k i_t)R_t = \alpha A_t {k_t}^{\alpha-1} {h_t}^{1-\alpha}$$
$$(1+\eta_h i_t)w_t = (1-\alpha) A_t {k_t}^{\alpha} {h_t}^{-\alpha}$$

In the appendix, I show the importance of labour and investment (capital) wedges in business cycle fluctuations. The wedges in the above equations change with the firm's cost of borrowing (i_t), which is affected by shocks. As the equations show, a shock that changes i_t will change the wedges and consequently the optimal demand for capital and labour by the firm. This in turn affects the firm's level of production and therefore aggregate output. In addition, it affects equilibrium prices of capital and labour, which affects the household's optimal decisions. Therefore, this will affect the overall economic activity.

Financial shocks originate in the financial sector and change i_t. Therefore, through affecting the firm's cost of borrowing, financial shocks can cause changes in real macroeconomic variables as shown above. This is the main channel through which financial shocks affect business cycle fluctuations in the model. Productivity shocks have a direct effect, since changes in A_t change the marginal product of capital and the marginal product of labour, and an indirect effect, since i_t also changes when A_t changes.

1.3.2 Financial Sector

The financial sector is composed of heterogenous intermediaries that differ in their intermediation efficiency. At the end of each period t-1, period t intermediaries are born (continuum of measure one). When they are born, they are homogenous, and each intermediary collects funds (d_t) from the representative household. At the beginning of each period t, which is arbitrarily close to the end of period t-1, the financial shock, which affects the financial sector's overall intermediation efficiency (Z_t), is realized. Further, each intermediary draws an individual efficiency level $\theta \in [0,1]$. θ has an increasing cumulative distribution function [$\mu(\theta)$], as in Boissay et al. (2016), with $\mu(0) = 0$ and $\mu(1) = 1$.

Intermediaries may borrow in an interbank market to increase individual funds beyond d_t. They can also lend funds to other intermediaries. An intermediary that lends to other intermediaries in the interbank market earns gross return per unit equal to κ_t.

Intermediaries can also invest in an “outside option” and earn gross return per unit equal to γ, which is assumed to be constant for simplicity. The outside option can be thought of as “storage technology” as per Boissay et al. (2016). It follows that for any intermediary lending to occur in equilibrium, we must have $\kappa_t \geq \gamma$. Otherwise, it would be more profitable for any financial intermediary to invest funds in the “outside option” rather than lending another intermediary.

In the absence of frictions, it is efficient for all intermediaries to lend to the most efficient financial intermediary, the one with $\theta = 1$. However, frictions in the financial sector block this from happening. Particularly, there is an asymmetric information friction in the financial sector. This means that financial intermediaries don’t know each others’ types, and therefore the most efficient intermediary is not known to others.

Another friction in the financial sector is the moral hazard friction. Intermediaries that borrow ϕ units per d_t in the interbank market can walk away with (1+ ϕ)$\xi\gamma$ per unit and lending intermediaries can't recover these returns. ξ is a fraction of the gross return on the outside option (that is, it is between 0 and 1). This gives an incentive for intermediaries to borrow in the interbank market and walk away from their interbank debt obligations when (1+ ϕ) $\xi\gamma > \kappa_t$.

As a result, lending intermediaries put a limit on borrowing intermediaries. The fact that types are unknown due to asymmetric information make all intermediaries face the same borrowing limit in the interbank market. The limit ensures that all intermediaries that borrow in the interbank market are doing so to expand their funds available to lend to the firm. That is, the limit in any period t is such that (1+ ϕ)$\xi\gamma \leq \kappa_t$. It can be shown that the constraint binds for any borrowing intermediary (Boissay et al., 2016). So, in any t:

$$\phi_t = \frac{\kappa_t - \xi\gamma}{\xi\gamma}.$$

Intermediaries can also lend their funds to the representative firm. An intermediary with efficiency level (θ) earns $Z_t\theta(1+i_t)$ gross return per unit lent to the firm. This is because the intermediary pays an "intermediation cost" equal to $Z_t(1-\theta)(1+i_t)$ per unit of loan. To avoid having a deadweight loss, it is assumed that the intermediation cost is rebated as a lumpsum payment or transfer (τ_t) to the household as in Boissay et al. (2016).

The higher the θ the lower the intermediation cost to be paid. In the case of $\theta = 1$, the intermediation cost is equal to zero. It follows that for any firm lending to occur in equilibrium, we must have $Z_t(1+i_t) \geq \kappa_t$. Otherwise, it would be more profitable for any financial intermediary to lend to other intermediaries rather than lending to the firm. It also follows that $Z_t(1+i_t) \geq \gamma$ since $\kappa_t \geq \gamma$.

Also, the higher the Z_t, the lower the intermediation cost and therefore, ceteris paribus, the higher the gross return per unit of loan provided to the representative firm by any intermediary. This is expected to increase the demand for interbank borrowing and decrease the supply of interbank lending as more intermediaries would find it more profitable to lend to the firm. This results in an upward pressure on κ_t and a downward pressure on i_t. In equilibrium, and since financial shocks are persistent, κ_t will be above trend while i_t will be below trend for a number of periods following a positive financial shock. Therefore, the spread between the two will be below trend during these periods as well. With a lower i_t, the representative firm increases its demand for inputs. This leads to higher output. Therefore, output will be above trend for this number of periods. As a result, with financial shocks, the model predicts that the interbank rate will be procyclical, the corporate debt rate will be countercyclical, and the spread will be countercyclical, in line with US data.

By borrowing ϕ_t units per unit of d_t, an intermediary with efficiency level (θ) can earn an extra $Z_t\theta(1+i_t)\phi_t$ while having to pay $\kappa_t\phi_t$. Hence, an intermediary, θ, will choose to borrow from other intermediaries as long as:

$$Z_t\theta(1+i_t)(1+\phi_t) - \kappa_t\phi_t \geq \kappa_t.$$

Otherwise, it will be a lender in the interbank market. The threshold, $\bar{\theta}_t$, that makes an intermediary indifferent between borrowing from or lending to other intermediaries is hence given by:

$$Z_t\bar{\theta}_t(1+i_t)(1+\phi_t) - \kappa_t\phi_t = \kappa_t$$

$$\Rightarrow Z_t\bar{\theta}_t(1+i_t)(1+\phi_t) = (1+\phi_t)\kappa_t$$

$$\Rightarrow Z_t\bar{\theta}_t(1+i_t) = \kappa_t$$

$$\Rightarrow \bar{\theta}_t = \frac{\kappa_t}{Z_t(1+i_t)}$$

Interbank market clearing implies that $\mu(\bar{\theta}_t)d_t = [1-\mu(\bar{\theta}_t)]\phi_t d_t$. The left-hand side is the supply of interbank loans, and the right-hand side is the demand for interbank loans. d_t cancels out from both sides, so we get:

$$\mu(\bar{\theta}_t) = [1-\mu(\bar{\theta}_t)]\phi_t$$

An increase in the interbank rate (κ_t) increases the interbank borrowing limit (ϕ_t). Intuitively, a higher κ_t makes it less likely for borrowing in the interbank market and investing in the outside option to be more profitable than simply lending in the interbank market.

At the end of t, each intermediary collects its returns, pays back d_t plus a return on d_t to the household, and exits this world. Intermediaries' profit maximization implies that the average gross return $(1+r_t)$ on d_t for the representative household is given by:

$$1+r_t = \int_0^{\bar{\theta}_t} \kappa_t \, d\mu(\theta) + \int_{\underline{\theta}_t}^{1} [Z_t \theta (1+ i_t)(1+ \phi_t) - \kappa_t \, \phi_t] \, d\mu(\theta)$$

1.3.3 Household

The representative household faces an infinite horizon. It values consumption and leisure. It supplies funds to the financial sector. It supplies labour to the representative firm. Also, it accumulates capital. The representative household's utility maximization problem is as follows:

$$max_{\{c_t,\ h_t,\ k_{t+1},\ d_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t,\ h_t)\ ,$$

$$s.t. \qquad c_t + x_t + d_{t+1} = w_t h_t + R_t k_t + (1+ r_t) d_t + \tau_t,$$

$$x_t = k_{t+1} - (1-\delta) k_t\ ,$$

$$c_t \geq 0\ , 0 \leq h_t \leq 1\ , \forall t \geq 0\ ,$$

$$d_0, k_0 \text{ given.}$$

This yields the following standard first order conditions for the household's optimal decisions on consumption (c_t), labour supply (h_t), future period capital (k_{t+1}) and d_{t+1}:

$$U_{h_t} / U_{c_t} = w_t,$$
$$U_{c_t} = \beta E_{\mathrm{t}} \left[U_{c_{t+1}} (1 + R_{t+1} - \delta) \right],$$

$$U_{c_t} = \beta E_{\mathrm{t}} \left[U_{c_{t+1}} (1 + r_{t+1}) \right].$$

In the macroeconomic literature, it is established that productivity shocks affect the representative household's optimal decisions. This is because when A_t changes, so will w_t and the expectation of R_{t+1} (and r_{t+1} in this model). In this model, financial shocks, through changing i_t and κ_t, also affect w_t, R_t, and r_t. In addition, they affect the expectations of R_{t+1}, and r_{t+1}. Therefore, shocks in the financial sector affect the representative households' intratemporal and intertemporal decisions each period.

1.3.4 Equilibrium Equations:

In any t, there are 11 unknowns $\{k_{t+1}, d_{t+1}, c_t, h_t, w_t, R_t, r_t, i_t, \kappa_t, \phi_t, \bar{\theta}_t\}$ and 11 equilibrium equations as follows (A_t, Z_t, k_t, d_t are known by the beginning of t):

(1) $(1+\eta_k i_t)R_t = \alpha A_t {k_t}^{\alpha-1} {h_t}^{1-\alpha}$

(2) $(1+\eta_h i_t)w_t = (1-\alpha)A_t {k_t}^{\alpha} {h_t}^{-\alpha}$

(3) $U_{h_t} / U_{c_t} = w_t$

(4) $U_{c_t} = \beta E_{\mathrm{t}}\left[U_{c_{t+1}}(1+R_{t+1}-\delta)\right]$

(5) $U_{c_t} = \beta E_{\mathrm{t}}\left[U_{c_{t+1}}(1+r_{t+1})\right]$

(6) $\phi_t = \frac{\kappa_t - \xi\gamma}{\xi\gamma}$

(7) $\bar{\theta}_t = \frac{\kappa_t}{Z_t(1+i_t)}$

(8) $\mu(\bar{\theta}_t) = [1-\mu(\bar{\theta}_t)]\phi_t$

(9) $1+r_t = \int_0^{\bar{\theta}_t} \kappa_t \, d\mu(\theta) + \int_{\bar{\theta}_t}^{1} [Z_t\theta(1+i_t)(1+\phi_t) - \kappa_t\phi_t] \, d\mu(\theta)$

(10) $c_t + x_t + d_{t+1} = w_t h_t + R_t k_t + (1+r_t)d_t + \tau_t$

(11) $\eta_k R_t k_t + \eta_h w_t h_t = d_t$

1.4 Model Simulation and Results

1.4.1 Parameterization

For benchmark model simulations, I use the following utility function:

$$\frac{{c_t}^{1-\sigma}}{1-\sigma} - \frac{{h_t}^{1+\vartheta}}{1+\vartheta}.$$

I set $\sigma = 1$ so the function becomes $log\ (c_t) - \frac{{h_t}^{1+\vartheta}}{1+\vartheta}$. The Frisch elasticity of labour supply is given by 1/ ϑ with this utility functional form. To that end, I set ϑ to 1/2 which implies a Frisch elasticity of 2 which is in line with macroeconomic estimates. In section 1.5, I show results with $\sigma = 2$ and $\vartheta = 1$. Also, in Appendix A, I show the results of model simulation with a GHH utility function.

To estimate the financial shocks, I assume that in any period, Z_t is equal to a steady state Z multiplied by e^{u_t}, where u_t follows an AR(1) process with an i.i.d. error term $\varepsilon_t^u \sim N(0, \sigma_u^2)$:

$$u_t = \rho_u u_{t-1} + \varepsilon_t^u$$

I jointly calibrate the steady state value of Z with $\xi\gamma$ to target the long-run averages of the real interbank rate (3m Libor) and real corporate bond rate (average of AAA and BAA). To obtain estimates for ρ_u and σ_u, I construct a time series for Z_t using equilibrium equations from the model along with data on 3m Libor and corporate bond rates as follows.

From equilibrium equation (8):

$$\mu(\bar{\theta}_t) = [1 - \mu(\bar{\theta}_t)]\phi_t \Rightarrow \mu(\bar{\theta}_t) = \left(\frac{\phi_t}{1+\phi_t}\right) \qquad (12)$$

From equilibrium equation (6):

$$\phi_t = \frac{\kappa_t - \xi\gamma}{\xi\gamma} \Rightarrow \frac{\phi_t}{1+\phi_t} = \frac{\kappa_t - \xi\gamma}{\kappa_t} \qquad (13)$$

I follow Boissay et al. (2016) and assume that $\mu(\theta) = \theta^{\lambda}$ with $\lambda = 26$. When combining this with (12) and (13), I get that:

$$\bar{\theta}_t = \left(\frac{\kappa_t - \xi\gamma}{\kappa_t}\right)^{1/\lambda} \quad (14)$$

Combining (14) with equilibrium equation (7), I get:

$$Z_t = \frac{\kappa_t}{(1+i_t)\left(\frac{\kappa_t - \xi\gamma}{\kappa_t}\right)^{1/\lambda}} \quad (15)$$

Using data on κ_t, the gross real interbank rate, for which I use 3m Libor minus inflation, and on i_t, the real corporate bond rate, for which I use the average of (AAA-inflation) and (BAA-inflation), with the calibrated values of $\xi\gamma$ and λ, I construct a time series for Z_t using equation (15). I use the constructed series to estimate $\rho_u$and σ_u. Estimated ρ_u and σ_u are 0.9611 and 0.0042 respectively.

For productivity shocks, I follow the standard method of constructing a time series for A_t using $y_t = A_t {k_t}^{\alpha} {h_t}^{1-\alpha}$ and data on output, capital, and labour assuming that $A_t = Ae^{z_t}$, where $A = 1$ and z_t follows an AR(1) process as follows:

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z,$$

where $\varepsilon_t^z \sim N(0, \sigma_z^2)$. Estimated ρ_z and σ_z are 0.9802 and 0.0047 respectively.

Parameter values used in the benchmark simulation are shown in Table 1-5 below.

1.4.2 Results

Tables 1-6, 1-7 and 1-8 below show the results of the benchmark model simulation with financial shocks only, with productivity shocks only, and with both types of shocks using the utility function from the previous section and parameter values from Table 1-5.

Results in Table 1-6 show that simulating the model with financial or productivity or both types of shocks capture the relative volatilities of consumption and investment and their correlations with GDP fairly well.

Table 1-5: Parameter Values for Benchmark Model Simulation

Parameter	Value	Target or Source
σ	1	Standard
ϑ	0.5	Standard
β	0.98	Standard
δ	0.025	Standard
α	0.39	Average capital share in the US since 1986
η_k	0.5	Fraction of capital rent borrowed = 50% (Phaneuf & Victor, 2017)
η_h	0.43	Fraction of labour wage borrowed = 43% (Phaneuf & Victor, 2017)
Z	0.981	jointly calibrated to target long-run average interbank rate and average corporate rate
ξ	0.255	jointly calibrated to target long-run average interbank rate and average corporate rate
γ	0.952	Boissay et al. (2016)
$\mu(\theta)$	θ^{λ}	Boissay et al. (2016)
λ	26	Boissay et al. (2016)
ρ_u	0.9611	Estimated using Z_t constructed time series
σ_u	0.0042	Estimated using Z_t constructed time series
ρ_z	0.9802	Estimated using A_t constructed time series
σ_z	0.0047	Estimated using A_t constructed time series

Table 1-6: Model Simulation Results - Benchmark

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.676	0.668	0.682
Investment	4.958	3.114	2.728	2.809
Hours worked	**1.245**	**0.941**	**0.333**	**0.545**
Correlation to GDP				
Consumption	0.891	0.813	0.902	0.878
Investment	0.867	0.876	0.894	0.883
Hours worked	0.873	0.920	0.745	0.697

Variables are detrended. Std. deviations & correlations are computed using deviations from trend.

However, simulating the model with productivity shocks only yields a relatively low standard deviation of hours worked relative to GDP when compared to data. Adding financial shocks to the model improves the estimated relative standard deviation of hours worked and brings it closer to data. In particular, when the model is simulated with only financial shocks, the relative standard deviation of hours is much closer to data than when productivity shocks are included. This is because the direct effect of financial shocks on output is through input demand. In contrast, productivity shocks have a direct effect on output (as a higher A_t results in higher y_t, ceteris paribus). In addition, changes in A_t change input demand. As a result, the volatility of hours is higher with financial shocks.

In addition, when financial shocks are included, simulating the model (whether with only financial shocks or with both shocks together) yields procyclical interbank rate, countercyclical corporate rate, and countercyclical spread as shown in Table 1-7. It also yields the right sign for the correlations between the spread and consumption, investment, and hours worked, as shown in Table 1-8.

In contrast, simulating the model with productivity shocks only fails to capture the cyclicality of rates and the correlations of the spread with GDP and other macroeconomic variables as shown in Table 1-7 and Table 1-8.

Table 1-7: Rates & Spread Correlations with GDP - Benchmark

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.497	0.158	0.136	0.130
Corporate	-0.240	-0.979	0.136	-0.393
Spread	-0.713	-0.959	0.136	-0.463

Table 1-8: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables - Benchmark

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.713	-0.959	0.136	-0.463
Consumption	-0.604	-0.639	0.045	-0.195
Investment	-0.702	-0.905	-0.082	-0.565
Hours Worked	-0.755	-0.967	-0.235	-0.847

1.5 Sensitivity Analysis and Alternative Specifications

In this section, I show the results of simulating the model using different parameter values and alternative specifications. While the values of estimated statistics change as expected, the main conclusion stands. That is, when financial shocks are included, whether standalone or with productivity shocks, simulating the model, while capturing the right signs of the correlations of the interbank and corporate rates and their spread with GDP and other macroeconomic variables, also brings the relative volatility of hours worked closer to data while generating other statistics broadly in line with data.

In contrast, simulating the model with productivity shocks as a sole source of disturbance, not only underestimates hours' relative volatility, but it also generates the wrong sign of the correlation between GDP and the corporate debt rate and between GDP and the corporate-interbank spread.

When financial shocks are included in the simulation, the generated correlations between consumption, investment and hours worked on one hand, and the interbank rate, the corporate debt rate and their spread on another hand are closer to data relative to when the model is simulated with only productivity shocks.

1.5.1 Sensitivity to Parameter Values

I start with simulating the model with $\sigma = 2$. Results are shown in Tables 1-9 to 1-11 below. With $\sigma = 2$, the household prefers a smoother consumption path than with $\sigma = 1$. As a result, with a higher σ, there is a decrease in consumption volatility and an increase in the volatilities of investment and hours worked. While this moves the relative volatility of consumption further from what it is in data, it brings the relative volatilities of investment and hours worked closer to data.

Interestingly, when σ is set to 2 rather than 1, simulating the model with productivity shocks not only underestimates the relative volatility of hours worked, but it also generates hours that are countercyclical which contradicts the procyclicality of hours worked observed in data. The statistics generated when simulating the model with financial shocks remain broadly in line with data.

When it comes to the interbank and corporate debt rates' correlations with GDP and other macroeconomic variables, no significant changes are observed when simulating the model with $\sigma = 2$. That is, with productivity shocks only, the interbank rate, the corporate debt rate, and their spread are all procyclical. This contradicts data. When financial shocks are included, model simulation still captures the right cyclicality of the interbank and corporate debt rates and their spread. In addition, no significant changes are noted in the estimated correlations between the spread and consumption, investment and hours worked generated by simulating the model with different shocks.

Table 1-9: Model Simulation Results – σ = 2

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.540	0.617	0.614
Investment	4.958	3.484	2.749	2.937
Hours worked	**1.245**	**0.988**	**0.343**	**0.600**
Correlation to GDP				
Consumption	0.891	0.809	0.941	0.903
Investment	0.867	0.912	0.914	0.904
Hours worked	0.873	0.860	-0.391	0.142

Table 1-10: Rates & Spread Correlations with GDP – σ = 2

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.497	0.165	0.160	0.142
Corporate	-0.240	-0.992	0.160	-0.440
Spread	-0.713	-0.972	0.160	-0.491

Table 1-11: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables – σ = 2

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.713	-0.972	0.160	-0.491
Consumption	-0.604	-0.698	0.135	-0.225
Investment	-0.702	-0.881	-0.126	-0.576
Hours Worked	-0.755	-0.904	-0.477	-0.786

Therefore, the general picture when simulating the model with σ = 2 does not change. Simulating the model with only productivity shocks generates many statistics that contradict data. If anything, when σ = 2 some statistics are further away from what they are in data (like the correlation between the deviations from trend in hours worked and the deviations from trend in (log) GDP, for example). In contrast, when financial shocks are included, all statistics remain broadly in line with data. In particular, hours' relative volatility is closer to data, and the correlations between the interbank rate, the corporate debt rate and their spread and GDP and other macroeconomic variables are broadly in line with data.

Next, I simulate the model with $\vartheta = 1$ rather than $\vartheta = 1/2$. With $\vartheta = 1$, the Frisch elasticity of labour supply is lower (1 as opposed to 2). This leads to lower volatility in hours worked. With a lower Frisch elasticity, the household's optimal labour supply decision is less responsive to changes in wages caused by financial shocks and productivity shocks. As a result, it is not surprising that hours' relative volatility generated by model simulation decreases. Other statistics are close to estimates from previous simulations as shown in Tables 1-12, 1-13, and 1-14 below.

Table 1-12: Model Simulation Results – $\vartheta = 1$

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.679	0.675	0.693
Investment	4.958	3.323	2.653	2.771
Hours worked	**1.245**	**0.863**	**0.244**	**0.425**
Correlation to GDP				
Consumption	0.891	0.751	0.906	0.873
Investment	0.867	0.866	0.898	0.879
Hours worked	0.873	0.909	0.727	0.637

Table 1-13: Rates & Spread Correlations with GDP – $\vartheta = 1$

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.497	0.155	0.155	0.138
Corporate	-0.240	-0.965	0.155	-0.306
Spread	-0.713	-0.945	0.155	-0.387

Table 1-14: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables – $\vartheta = 1$

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.713	-0.945	0.155	-0.387
Consumption	-0.604	-0.509	0.044	-0.083
Investment	-0.702	-0.921	-0.045	-0.544
Hours Worked	-0.755	-0.975	-0.255	-0.857

As shown in Tables 1-12 to 1-14, the main conclusion remains unchanged. Simulating the model with financial shocks, whether on their own or combined with productivity shocks, generates statistics (correlations and relative standard deviations) that are closer to data than those generated when simulating the model with productivity shocks only. When financial shocks are included, hours' relative volatility is closer to data, the correlations between the interbank rate, the corporate debt rate and their spread and GDP and other macroeconomic variables are in line with data. All other statistics are also in line with data.

1.5.2 Alternative Specifications

1.5.2.1 Financial Shocks as a Function of Productivity Shocks

In the benchmark simulation, it is assumed that financial shocks are uncorrelated to productivity shocks. In this section, I assume that financial shocks are perfectly correlated to productivity shocks. In particular, as an alternative specification, I assume that the financial sector's overall efficiency (Z_t) is a linear function of aggregate productivity (A_t):

$$Z_t = \zeta A_t.$$

I jointly calibrate ζ and $\xi\gamma$ to target the long-run averages of the real interbank rate (3m Libor) and real corporate bond rate (average of AAA and BAA). All other parameter values are the same as the ones used for the benchmark simulation (values reported in Table 1-5). I simulate the model with productivity shocks, assuming that Z_t changes with A_t as shown above. Results are reported in Tables 1-15 to 1-17 below.

As the results reported in Tables 1-15 to 1-17 below show, when simulating the model with Z_t being perfectly correlated to A_t, the statistics generated are once again broadly in line with data. In terms of consumption, investment, and hours worked, the correlations with GDP and the relative standard deviations generated are close to those generated in the benchmark simulation (Table 1-6). In terms of rates and the spread, the alternative simulation also generates the right signs of their correlations with GDP and other macroeconomic variables.

Therefore, the alternative specification maintains the main results from the benchmark simulation and supports the same conclusion. That is, having variations in the financial sector's efficiency improves the model's ability to capture the right signs of the correlations between the interbank and corporate rates and their spread with GDP and other macroeconomic variables, and to bring the relative volatility of hours closer to data while generating other statistics in line with data. This conclusion holds whether financial shocks are assumed to be uncorrelated to productivity shocks, as in the benchmark simulation, or perfectly correlated to productivity shocks, as in this specification.

Table 1-15: Model Simulation Results - Z_t as a Function of A_t

	Data 1986:Q1 to 2019:Q4	Model – Benchmark with Both Types of Shocks	Model – with $Z_t = \zeta A_t$
Standard deviation relative to GDP			
Consumption	0.838	0.682	0.618
Investment	4.958	2.809	3.230
Hours worked	**1.245**	**0.545**	**0.559**
Correlation to GDP			
Consumption	0.891	0.878	0.808
Investment	0.867	0.883	0.885
Hours worked	0.873	0.697	0.861

Table 1-16: Rates & Spread Correlations with GDP - Z_t as a Function of A_t

	Data 1986:Q1 to 2019:Q4	Model – Benchmark with Both Types of Shocks	Model – with $Z_t = \zeta A_t$
Interbank	0.497	0.130	0.095
Corporate	-0.240	-0.393	-0.681
Spread	-0.713	-0.463	-0.964

Table 1-17: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables - Z_t as a Function of A_t

	Data 1986:Q1 to 2019:Q4	Model – Benchmark with Both Types of Shocks	Model – with $Z_t = \zeta A_t$
GDP	-0.713	-0.463	-0.964
Consumption	-0.604	-0.195	-0.654
Investment	-0.702	-0.565	-0.884
Hours Worked	-0.755	-0.847	-0.878

1.5.2.2 Borrowing Only Capital Input Costs

It is noteworthy that many papers from the literature on the macrofinance link ignore the need of firms to borrow labour input costs, and focus only on the need to borrow funds to finance capital investments (e.g.; Boissay et al., 2016). To that end, in this section, I drop the need to borrow labour input costs, and assume that the representative firm needs only to borrow part of its capital input costs before production takes place.

In this case, the firm's objective function is rewritten as follows:

$$max_{\{k_t,\ h_t\}}\ y_t - (1+\eta_k i_t)R_t k_t - w_t h_t\ ,$$
$$s.t.\quad y_t = A_t {k_t}^{\alpha} {h_t}^{1-\alpha}.$$

First order conditions now show only a capital wedge, but no labour wedge.

$$(1+\eta_k i_t)R_t = \alpha A_t {k_t}^{\alpha-1} {h_t}^{1-\alpha}$$
$$w_t = (1-\alpha) A_t {k_t}^{\alpha} {h_t}^{-\alpha}$$

All other equilibrium equations remain the same as in the benchmark model. Again, I simulate the model with productivity shocks only, financial shocks only, and both types of shocks, using parameter values from Table 1-5. Results are reported in Tables 1-18 to 1-20 below.

Table 1-18: Model Simulation Results - Borrowing Only Capital Input Costs

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.703	0.666	0.689
Investment	4.958	4.299	2.631	2.744
Hours worked	**1.245**	**0.641**	**0.331**	**0.358**
Correlation to GDP				
Consumption	0.891	0.405	0.904	0.866
Investment	0.867	0.851	0.926	0.897
Hours worked	0.873	0.743	0.813	0.760

The results show that while model simulation with financial shocks is still able to generate the right signs of the correlations between the interbank and corporate rates and their spread with GDP and other macroeconomic variables, it performs worse than the benchmark simulation in terms of the relative volatility of hours worked. This is expected since in this specification, the firm’s labour demand decision is no longer directly related to its cost of borrowing. As a result, while variations in i_t still affect optimal labour demand and therefore equilibrium hours through the effect on the firm’s capital demand, the variations in equilibrium hours are now less correlated to variations in i_t. That being said, with this specification, simulating the model with only financial shocks generates relative volatilities of consumption and investment that are closer to data that those generated by the benchmark simulation. However, the correlation between consumption and GDP is weaker under this specification.

Table 1-19: Rates & Spread Correlations with GDP - Borrowing Only Capital Input Costs

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.497	0.244	0.246	0.219
Corporate	-0.240	-0.946	0.246	-0.085
Spread	-0.713	-0.959	0.246	-0.254

Table 1-20: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables - Borrowing Only Capital Input Costs

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.713	-0.959	0.246	-0.254
Consumption	-0.604	-0.128	0.055	0.054
Investment	-0.702	-0.963	0.271	-0.475
Hours Worked	-0.755	-0.903	0.426	-0.547

1.5.2.3 Borrowing Only Labour Input Costs

In this section, I go to the other end. I drop the need to borrow capital input costs and assume that the representative firm needs only to borrow part of its labour input costs before production takes place. This is expected to increase the relative volatility of hours worked.

In this case, the firm's objective function is rewritten as follows:

$$max_{\{k_t,\ h_t\}}\ y_t - R_t k_t - (1 + \eta_h i_t) w_t h_t\ ,$$
$$s.t.\quad y_t = A_t {k_t}^{\alpha} {h_t}^{1-\alpha}.$$

First order conditions now show only a labour wedge, but no capital wedge.

$$R_t = \ \alpha A_t {k_t}^{\alpha-1} {h_t}^{1-\alpha}$$
$$(1 + \eta_h i_t) w_t = \ (1-\alpha) A_t {k_t}^{\alpha} {h_t}^{-\alpha}$$

All other equilibrium equations remain the same as in the benchmark model. I simulate the model with productivity shocks only, financial shocks only, and both types of shocks, using parameter values from Table 1-5. Results are reported in Tables 1-21 to 1-23.

The results show that with this alternative specification, model simulation with financial shocks generates volatility in hours that is higher than GDP (in terms of deviations from trend), which is in line with data. That is, with this specification, the model simulation with only financial shocks generates a ratio between standard deviation of hours worked and GDP that is higher than 1. This is in line with what we observe in data, that is, the standard deviation of hours worked is higher than the standard deviation that GDP. Simulating the model with financial shocks is able to generate this statistic when the firm needs to borrow to pay for only its labour input and not for the capital input. This is because, in this specification, the direct channel through which financial shocks affect GDP is through labour. That being said, the generated relative volatility of investment under this specification is further from data compared to benchmark simulation.

Table 1-21: Model Simulation Results - Borrowing Only Labour Input Costs

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.789	0.666	0.669
Investment	4.958	2.315	2.669	2.643
Hours worked	**1.245**	**1.194**	**0.339**	**0.508**
Correlation to GDP				
Consumption	0.891	0.949	0.900	0.911
Investment	0.867	0.856	0.913	0.915
Hours worked	0.873	0.969	0.741	0.676

Table 1-22: Rates & Spread Correlations with GDP - Borrowing Only Labour Input Costs

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.497	0.068	0.127	0.102
Corporate	-0.240	-0.990	0.127	-0.256
Spread	-0.713	-0.961	0.127	-0.316

Table 1-23: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables - Borrowing Only Labour Input Costs

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.713	-0.961	0.127	-0.316
Consumption	-0.604	-0.885	0.043	-0.205
Investment	-0.702	-0.792	0.022	-0.343
Hours Worked	-0.755	-0.964	-0.259	-0.766

In addition, other statistics remain broadly in line with data when financial shocks are included. Hence, once again the main conclusion holds. Model simulation with only productivity shocks fails in capturing the right signs of correlations between rates and spread with GDP and other macroeconomic variables and underestimates hours relative volatility. Adding financial shocks to the model, whether as the only source of disturbance or together with productivity shocks, improves the model's ability in generating statistics that are closer to data.

Appendix A shows results of simulating the model with another alternative specification. In that specification, Z_t is assumed to equal Z for all t, and financial shocks are modelled as variations in ξ. As shown in Appendix A, the main conclusion holds; however, modelling financial shocks as variations in Z_t generates statistics that are overall closer to data.

In addition, Appendix A also shows the results of the benchmark simulation when using data on 12m Libor in one case and on the effective federal funds rate in another case as measures of the interbank rate when estimating financial shocks. In either case, simulating the model with financial shocks still leads to the same conclusion.

1.6 Conclusion

In this chapter, I build on the model of Boissay et al. (2016) to include financial shocks, exogenous variations in the efficiency of the financial sector, and a firm's working capital loan requirement. I use the model's equilibrium equations along with data on interbank and corporate debt rates to estimate financial shocks.

Simulating the model with financial shocks (whether alone or with productivity shocks) generates procyclical interbank rate, countercyclical corporate debt rate, and countercyclical spread between the two in line with data. It also generates the right sign for the correlations between the spread and other macroeconomic variables. In addition, the model generates business cycle fluctuations in line with the US data since the mid-1980s. In particular, the model simulation with financial shocks generates volatility in hours worked relative to GDP that is closer to data. In contrast, simulating the model with only productivity shocks fails in capturing the cyclicality of rates and the correlations of the spread with macroeconomic variables. It also underestimates the relative volatility of hours worked.

This highlights the importance of fluctuations in the financial sector as a source of wider economic fluctuations. This is in line with the empirical findings of Caldara et al. (2016) that since the mid-1980s in the US, financial shocks have been a significant source of business cycle fluctuations. This implies that reducing fluctuations in the financial sector can help reduce economic fluctuations.

Chapter 2

2 Tighter Debt Limits, Default, and Labour Supply

2.1 Introduction

During the financial crisis that started in 2007 and the Great Recession that followed, banks in the United States (US) and around the world tightened lending standards (Quadrini, 2011; Puri, et al.2011). For example, in the US, the median credit card limit decreased by 20% (Santucci, 2015).

Meanwhile, non-business bankruptcy filings almost doubled, and hours worked dropped during that period. The number of non-business bankruptcy filings increased from 775,344 in 2007 to more than 1.3 million in 2009 before peaking at more than 1.5 million in 2010 (Courts, 2018). Also, hours worked in the non-farm business sector in the US decreased by 10% between Q4:2007 and Q4:2009.

In this chapter, I first ask how does tightening debt limits affect labour supply decisions? Conventional wisdom says that a tighter debt limit is like a negative wealth shock which pushes indebted households to increase labour supply (Guerrieri and Lorenzoni, 2017). However, in the Great Recession we witnessed tightening debt limits and a decrease in aggregate hours worked.

Given the rise in non-business bankruptcy filings that accompanied the decrease in hours worked, I therefore ask the following. How does default (bankruptcy filing) affect labour supply decisions? To the best of my knowledge, this question has been overlooked by the literature on consumer bankruptcy, with few exceptions. An example is Han and Li (2007), who find a negative yet insignificant effect in an empirical study. In contrast, Chen and Zhao (2017) report a positive effect. In this chapter, I aim to contribute to answering this question theoretically.

As mentioned, there was a notable increase in non-business bankruptcy during the financial crisis, between 2007 and 2010. In addition, there has been a growing interest in studying consumer bankruptcy given the increase in consumer bankruptcy that occurred in the US over the past few decades (Livshits et al., 2010). Livshits et al. (2010) mention that one of the main contributors to that increase is the drop in the cost of bankruptcy and the drop in the cost of lending. In addition, Li et al. (2011) highlight the role of consumer bankruptcy in avoiding foreclosures. Bankruptcy is even mentioned as a source of health insurance (Mahoney, 2015). Fieldhouse et al. (2018) study cyclical fluctuations in consumer bankruptcy. However, this literature has mostly abstracted from the effect of bankruptcy filing on households' labour supply decisions (Chen & Zhao, 2017).

To study the effect of tightening debt limits on households' labour supply decisions when default (bankruptcy) is allowed, I build on the models from Guerrieri and Lorenzoni (2017) and Fieldhouse et al. (2018). In the model in this chapter, households live infinitely. They enter with different debt levels and draw different levels of productivity. Productivity is persistent. Markets are incomplete. That is, households can borrow by issuing one-period non-contingent bonds. They borrow from a risk-neutral competitive financial intermediary. Households can default on their debt.

The financial intermediary has an outside option paying a net return of r. It faces a transaction cost of lending to households equal to a fraction $\tau \in [0,1]$. A negative financial shock is modeled as an unexpected increase in τ, which tightens debt limits.

I solve for the model's stationary equilibrium with and without default, before and after a negative financial shock. When debt gets discharged for a household that defaults, this acts like a positive wealth shock. As a result, I find that households who find it optimal to default after the shock decrease their labour supply. They increase it if default is not allowed. This is because a tighter debt limit is like a negative wealth shock as mentioned.

The rest of the chapter is organized as follows: the model is presented in Section 2.2, main results are reported in Section 2.3, and Section 2.4 concludes.

2.2 Model

The economy is populated by measure one of heterogeneous households. Households live infinitely. Each household values consumption and leisure. Households borrow by issuing one period non-contingent bonds, so markets are incomplete. Default is allowed. Loans are provided by a competitive financial intermediary with an exogenous outside option, and a transaction cost of lending.

2.2.1 Households

Households value consumption and leisure. They have different levels of debt ($b < 0$) and draw different levels of productivity (θ) which are (partially) persistent. Households borrow to smooth consumption and may rollover previous debt.

Default is possible in any given period. If default occurs, then the household is excluded from borrowing for a random number of periods. Each period of exclusion, there is a probability (δ) of being allowed to borrow next period. A defaulting household loses a fraction (γ) of its income each period it is excluded from borrowing as in Fieldhouse et al. (2018).

In any period, each household is endowed with one unit of productive time. The income of a household with productivity (θ) supplying l units of time as labour is θl. Therefore, the period consumption of a non-defaulting household is given by $c = \theta l + b - qb'$, where b' is future borrowing and q is the price of the bond. In contrast, the period consumption of a defaulting household is given by $c = (1-\gamma)\theta l$.

Based on the above, the value function of a household with productivity (θ) and debt level (b) in any period is given by $V^0(\theta, b)$ as follows:

(1) $V^0(\theta, b) = max\{V^R(\theta, b), V^D(\theta)\}$,

where,

(2) $V^R(\theta, b) = max_{l,b'}\{U(\theta l + b - qb') + \beta E[V^0(\theta', b')]\}$,

(3) $V^D(\theta) = max_l\{U((1-\gamma)\theta l) + \beta(\delta E[V^0(\theta', 0)] + (1-\delta)E[V^D(\theta')])\}$.

$V^R(\theta, b)$ is the value of repayment for a household with productivity (θ) and debt level (b) in the current period. θ' and b' stand for future period productivity and future period debt level respectively. $V^D(\theta)$ is the value of default (bankruptcy) for a household with productivity (θ) in the current period.

2.2.2 Financial Intermediary

Loans are provided by a risk-neutral competitive financial intermediary. It has an outside option with an exogenous net rate of return (r). If the intermediary lends to households, it incurs a transaction cost of lending (τ). The intermediary prices loans taking into account τ and the probability of default in the next period, $d(b', \theta)$, for each household. Hence, the price of a bond with face value (b') is given by:

$$q(b', \theta) = (1 - \tau)\frac{[1 - \mathrm{d}(b', \theta)]}{1 + r} \qquad (4)$$

A negative financial shock is modeled as an unexpected increase in the transaction cost (τ). As shown in equation (4), this leads to a drop in bond prices. That is, it causes a shift in the whole bond-pricing schedule equivalent to a tightening of debt limits for all pairs of (b', θ).

2.2.3 Equilibrium

Given r, τ, γ, δ, an equilibrium is a sequence of value functions, policy functions, default probabilities, and bond prices that satisfy equations (1) to (4) above. The equilibrium is characterized by the following:

- Repayment Set, $R(b) = \{\theta : V^R(\theta, b) \geq V^D(\theta)\}$.
- Default (Bankruptcy) Set, $D(b) = \{\theta : V^R(\theta, b) < V^D(\theta)\}$.
- Probability of default, $d(b', \theta)$.
- Optimal borrowing policy function $[b'(\theta, b)]$.
- Optimal labour supply policy functions $[l(\theta, b)]$.

2.3 Results

To solve for the model's stationary equilibrium, I assume the following. For the utility function, I use the following function, which is commonly used in literature.

$$\frac{c^{1-\sigma}}{1-\sigma}+\mu\frac{(1-l)^{1-\eta}}{1-\eta}$$

In addition, θ is assumed to follow an AR1 process in logs with autocorrelation coefficient (ρ) and standard deviation (σ_{ε}). The process is approximated by a 7-state Markov chain. I set the values of ρ and σ_{ε} to 0.967 and 0.017 respectively, as in Guerrieri and Lorenzoni (2017).

I assume that if a household defaults in any period, it has a 10% chance of being allowed to borrow again the next period. This is to reflect the fact that when a household files for bankruptcy under Chapter 7 in the US, the "bankruptcy flag" is removed in 10 years (Chen & Zhao, 2017). Table 2-1 below shows the parameter values used.

I solve (numerically) for the model's stationary equilibrium under the following settings: with and without default, before and after a negative shock. Before the shock, I set τ = 0. This is meant to reflect an economy in "normal" times or before a financial crisis. In the second case I set τ = 0.2. This increase in τ tightens borrowing limits by decreasing bond prices for households as mentioned.

Figure 2-1 shows optimal labour supply before the shock ($\tau = 0$) and after the shock ($\tau = 0.2$) when default is not allowed for average productivity household. As Figure 2-1 shows, when indebted households are not allowed to default, they increase their labour supply as they face tighter debt limits. This result is in line with the result from Guerrieri and Lorenzoni (2017). It is due to the negative wealth effect resulting from facing tighter debt limits.

Figure 2-2 shows optimal labour supply after the shock (i.e. when $\tau = 0.2$) when default is allowed versus when it is not. When the household is allowed to default, its optimal labour supply is lower for all levels of debt at which it defaults. As debt gets discharged in case of default, labour supply depends only on the level of productivity in this case. Hence, for all levels of debt at which the household decides to default, its optimal labour supply is the same and the line is horizontal.

For lower levels of debt (in absolute terms), the household finds it optimal to repay its debt. This means that its optimal labour supply in that region depends on both the level of debt and productivity. As the figure shows, the higher the debt (in absolute terms), the higher the labour supply. Also, for levels of debt at which the household decides to repay, the optimal labour supply is the same whether default is allowed or not since the household is not taking the default option at these debt levels. Hence, the two lines overlap for these debt levels.

Similar results hold for households with above and below average productivity. However, with higher (lower) productivity households, default is optimal at higher (lower) levels of debt (in absolute terms) relative to the average productivity household.

Table 2-1: Parameter Values

Parameter	Value	Target or Source
σ	2	Standard
η	1.5	Standard
β	0.98	Standard
r	1.4%	Avg. 1-yr Real US Treasury Rate since 1986
δ	0.1	“bankruptcy flag” removed in 10 years
γ	0.319	Fieldhouse et al. (2018)
ρ	0.967	Guerrieri and Lorenzoni (2017)
σ_ε	0.017	Guerrieri and Lorenzoni (2017)

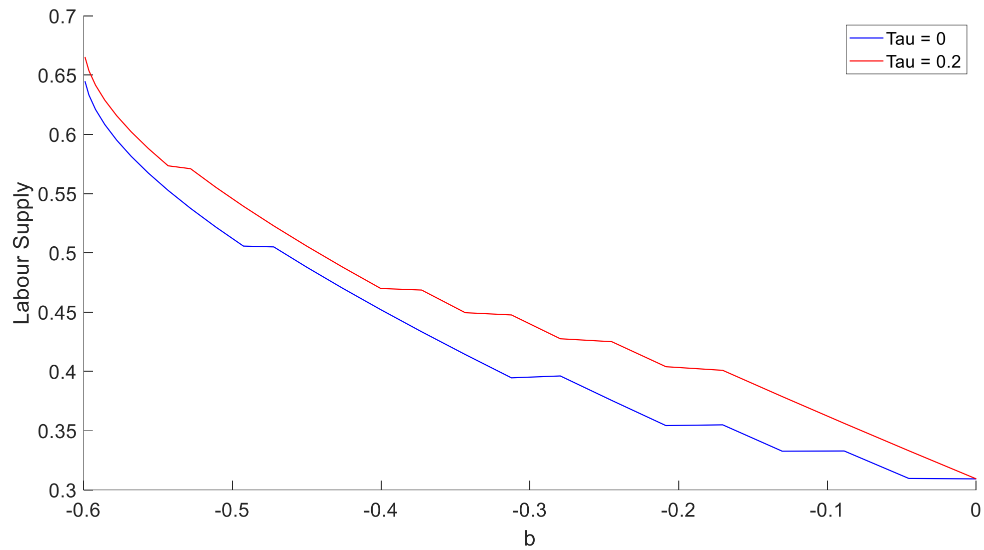

Figure 2-1: Optimal Labour Supply Before and After a Negative Financial Shock Default Not Allowed - Average Productivity Household

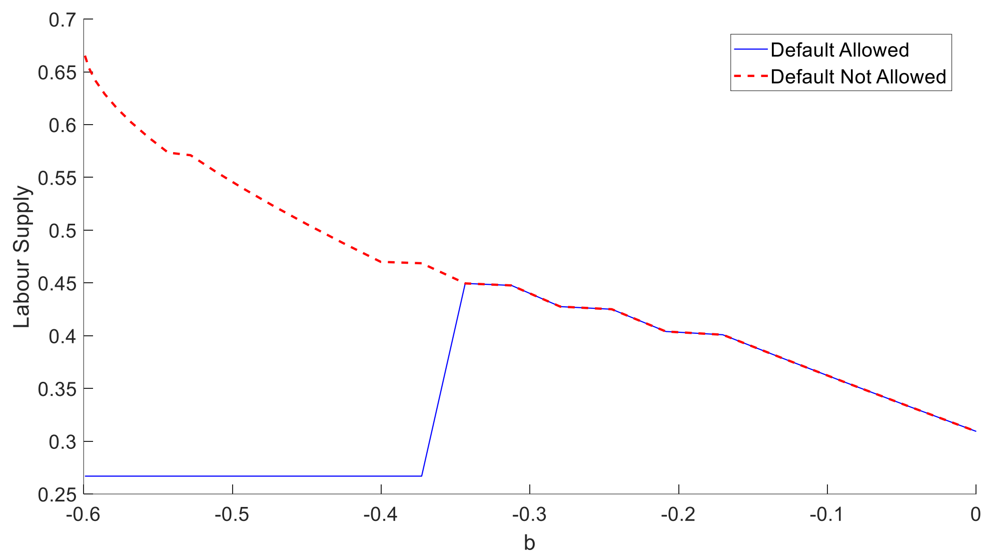

Figure 2-2: Optimal Labour Supply After a Negative Financial Shock - Average Productivity Household

Therefore, the model in this chapter predicts that the effect of default on labour supply is negative. Households who find it optimal to default receive a positive wealth shock as their debt gets discharged. They decrease their labour supply as a result. This is the main result in this chapter.

Whether aggregate labour supply drops after the shock depends on whether the drop in labour supply of households who default after the shock is big enough relative to the increase in the labour supply of households who don’t. If this drop is larger than the increase in labour supply for households who keep repaying, then aggregate labour supply drops. Otherwise, aggregate labour supply increases. In addition, to capture the full interaction between default and labour market outcomes, labour demand needs to be added to the model. This is left for future work.

2.4 Conclusion

Following the financial crisis that started in 2007, the US economy witnessed a tightening of lending standards, an increase in non-business bankruptcy filings, and a decrease in hours worked. In this chapter, I study the effect of tighter debt limits on households' labour supply decisions, and whether the effect changes with default. I find that following a decrease in debt limits, households who find it optimal to default decrease their labour supply. If not allowed to default, they increase their labour supply.

Chapter 3

3 External Debt, Initial Conditions, and Economic Growth in Low- and Middle-Income Countries

3.1 Introduction

External debt is an important source of funds for low- and middle-income countries. Pienkowski (2017) mentions that 70% of public debt in developing countries is foreign debt. In addition, World Bank data show that the average external debt to gross national income almost tripled since 1970 in low- and middle-income countries.

On one hand, external debt provides an extra source of funding for economic growth enhancing projects (like infrastructure for e.g.). On the other hand, elevated levels of external debt means that more resources are devoted for debt service, which hinders an economy's ability to use these resources for more productive activities (see e.g.; Greene, 1989). This may negatively affect economic growth. It may also make obtaining more external debt difficult if lenders view high levels of external debt as a signal of a possible upcoming economic trouble or crisis. That being said, the question that motivates this chapter is: what is the relationship between external debt and economic growth in low- and middle-income countries?

Empirical studies report mixed results on the relationship between external debt and economic growth in this group of countries. A group of studies report a non-linear relationship. That is, they find that the relationship between external debt and economic growth in low- and middle-income countries is characterized by the existence of a threshold, above which the relationship changes compared to when external debt is below threshold. Other studies report a negative relationship, regardless of external debt level. Finally, some studies find a positive relationship.

For example, Reinhart and Rogoff (2010) find that the ratio of external debt to gross national income is irrelevant for economic growth in low- and middle-income economies when the ratio is below 60%. Beyond 60%, it is negatively related to economic growth. Pattillo et al. (2011) use data from a sample of 93 low- and middle-income countries, and they also find a non-linear relationship between external debt and economic growth. Shkolnyk and Koilo (2018) report a non-linear relationship as well. Zaghdoudi (2019) reports a “threshold” as low as 15% approximately, above which external debt is found to be negatively related to economic growth in low- and middle-income economies.

Moreover, Ehikioya et al. (2020) find a negative relationship between external debt and economic growth in a sample of 43 African countries. Awan and Qasim (2020) recommend the reduction of external debt as they find it is negatively related to economic growth. Wang et al. (2021) also report a negative relationship in a different group of countries. Kharusi and Ada (2018) find a negative relationship but conclude that external debt can be used in a more “productive” way to contribute positively to growth. Likewise, Dey and Tareque (2020) find a negative relationship that can be “mitigated” or “nullified” if proper policies are put in place.

Indeed, Uzun et al. (2012) find a positive effect of external debt on economic growth in a group of Eastern European countries in the post-Soviet era. Mohamed (2018) also reports a positive relationship using a different sample. Similarly, Mohsin et al. (2021) find a positive relationship between external debt and economic growth in a group of South Asian countries.

Therefore, this sample of studies show that the relationship reported ranges from non-linear to negative to positive. Reported results may depend on the group of countries included in the sample. It may also depend on the time period covered.

In this chapter, I look at the external debt and economic growth relationship from a new angle. I ask whether where an economy starts in terms of its income per capita affects the external debt-growth relationship. The intuition is that when an economy starts at a relatively low income per capita, it has a bigger growth potential. This means it is more likely to benefit from the extra source of funding to finance investments that boost economic growth.

To that end, I first test this hypothesis empirically by estimating the parameters of growth regression models augmented to include the external debt-to-gross national income ratio and an interaction variable between that ratio and lagged-to-average income per capita. When I include the external debt-to-income ratio only, its estimated coefficients are mostly negative and/or insignificant. Similarly, when I break the sample according to an external debt-to-income threshold, estimated coefficients are mostly insignificant. This could lead to concluding that the external debt-growth relationship is overall negative or insignificant.

However, when I include the interaction variable, the estimated coefficient of external debt-to-income becomes positive and significant while the estimated coefficient of the interaction variable is negative and significant. This supports the hypothesis that in periods when a low- or middle-income economy starts with income per capita lower than its long-run average, external debt is more likely to be positively related with economic growth.

Next, I test whether a standard stochastic growth model with external borrowing can account for this observation. To that end, I simulate the model with different levels of initial external debt, initial output per capita and different productivity shock parameters. This is to reflect the differences between countries in the sample used in estimating the growth regression models. Then, I use the simulated data to estimate the external debt and growth relationship using the same growth regression models. Simulated data produce results in line with the results when estimating the model parameters using the original data. That is, the estimated coefficient of external debt-to-income is positive and significant, and the estimated coefficient of the interaction variable is negative and significant when the growth regression model coefficients are estimated using simulated data.

The rest of the chapter is organized as follows: Section 3.2 presents the growth regression models and estimation results. Section 3.3 presents the stochastic growth model and estimation results. A conclusion is provided in Section 3.4.

3.2 Growth Regression Model Estimation

3.2.1 Benchmark Estimations

I start by estimating the parameters of the following growth regression models à la Barro and Sala-i-Martin (2003), augmented to include the ratio of external debt-to-gross national income as an additional explanatory variable. This class of models is widely used in the macroeconomic empirical literature on economic growth (see e.g.; Checherita-Westphal & Rother, 2012; Woo & Kumar, 2015; Hansen, 2017):

Model 1: $$gr_{it} = \beta_1 X_{it} + \beta_2 \frac{b_{\text{it}}}{y_{it}} + \varepsilon_{it}$$

Model 2: $$gr_{it} = \beta_1 X_{it} + \beta_2 \frac{b_{\text{it}}}{y_{it}} + \alpha_i + \vartheta_t + \varepsilon_{it}$$

- gr_{it} is the growth rate of GDP per capita in country i at time t.
- I set t to 5 years which is the usual period used in economic growth regression models' estimation. So, gr_{it} is average growth over 5-year periods in each i.
- $\frac{b_{it}}{y_{it}}$ is the external debt-to-gross national income (GNI) ratio in country i at time t.
- X_{it} includes (log) initial GDP per capita and investment-to-GDP as a benchmark. As a robustness check, I repeat the estimation while adding a set of regressors that are usually included in growth regression models, like government expenditure as share of GDP, trade openness measure [(exports+imports)/GDP], and inflation.
- α_i is country fixed effects, and ϑ_t is time fixed effects.

Model 1 does not account for country fixed effects and time fixed effects. Therefore, coefficients obtained from estimating the parameters from Model 1 are pooled OLS estimators. Pooled OLS estimators need strong assumption, "strict mean independence", to be consistent. In addition, if there is a correlation between X_{it} and α_i , which is what one would expect, then pooled OLS estimators are biased (Hansen, 2022).

It is reasonable to assume that there is some unobserved time-invariant country-specific characteristics (country fixed effects) and time fixed effects that affect economic growth in the group of countries included in the sample. Model 2 accounts for such fixed effects. Coefficients obtained from estimating the parameters from Model 2 are fixed effects (FE) estimators.

I estimate the parameters of Model 1 and Model 2 using panel data on 35 low- and middle-income countries (N = 35) since 1970 (T =10, given that each period is 5 years). Countries included in the sample are shown in Appendix C. Data availability dictated the number of countries included. Data on growth, external debt, and other variables included in the regression models are retrieved from the World Bank's World Development Indicators (WDI) database. The estimated coefficients are shown in the Table 3-1 and Table 3-2 below:[2]

Table 3-1: Estimated $\boldsymbol{\beta_2}$ – Benchmark $\boldsymbol{X_{it}}$ (Model 1 and Model 2)

	Pooled OLS	**FE**
$\hat{\beta}_2$	-0.017***	-0.001

Table 3-2: Estimated $\boldsymbol{\beta_2}$ – More Regressors (Model 1 and Model 2)

	Pooled OLS	**FE**
$\hat{\beta}_2$	-0.017***	-0.001

[2] Whenever used, *** indicates significant at 1%, ** significant at 5%, and * significant at 10% levels.

Table 3-1 shows the estimated β_2 from Model 1 and Model 2 when X_{it} includes (log) initial GDP per capita and investment-to-GDP only. This is the benchmark X_{it}. As mentioned, more explanatory variables are added to X_{it} and the estimation is repeated as a robustness check. Table 3-2 shows the estimated β_2 from Model 1 and Model 2 when X_{it} includes additional regressors (government expenditure as share of GDP, trade openness, and inflation.) as mentioned above. As Table 3-2 shows, estimated coefficient and its significance do not change when more regressors are included.

In Table 3-1, the estimated coefficient is always negative albeit only the pooled OLS estimator is significant. In Table 3-2, once again both estimates are negative and only the coefficient estimated from Model 1 (pooled OLS) is significant.

Therefore, adding external debt-to-gross national income to a growth regression model as an explanatory variable, and estimating Model 1 and Model 2 leads to a conclusion that the relationship between economic growth and external debt-to-gross national income is insignificant. If any relationship exists, then it is probably negative as per the pooled OLS estimated coefficients. Note that adding more regressors, as shown in Table 3-2, does not significantly change the magnitude or the significance of the estimated coefficient of external debt-to-gross national income.

As mentioned, Reinhart and Rogoff (2010) point out to the potential existence of a "threshold" beyond which the relationship between external debt and economic growth changes. To that end, I modify Model 1 and Model 2 to include two parameters for external debt-to-gross national income, β_2 and β_3, as in Model 3 and Model 4. In Model 3 and Model 4, β_2 measures the effect of external debt-to-gross national income on economic growth when the external debt-to-income ratio is above threshold, and β_3 measures the effect of external debt-to-gross national income on economic growth when the external debt-to-income ratio is below threshold, ceteris paribus.

The threshold is chosen as the average external debt-to-gross national income in the sample. The average external debt-to-gross national income in the sample is approximately 49%. Out of 350 observations, 130 observations are with $\frac{b_{\mathrm{it}}}{y_{it}} \geq 49\%$ and

120 observations are with $\frac{b_{\text{it}}}{y_{it}} < 49\%$. Model 3 and Model 4 are shown below. Results are reported in Table 3-3 and Table 3-4.

Model 3: $$gr_{it} = \beta_1 X_{it} + \beta_2 \frac{b_{\text{it}}}{y_{it}} \geq 49\% + \beta_3 \frac{b_{\text{it}}}{y_{it}} < 49\% + \varepsilon_{it}$$

Model 4: $$gr_{it} = \beta_1 X_{it} + \beta_2 \frac{b_{\text{it}}}{y_{it}} \geq 49\% + \beta_3 \frac{b_{\text{it}}}{y_{it}} < 49\% + \alpha_i + \vartheta_t + \varepsilon_{it}$$

Table 3-3: Estimated $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ – Benchmark $\boldsymbol{X_{it}}$ (Model 3 and Model 4)

	Pooled OLS	FE
$\hat{\beta}_2$	-0.012***	0.003
$\hat{\beta}_3$	0.011	0.026**

Table 3-4: Estimated $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ – More Regressors (Model 3 and Model 4)

	Pooled OLS	FE
$\hat{\beta}_2$	-0.012***	0.003
$\hat{\beta}_3$	0.009	0.026**

Results from Tables 3-3 and 3-4 show that the relationship between economic growth and external debt in this sample is positive below threshold. The estimated coefficient is insignificant with pooled OLS and turns to significant when fixed effects are included. In contrast, above threshold, the relationship is negative and significant with pooled OLS and turns into insignificant when fixed effects are included.

As mentioned, I ask whether where an economy starts in terms of its income per capita and how far it is from its long-run average affects the external debt-growth relationship. The intuition is that when an economy starts at a relatively low income per capita, it has a bigger growth potential. This means it is more likely to benefit from the extra source of funding to finance investments that boost economic growth.

To test whether the starting income per capita of an economy relative to its long-run average affects the relationship between external debt and economic growth, I estimate the parameters of the following growth regression models, Model 5 and Model 6. Results are reported in Table 3-5 and Table 3-6.

Model 5: $$gr_{it} = \beta_1 X_{it} + \beta_2 \frac{b_{it}}{y_{it}} + \beta_3(interaction\ variable) + \varepsilon_{it}$$

Model 6: $$gr_{it} = \beta_1 X_{it} + \beta_2 \frac{b_{it}}{y_{it}} + \beta_3(interaction\ variable) + \alpha_i + \vartheta_t + \varepsilon_{it}$$

- The $interaction\ variable$ is $\left[\frac{b_{it}}{y_{it}}\ x\ (lagged\_to\_averge\ GDP\ per\ capita)_{it}\right]$.

Table 3-5: Estimated $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ – Benchmark $\boldsymbol{X_{it}}$ (Model 5 and Model 6)

	Pooled OLS	**FE**
$\hat{\beta}_2$	0.022*	0.043***
$\hat{\beta}_3$	-0.038***	-0.040***

Table 3-6: Estimated $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ – More Regressors (Model 5 and Model 6)

	Pooled OLS	**FE**
$\hat{\beta}_2$	0.020*	0.043***
$\hat{\beta}_3$	-0.036***	-0.041***

Table 3-7: Summary of Results (No Fixed Effects)

Explanatory Variable						
$\frac{b_{\mathrm{it}}}{y_{it}}$	-0.017 (0.004)	-0.017 (0.004)			0.022 (0.011)	0.020 (0.011)
$\frac{b_{\mathrm{it}}}{y_{it}} \geq 49\%$			-0.012 (0.004)	-0.012 (0.004)		
$\frac{b_{\mathrm{it}}}{y_{it}} < 49\%$			0.011 (0.012)	0.009 (0.012)		
$interaction\ variable$					-0.038 (0.010)	-0.036 (0.010)
Log (initial real GDP)	-0.131 (0.147)	-0.184 (0.150)	-0.210 (0.150)	-0.264 (0.154)	-0.033 (0.147)	-0.080 (0.151)
Investment / GDP	0.114 (0.019)	0.104 (0.021)	0.118 (0.019)	0.105 (0.021)	0.112 (0.018)	0.102 (0.020)
Govt / GDP		-0.097 (0.028)		-0.092 (0.028)		-0.088 (0.028)
Trade Openness		0.009 (0.006)		0.010 (0.006)		0.008 (0.006)
Inflation		-0.001 (0.001)		-0.001 (0.001)		-0.001 (0.001)
FE	No	No	No	No	No	No

Table 3-8: Summary of Results (With Fixed Effects)

Explanatory Variable						
$\frac{b_{\text{it}}}{y_{it}}$	-0.001 (0.004)	-0.001 (0.005)			0.043 (0.013)	0.043 (0.013)
$\frac{b_{\text{it}}}{y_{it}} \geq 49\%$			0.003 (0.005)	0.003 (0.005)		
$\frac{b_{\text{it}}}{y_{it}} < 49\%$			0.026 (0.012)	0.026 (0.012)		
$interaction\ variable$					-0.040 (0.011)	-0.041 (0.011)
Log (initial real GDP)	-0.433 (0.148)	-0.339 (0.178)	-0.529 (0.152)	-0.445 (0.181)	-0.358 (0.147)	-0.231 (0.177)
Investment / GDP	0.128 (0.024)	0.111 (0.026)	0.133 (0.024)	0.116 (0.026)	0.108 (0.024)	0.093 (0.026)
Govt / GDP		-0.061 (0.037)		-0.059 (0.036)		-0.068 (0.036)
Trade Openness		0.016 (0.011)		0.017 (0.011)		0.012 (0.010)
Inflation		-0.000 (0.001)		-0.000 (0.001)		-0.000 (0.001)
FE	Yes	Yes	Yes	Yes	Yes	Yes

Results from Tables 3-1 to 3-6 are summarized in Tables 3-7 and 3-8. The dependant variable in all models is the 5-year average growth rate in GDP per capita. Standard errors are between parentheses. A discussion of results is presented in the next subsection. In particular, I show the implication of the estimated coefficients for the external debt-to-gross national income and the interaction variable.

3.2.2 Discussion

Results reported in Table 3-5 and Table 3-6 show that when the interaction variable is added to the regression models, the estimated coefficient of external debt-to-income is always positive and significant while the estimated coefficient of the interaction variable is always negative and significant. This supports the hypothesis that where an economy starts in terms of income per capita matters for the external debt-growth relationship.

Table 3-9 below shows the predicted change in economic growth from a one percentage point increase in the external debt-to-income ratio using $\hat{\beta}_2$ and $\hat{\beta}_3$ from estimating Model 6 with t = 5 as per results reported in Table 3-6.

Table 3-9: Predicted Change in Economic Growth From 1pp increase in b/y

Lagged-to-Average GDP per Capita	$\frac{\partial growth}{\partial (b/y)}$
0.25	0.033
0.50	0.023
0.75	0.012
1.00	0.002
1.25	-0.008
1.50	-0.019
1.75	-0.029

As the table above shows, higher lagged-to-average GDP per capita is predicted to move the relationship between external debt-to-income and growth in GDP per capita from positive to negative. That is, in periods when an economy starts with income per capita lower than its long-run average, external debt is more likely to be positively related with economic growth and vice versa.

3.2.3 Robustness Check

I repeat the estimation of Model 5 and Model 6 using the lagged external debt-to-income ratio. Estimated coefficients and predicted change in economic growth remain the same qualitatively (in terms of direction) and close quantitatively (in terms of magnitude). These results are shown in Tables 3-10 to 3-12 below.

Once again, reported results show that with the interaction variable added to the models, the estimated coefficient of lagged external debt-to-income is always positive and significant while the estimated coefficient of the interaction variable is always negative and significant.

Table 3-10: Estimated β_2 and β_3 – Benchmark X_{it} (Lagged b/y)

	Pooled OLS	FE
$\hat{\beta}_2$	0.035***	0.054***
$\hat{\beta}_3$	-0.045***	-0.044***

Table 3-11: Estimated β_2 and β_3 – More Regressors (Lagged b/y)

	Pooled OLS	FE
$\hat{\beta}_2$	0.033***	0.053***
$\hat{\beta}_3$	-0.043***	-0.044***

Table 3-12 below shows the predicted change in economic growth from a one percentage point increase in the lagged external debt-to-income ratio using $\hat{\beta}_2$ and $\hat{\beta}_3$ from estimating Model 6 with t = 5 as per results reported in Table 3-11.

Table 3-12: Predicted Change in growth From 1pp increase in Lagged b/y

Lagged-to-Average GDP per Capita	$\frac{\partial growth}{\partial(lagged\ b/y)}$
0.25	0.042
0.50	0.031
0.75	0.020
1.00	0.009
1.25	-0.002
1.50	-0.013
1.75	-0.024

As an additional robustness check, I repeat the estimations with t = 3, and with t = 7. As shown in Tables 3-13 to 3-16, the same conclusion holds. $\hat{\beta}_2$ is positive and mostly significant while $\hat{\beta}_3$ is negative and always significant, whether t = 3 or t = 7.

Table 3-13: Estimated $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ – Benchmark $\boldsymbol{X_{it}}$ (t=3)

	Pooled OLS	**FE**
$\hat{\beta}_2$	0.014	0.033***
$\hat{\beta}_3$	-0.031***	-0.034***

Table 3-14: Estimated β_2 and β_3 – More Regressors (t=3)

	Pooled OLS	FE
$\hat{\beta}_2$	0.017*	0.035***
$\hat{\beta}_3$	-0.033***	-0.036***

Table 3-15: Estimated β_2 and β_3 – Benchmark X_{it} (t=7)

	Pooled OLS	FE
$\hat{\beta}_2$	0.031**	0.047***
$\hat{\beta}_3$	-0.045***	-0.043***

Table 3-16: Estimated β_2 and β_3 – More Regressors (t=7)

	Pooled OLS	FE
$\hat{\beta}_2$	0.029**	0.049***
$\hat{\beta}_3$	-0.043***	-0.043***

To test whether the conclusion changes with the sample, I repeat the estimation with a different sample. As mentioned, data availability since 1970 is lacking for many low- and middle-income countries. Some countries were not independent at that time. For example, the former Soviet Union countries where all part of one country back then. Therefore, in the new sample, the starting date is 1994, which is a shorter time period. With this starting date, more low- and middle-income countries have their data available. Therefore, the number of countries included in the new sample is 82, as opposed to 35 when the starting data is 1970 (the benchmark sample). Even with this different sample, the conclusion holds. $\hat{\beta}_2$ is positive and significant while $\hat{\beta}_3$ is negative and significant. Results are reported in Appendix C to save space.

3.3 Stochastic Growth Model With External Borrowing

In this section, I test whether a standard stochastic growth model with external borrowing can account for the observation from the previous section. I briefly describe the model environment next. This is a standard stochastic growth model commonly used in macroeconomic literature, augmented to include external borrowing and interest on external debt that is a function of the level of debt.

A representative household with an infinite time horizon values consumption, accumulates capital and can borrow internationally. The interest rate on external debt is a function of debt as mentioned. It is reasonable to assume that as debt levels increase, the interest rate charged on debt increases as well.

Also, the economy has a profit-maximizing representative firm. The firm has a Cobb-Douglas production function. Productivity is subject to exogenous shocks each period.

The social planner's problem is as follows:

$$max_{\{c_t, l_t,\, k_{t+1},\, b_{t+1}\}} E_0 \left[\sum_{t=0}^{\infty} \beta^t U(c_t) \right]$$

$$s.t. \qquad c_t + x_t = A_t {k_t}^{\alpha} {l_t}^{1-\alpha} + b_{t+1} - [1 + r(b_t)] b_t \quad \forall t$$

$$x_t = k_{t+1} - (1 - \delta) k_t$$

$$A_t = A e^{z_t}$$

$$A = 1$$

$$z_t = \rho_z z_{t-1} + \varepsilon_t$$

$$\varepsilon_t \sim i.i.d.\ N\left(0, {\sigma_z}^2\right)$$

$$c_t \geq 0\,;\, 0 \leq l_t \leq 1$$

$$k_0, b_0 \textit{ given.}$$

3.3.1 Stochastic Growth Model Simulation

For the stochastic growth model simulations, I use the following utility function:

$$\frac{c^{1-\sigma}}{1-\sigma}$$

I set σ to 2, β to 0.96, α to 0.36 and δ to 0.05 (all are standard).

For the interest rate function, I use the following function from Schmitt-Grohé and Uribe (2003):

$$r(b_t) = r + \gamma\left(\exp\left(b_t - \hat{b}\right) - 1\right)$$

r is a base rate, assumed to equal 2%. b_t is external debt level in time t. $\hat{b}$ and γ are parameters whose values are set in each simulation so that the steady state external debt-to-income ratio (b/y) matches the long-run average b/y for a country from the panel data sample used to estimate the growth regression models from the previous section.

I simulate the model 35 times, to generate a sample with the same number of countries as in the original sample. For each simulation, I estimate ρ_z and σ_z using data on output, capital, and labour for a country in the sample. I also set k_0 and b_0 to match the country's initial conditions *(*output per capita and external debt-to-income). Initial A is set to 1.

Using the data generated from the stochastic growth model simulations, I estimate $\hat{\beta}_2$ and $\hat{\beta}_3$ from Model 5 and Model 6 with t = 5. The estimation yields $\hat{\beta}_2$ = 0.029 and $\hat{\beta}_3 =$ -0.026 with pooled OLS and $\hat{\beta}_2$ = 0.025 and $\hat{\beta}_3 =$ -0.021 with FE. All are statistically significant. Since $\hat{\beta}_2$ is positive and significant and $\hat{\beta}_3$ is negative and significant, this means that the predicted external debt-growth relationship using simulated data from the stochastic growth model with external borrowing is in line with the predicted relationship using the original ("real world") panel data.

In Appendix C, I show the time paths of investment-to-GDP with and without external borrowing in a simulated economy starting with GDP per capita below long-run average. External borrowing is shown to boost investment. This is in line with the intuition that when an economy starts at a relatively low GDP per capita, it has a bigger growth potential which means it is more likely to benefit from the extra source of funding to finance investments that boost economic growth.

Table 3-17 below shows the predicted change in economic growth from one percentage point increase in the external debt-to-income ratio implied by the estimated coefficients from Model 6 using original data (the panel data sample) and simulated data.

Table 3-17: Predicted Change in growth From 1pp increase in b/y

Lagged-to-Average GDP per Capita	$\frac{\partial growth}{\partial(b/y)}$ - Original	$\frac{\partial growth}{\partial(b/y)}$ - Simulated
0.25	0.033	0.020
0.50	0.023	0.015
0.75	0.012	0.009
1.00	0.002	0.004
1.25	-0.008	-0.001
1.50	-0.019	-0.007
1.75	-0.029	-0.012

3.4 Conclusion

In this chapter, I look at the relationship between external debt and economic growth in low- and middle-income countries from a new angle. I ask whether where an economy starts in terms of its income per capita affects the external debt-growth relationship. I find that when an economy starts below its long-run average output per capita, the relationship is more likely to be positive and vice-versa.

Then, I ask whether a stochastic growth model with external borrowing captures this observation. Simulated data also show that higher lagged-to-average GDP per capita is predicted to turn the relationship between external debt-to-income and growth in GDP per capita from positive to negative.

Overall, this indicates that for low- and middle-income economies, in periods when they start with output per capita lower than average, external borrowing may boost economic growth.

References

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, *68*(1), 29-51.

Awan, A. G., & Qasim, H. (2020). The impact of external debt on Economic Growth of Pakistan. *Global Journal of Management, Social Scienes and Humanities*, *6*(1), 30-61.

Barro, R. J., & Sala-i-Martin, X. I. (2003). *Economic growth*. MIT press.

Bernanke, B. S. (1993). Credit in the Macroeconomy. *Quarterly Review-Federal Reserve Bank of New York*, *18*, 50-50.

Bernanke, B., & Gertler, M. (1989). Agency Costs, Net Worth, and Business Fluctuations. *The American Economic Review*, *79*(1), 14-31.

Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics*, *1*, 1341-1393.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115-143.

Boissay, F., Collard, F., & Smets, F. (2016). Booms and banking crises. *Journal of Political Economy*, *124*(2), 489-538.

Caldara, D., Fuentes-Albero, C., Gilchrist, S., & Zakrajšek, E. (2016). The macroeconomic impact of financial and uncertainty shocks. *European Economic Review*, *88*, 185-207.

Chari, V. V., Kehoe, P. J., & McGrattan, E. R. (2002). Accounting for the great depression. *American Economic Review*, *92*(2), 22-27.

Chari, V. V., Kehoe, P. J., & McGrattan, E. R. (2007). Business cycle accounting. *Econometrica*, *75*(3), 781-836.

Checherita-Westphal, C., & Rother, P. (2012). The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. *European economic review*, *56*(7), 1392-1405.

Chen, D., & Zhao, J. (2017). The impact of personal bankruptcy on labor supply decisions. *Review of Economic Dynamics*, *26*, 40-61.

Claessens, S., & Kose, M. A. (2018). Frontiers of macrofinancial linkages. *BIS Paper*, (95).

Courts, U. S. (2018). Just the Facts: Consumer Bankruptcy Filings, 2006-2017. *United States Courts. Retrieved June*, *21, 2022*.

Dey, S. R., & Tareque, M. (2020). External debt and growth: role of stable macroeconomic policies. *Journal of Economics, Finance and Administrative Science*.

Fieldhouse, D., Livshits, I., & MacGee, J. (2018). Aggregate fluctuations, consumer credit and bankruptcy. *Unpublished Manuscript, University of Western Ontario*.

Gertler, M., & Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. In *Handbook of monetary economics* (Vol. 3, pp. 547-599). Elsevier.

Gertler, M., Kiyotaki, N., & Prestipino, A. (2020). A macroeconomic model with financial panics. *The Review of Economic Studies*, *87*(1), 240-288.

Gilchrist, S., & Zakrajšek, E. (2011). Monetary policy and credit supply shocks. *IMF Economic Review*, *59*(2), 195-232.

Greene, J. (1989). The external debt problem of sub-Saharan Africa. *Staff Papers*, *36*(4), 836-874.

Greenwood, J., Hercowitz, Z., & Huffman, G. W. (1988). Investment, capacity utilization, and the real business cycle. *The American Economic Review*, 402-417.

Guerrieri, V., & Lorenzoni, G. (2017). Credit crises, precautionary savings, and the liquidity trap. *The Quarterly Journal of Economics*, *132*(3), 1427-1467.

Han, S., & Li, W. (2007). Fresh start or head start? the effects of filing for personal bankruptcy on work effort. *Journal of Financial Services Research*, *31*(2), 123-152.

Hansen, B. E. (2017). Regression kink with an unknown threshold. *Journal of Business & Economic Statistics*, *35*(2), 228-240.

Hansen, B. E. (2022). *Econometrics*. Princeton University Press.

Jermann, U., & Quadrini, V. (2012). Macroeconomic effects of financial shocks. *American Economic Review*, *102*(1), 238-71.

Ighodalo Ehikioya, B., Omankhanlen, A. E., Osagie Osuma, G., & Iwiyisi Inua, O. (2020). Dynamic relations between public external debt and economic growth in African countries: a curse or blessing?. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(3), 88.

Kharusi, S. A., & Ada, M. S. (2018). External debt and economic growth: The case of emerging economy. *Journal of economic integration*, *33*(1), 1141-1157.

Kiyotaki, N., & Moore, J. (1997). Credit cycles. *Journal of political economy*, *105*(2), 211-248.

Li, W., White, M. J., & Zhu, N. (2011). Did bankruptcy reform cause mortgage defaults to rise?. *American Economic Journal: Economic Policy*, *3*(4), 123-47.

Liu, M., & Magnan, M. (2014). Conditional conservatism and underpricing in US corporate bond market. *Applied financial economics*, *24*(20), 1323-1334.

Livshits, I., MacGee, J., & Tertilt, M. (2010). Accounting for the rise in consumer bankruptcies. *American Economic Journal: Macroeconomics*, *2*(2), 165-93.

Mahoney, N. (2015). Bankruptcy as implicit health insurance. *American Economic Review*, *105*(2), 710-46.

Mohamed, E. S. (2018). Effect of external debt on economic growth of Sudan: Empirical analysis (1969-2015). *Journal of Economic Cooperation & Development*, *39*(1), 39-62.

Mohsin, M., Ullah, H., Iqbal, N., Iqbal, W., & Taghizadeh-Hesary, F. (2021). How external debt led to economic growth in South Asia: A policy perspective analysis from quantile regression. *Economic Analysis and Policy*, *72*, 423-437.

Mollenkamp, C., & Whitehouse, J. (2008). Bankers cast doubt on key rate amid crisis. *Wall Street Journal*, *16*, A1.

Pattillo, C., Poirson, H., & Ricci, L. A. (2011). External debt and growth. *Review of economics and institutions*, *2*(3), 30.

Phaneuf, L., & Victor, J. G. (2017). The Business Cycle in an Estimated DSGE Model With Production Networks and Working Capital. *Manuscript, University of Quebec at Montreal.*

Pienkowski, A. (2017). Debt limits and the structure of public debt. *Journal of Globalization and Development*, *8*(2).

Puri, M., Rocholl, J., & Steffen, S. (2011). Global retail lending in the aftermath of the US financial crisis: Distinguishing between supply and demand effects. *Journal of Financial Economics*, *100*(3), 556-578.

Quadrini, V. (2011). Financial frictions in macroeconomic fluctuations. *Available at SSRN 2190595*.

Reinhart, C. M., & Rogoff, K. S. (2010). Growth in a Time of Debt. *American Economic Review*, *100*(2), 573-78.

Santucci, L. (2015). A tale of two vintages: credit limit management before and after the CARD act and Great Recession. *FRB of Philadelphia Payment Cards Center Discussion Paper,* (15-01).

Schmitt-Grohé, S., & Uribe, M. (2003). Closing small open economy models. *Journal of International Economics, 61*(1), 163-185.

Shkolnyk, I., & Koilo, V. (2018). The relationship between external debt and economic growth: Empirical evidence from Ukraine and other emerging economies. *Investment management and financial innovations*, *15*(1).

Uzun, A., Karakoy, C., Kabadayi, B., & Emsen, O. S. (2012). The impacts of external debt on economic growth in transition economies. *Chinese business review*, *11*(5).

Wang, R., Xue, Y., & Zheng, W. (2021). Does high external debt predict lower economic growth? Role of sovereign spreads and institutional quality. *Economic Modelling*, *103*, 105591.

Woo, J., & Kumar, M. S. (2015). Public debt and growth. *Economica*, *82*(328), 705-739.

Zaghdoudi, T. (2020). Threshold effect in the relationship between external debt and economic growth: A dynamic panel threshold specification. *Journal of Quantitative Economics*, *18*(2), 447-456.

Appendices

Appendix A: Chapter 1

Impulse Response

Figures A 1 to A 3 below show the generated time paths, from the benchmark model, of the spread between the corporate rate and interbank rate and of output in three scenarios.

In the first scenario shown in Figure A 1, there is a positive financial shock, after which Z_t remains above trend for many periods due to persistence. We see that as a result, the spread is below trend and output is above trend.

In the second scenario shown in Figure A 2, there is a positive productivity shock, after which A_t remains above trend for many periods due to persistence. In contrast to the first scenario, now both the spread and output are above trend for a number of periods.

In the third scenario shown in Figure A 3, I include a positive financial shock along with a positive productivity shock, after which both Z_t and A_t remain above trend for many periods due to persistence. As in shown in Figure A 3, adding the financial shock results in the spread being again below trend while output being above trend, which is in line with data.

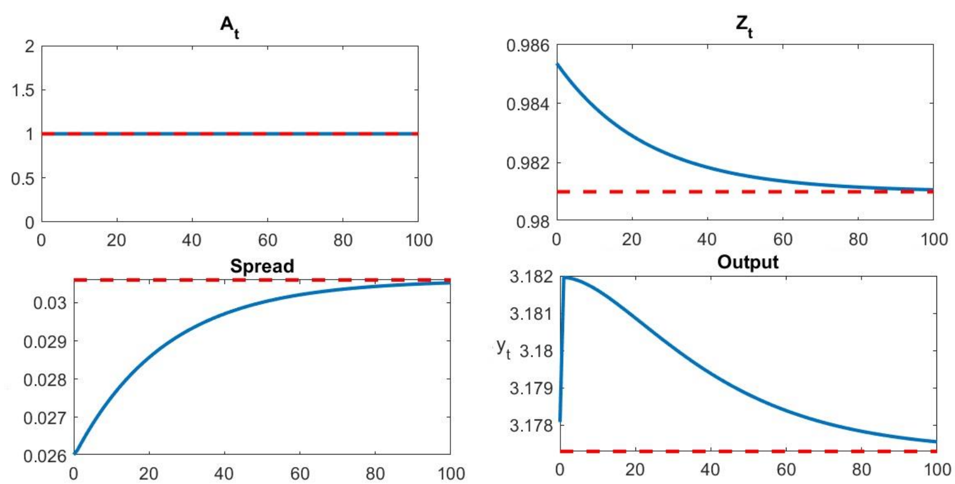

Figure A 1: Time Path of Spread and Output – Positive Financial Shock

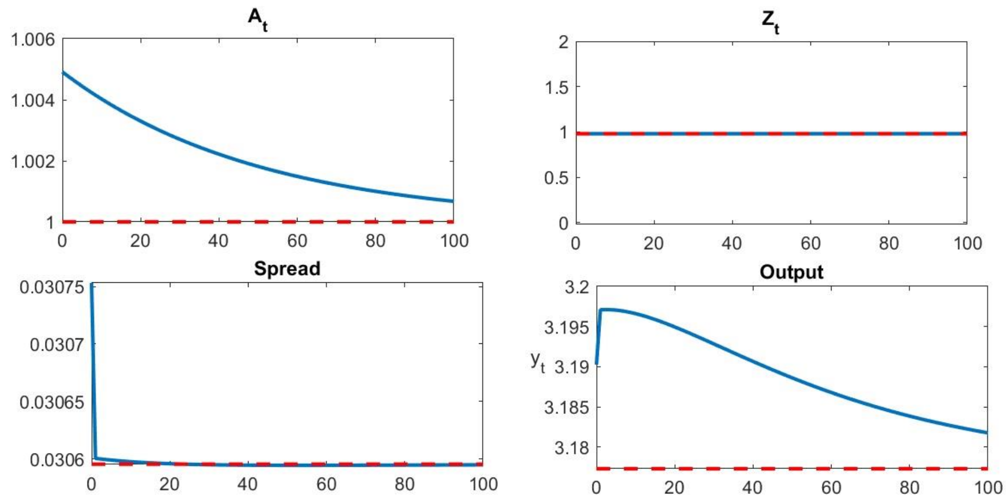

Figure A 2: Time Path of Spread and Output – Positive Productivity Shock

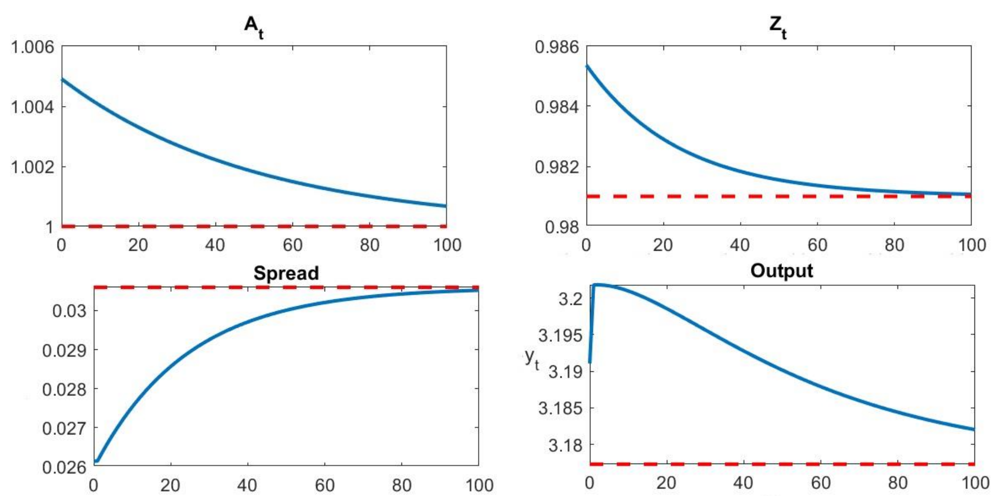

Figure A 3: Time Path of Spread and Output – Positive Productivity Shock and Positive Financial Shock

Benchmark Model vs. Standard RBC

Table A 1 below shows the correlations of consumption, investment, and hours worked with GDP (in terms of deviations from trend) in data and those generated from the benchmark simulations versus those generated from simulating a standard Real Business Cycle (RBC) model with no financial sector. In addition, the table shows the relative standard deviation of each variable.

As the results reported in Table A 1 show, when simulated with only productivity shocks, the model generates statistics that are close to those generated from simulating a standard RBC model. Adding financial shocks improves the generated business cycle statistics relative to a standard RBC, particularly in terms of the relative volatility of hours worked.

GHH Utility Function

The goal of this section is to check whether results significantly change when using an alternative utility function. To that end, I simulate the model using the following utility function:

$$\frac{1}{1-\sigma}\left(c_t - \omega\frac{{h_t}^{1+\eta}}{1+\eta}\right)^{1-\sigma}$$

With this functional form of utility, the representative household's first order condition now implies that:

$$h_t = \left({}^{w_t}/_{\omega}\right)^{1/\eta}$$

All other equilibrium equations remain similar to the benchmark. I simulate the model with productivity shocks only, financial shocks only, and both types of shocks, using parameter values from Table 1-5 and the utility function above. I set ω such that the steady state hours are equal to one third of time available. Results are reported in Tables A 2 to A 4 below.

With this utility function, the labour supply decision and the consumption-saving decisions are independent (Greenwood et al., 1988). Compared to the benchmark simulation, there is in an increase in the estimated relative volatility of consumption which brings the estimated relative volatility of consumption closer to data. In addition, with this utility function, when simulating the model with only financial shocks, hours are more volatile than GDP, which is in line with data. However, the estimated relative volatility of investment when simulating the model using this utility function is further away from data compared to simulating the model with the benchmark utility function. Correlations are still broadly in line with data in all simulations, except that now when simulating the model with both shocks, the spread is positively correlated to consumption, contrary to data. That being said, the main conclusion holds. That is, using either utility function, adding financial shocks brings the estimated statistics closer to data.

Table A 1: Model Simulation Results - Benchmark Model vs. RBC

	Data 1986:Q1 to 2019:Q4	Benchmark: Financial Shocks	Benchmark: Productivity Shocks	Benchmark: Both Shocks	RBC
Standard deviation relative to GDP					
Consumption	0.838	0.676	0.668	0.682	0.664
Investment	4.958	3.114	2.728	2.809	2.680
Hours worked	**1.245**	**0.941**	**0.333**	**0.545**	**0.333**
Correlation to GDP					
Consumption	0.891	0.813	0.902	0.878	0.902
Investment	0.867	0.876	0.894	0.883	0.921
Hours worked	0.873	0.920	0.745	0.697	0.814

Table A 2: Model Simulation Results - GHH Utility Function

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.762	0.783	0.789
Investment	4.958	2.454	2.311	2.427
Hours worked	**1.245**	**1.036**	**0.679**	**0.727**
Correlation to GDP				
Consumption	0.891	0.913	0.934	0.910
Investment	0.867	0.879	0.858	0.841
Hours worked	0.873	0.978	0.982	0.957

Table A 3: Rates & Spread Correlations with GDP - GHH Utility Function

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.497	0.111	0.060	0.051
Corporate	-0.240	-0.842	0.060	-0.092
Spread	-0.713	-0.810	0.060	-0.126

Table A 4: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables - GHH Utility Function

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.713	-0.810	0.060	-0.126
Consumption	-0.604	-0.511	0.018	0.200
Investment	-0.702	-0.926	-0.190	-0.439
Hours Worked	-0.755	-0.907	-0.131	-0.356

12m Libor and Federal Funds Rate to Estimate Financial Shocks

As mentioned, to estimate the financial shocks, as a benchmark, I assume that in any period, Z_t is equal to a steady state Z multiplied by e^{u_t}, where u_t follows an AR(1) process with an i.i.d. error term $\varepsilon_t^u \sim N(0, \sigma_u^2)$:

$$u_t = \rho_u u_{t-1} + \varepsilon_t^u$$

To obtain estimates for ρ_u and σ_u, I construct a time series for Z_t using:

$$Z_t = \frac{\kappa_t}{(1 + i_t)\left(\frac{\kappa_t - \xi\gamma}{\kappa_t}\right)^{1/\lambda}}$$

In the benchmark simulation, I jointly calibrate the steady state value of Z with $\xi\gamma$ to target the long-run average of the real 3m Libor and long-run average of the real AAA and BAA corporate bond rates. To construct a time series for Z_t, I use data on 3m Libor and corporate bond rates. Estimated ρ_u and σ_u for the benchmark simulation are 0.9611 and 0.0042 respectively.

In this section, I repeat the exercise using two different rates as a measure of the interbank rate. In the first, I use 12m Libor. In the second, I use the effective federal funds rate (FF). In both cases, the financial shocks are found to be slightly less persistent. Estimated ρ_u using data on 12m Libor is 0.9577 and using data on FF is 0.9531. As for volatility, financial shocks are most volatile when using FF in estimation (0.0046), and least when using 12m Libor in estimation (0.0039).

Tables A 5 to A 7 show the results from model simulation when using 12m Libor to estimate financial shocks, and Tables A 8 to A 10 show the results from model simulation when using FF to estimate financial shocks. Main conclusion still holds.

Table A 5: Model Simulation Results – Using 12m Libor to Estimate Financial Shocks

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.680	0.668	0.681
Investment	4.958	3.140	2.728	2.805
Hours worked	**1.245**	**0.951**	**0.333**	**0.521**
Correlation to GDP				
Consumption	0.891	0.808	0.902	0.881
Investment	0.867	0.872	0.894	0.883
Hours worked	0.873	0.918	0.745	0.687

Table A 6: Rates & Spread Correlations with GDP - Using 12m Libor

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.462	0.159	0.136	0.128
Corporate	-0.240	-0.979	0.136	-0.335
Spread	-0.709	-0.956	0.136	-0.416

Table A 7: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables – Using 12m Libor

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.709	-0.956	0.136	-0.416
Consumption	-0.606	-0.629	0.045	-0.156
Investment	-0.692	-0.897	-0.082	-0.523
Hours Worked	-0.733	-0.965	-0.235	-0.821

As the reported statistics show, the main conclusion holds. With financial shocks, whether constructed using data on 3m Libor, 12m Libor, or the effective federal funds rate as a measure of the interbank rate, model simulation yields the right signs of the correlations between the interbank rate, the corporate bond rate and their spread with GDP and other macroeconomic variables. It also yields relative volatility in hours worked closer to data and other statistics broadly in line with data.

Table A 8: Model Simulation Results – Using FF to Estimate Financial Shocks

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.684	0.668	0.681
Investment	4.958	3.179	2.728	2.830
Hours worked	**1.245**	**0.964**	**0.333**	**0.547**
Correlation to GDP				
Consumption	0.891	0.801	0.902	0.877
Investment	0.867	0.866	0.894	0.881
Hours worked	0.873	0.916	0.745	0.686

Table A 9: Rates & Spread Correlations with GDP - Using FF

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.485	0.160	0.136	0.126
Corporate	-0.240	-0.978	0.136	-0.368
Spread	-0.667	-0.953	0.136	-0.434

Table A 10: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables - Using FF

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.667	-0.953	0.136	-0.434
Consumption	-0.570	-0.614	0.045	-0.163
Investment	-0.656	-0.887	-0.082	-0.540
Hours Worked	-0.687	-0.963	-0.235	-0.838

Another Alternative Specification

In this section, I present an alternative specification for financial shocks in the model. Then, I show the results from simulating the model with this alternative specification.

In this specification, I assume that $Z_t = Z$ for all t. Then, rather than having a constant ξ, it is now assumed to be subject to exogenous shocks each period. These are the financial shocks in this alternative specification.

In this specification, it is assumed that ξ_t is equal to a steady state ξ multiplied by e^{ζ_t}, where ζ_t follows an AR(1) process with an i.i.d. error term $\varepsilon_t^{\zeta} \sim N\left(0, \sigma_{\zeta}^2\right)$.

$$\xi_t = \xi e^{\zeta_t},$$

$$\zeta_t = \rho_{\zeta} \zeta_{t-1} + \varepsilon_t^{\zeta}.$$

At the beginning of each period, the shock is realized and ξ_t is determined accordingly. Now, the interbank borrowing constraint becomes:

$$\phi_t = \frac{\kappa_t - \xi_t \gamma}{\xi_t \gamma}$$

The interbank market clearing condition is the same as in the benchmark model, so:

$$\mu(\bar{\theta}_t) = [1 - \mu(\bar{\theta}_t)]\phi_t \implies \mu(\bar{\theta}_t) = \left(\frac{\phi_t}{1+\phi_t}\right) \implies \mu(\bar{\theta}_t) = \frac{\kappa_t - \xi_t \gamma}{\kappa_t}$$

To simulate the model with this alternative specification, I use the same parameter values and functional forms used to simulate the benchmark model (Table 1-5). The exception is the parameter values used for financial shocks. For that, I assume that $\gamma = 1$ and set the steady state ξ (and Z) to target the long-run average of the real interbank rate (3m Libor).

Using $\mu(\bar{\theta}_t) = \frac{\kappa_t - \xi_t \gamma}{\kappa_t}$ and $\mu(\theta) = \theta^{\lambda}$, I get that $\bar{\theta}_t = \left(\frac{\kappa_t - \xi_t \gamma}{\kappa_t}\right)^{1/\lambda}$. I also now have that $\bar{\theta}_t = \frac{\kappa_t}{Z(1+\mathrm{i}_t)}$, since $Z_t = Z$ for all t. Putting them together, I obtain the following (with $\gamma = 1$ and $Z_t = Z$):

$$\xi_t = \frac{\kappa_t [Z(1+\mathrm{i}_t)]^{\lambda} - {\kappa_t}^{\lambda+1}}{[Z(1+\mathrm{i}_t)]^{\lambda}}$$

Again, I use data on 3m Libor minus inflation for the gross real interbank rate (κ_t) and the average of (AAA-inflation) and (BAA-inflation) for the real corporate debt rate (i_t). Using data on κ_t and i_t with the calibrated values of λ and Z, I construct a time series for ξ_t using the above equation. Finally, I use the constructed series to estimate ρ_{ζ} and σ_{ζ}.

Then, I simulate the model with the alternative specification in each case with only financial shocks, only productivity shocks, and both types of shocks. Results are reported in Tables A 11 to A 13 below.

As the results in Tables A 11 to A 13 below show, the main conclusion holds. Adding financial shocks bring the generated statistics closer to data. However, modelling financial shocks as variations in Z_t generates statistics that are overall closer to data than the case of variations in ξ.

Table A 11: Model Simulation Results – Variations in ξ

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Standard deviation relative to GDP				
Consumption	0.838	0.677	0.667	0.664
Investment	4.958	3.134	2.723	2.734
Hours worked	**1.245**	**0.953**	**0.335**	**0.340**
Correlation to GDP				
Consumption	0.891	0.822	0.900	0.900
Investment	0.867	0.867	0.894	0.895
Hours worked	0.873	0.925	0.746	0.755

Table A 12: Rates & Spread Correlations with GDP - Variations in ξ

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
Interbank	0.497	0.902	0.136	0.145
Corporate	-0.240	-0.980	0.136	0.093
Spread	-0.713	-0.952	-0.136	-0.064

Table A 13: Spread (Corporate – Interbank) Correlations with GDP & Other Macroeconomic Variables - Variations in ξ

	Data 1986:Q1 to 2019:Q4	Model with Financial Shocks	Model with Productivity Shocks	Model with Both Shocks
GDP	-0.713	-0.952	-0.136	-0.064
Consumption	-0.604	-0.657	-0.045	-0.152
Investment	-0.702	-0.854	0.083	0.015
Hours Worked	-0.755	-0.951	0.233	-0.143

Business Cycle Accounting Exercise

I conduct a business cycle accounting exercise (Chari et al., 2002; Chari et al., 2007). The goal is to show the role of different wedges in economic fluctuations. As suggested by the authors, I use a standard neoclassical growth model and data on output, hours worked, consumption, investment, and capital to recover four wedges: efficiency, labour, investment, and government consumption wedges. Then, I simulate the model with one wedge at a time and with a combination of wedges.

Table A 14 below shows the correlation of the deviations from trend of output, hours worked, consumption, and investment from model simulations with the deviations from trend of each variable in the data. Each row is from simulating the model with one wedge or a combination of wedges. The numbers show that the efficiency wedge (productivity) is the most important wedge for output fluctuations. However, adding labour and capital (investment) wedges is important to jointly capture fluctuations in hours worked, consumption, and investment, along with the fluctuations in GDP.

Table A 14: Business Cycle Accounting

Wedge	Output	Hours Worked	Consumption	Investment
Efficiency (z)	0.948	0.471	0.312	0.482
Labour (1-τ_H)	0.322	0.668	0.135	0.191
Investment (1-τ_K)	-0.638	-0.442	0.960	-0.149
Government	-0.222	-0.518	0.080	0.052
z, (1-τ_H), (1-τ_K)	**0.975**	**0.970**	**1.000**	**0.751**

Appendix B: Chapter 2

Non-Business Bankruptcy Filing & Hours Worked in the US (2007-2017)

The correlation between deviations from trend in non-business bankruptcy filings and hours worked in the non-farm business sector in the US is -0.89. This is a strong negative correlation. The figure below shows the percentage deviations from HP trend in each series for the decade between 2007 and 2017.

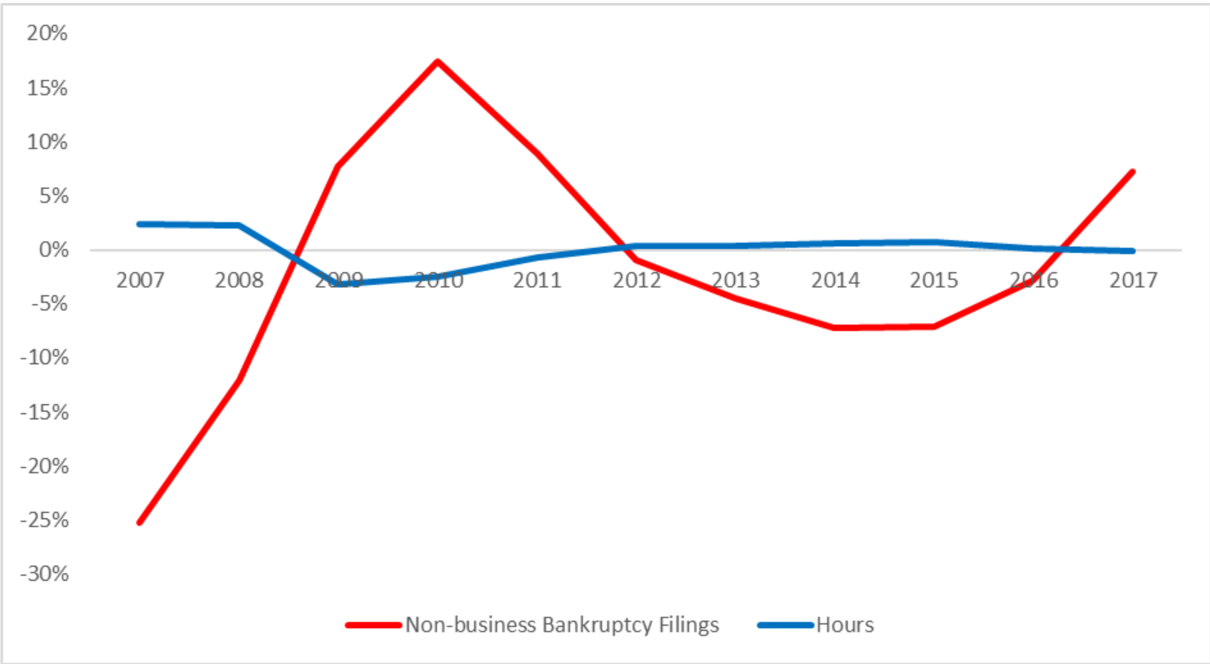

Figure B 1: Percentage Deviations From Trend in Bankruptcy Filings and in Hours

Appendix C: Chapter 3

Average External Debt to GNI and Growth in GDP per Capita Since 1970 in 35 Low- and Middle-Income Economies

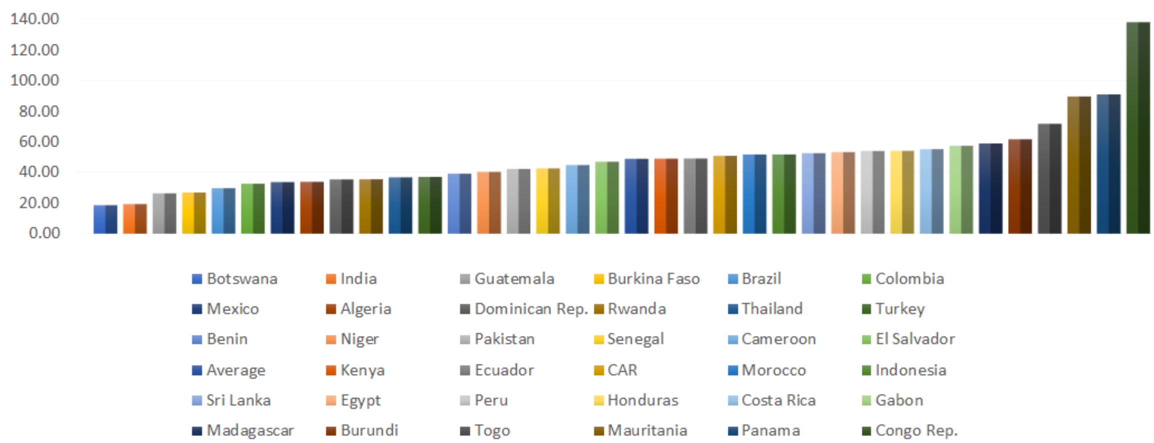

Figure C 1: Average External Debt to GNI in 35 Low- and Middle-Income Countries Since 1970

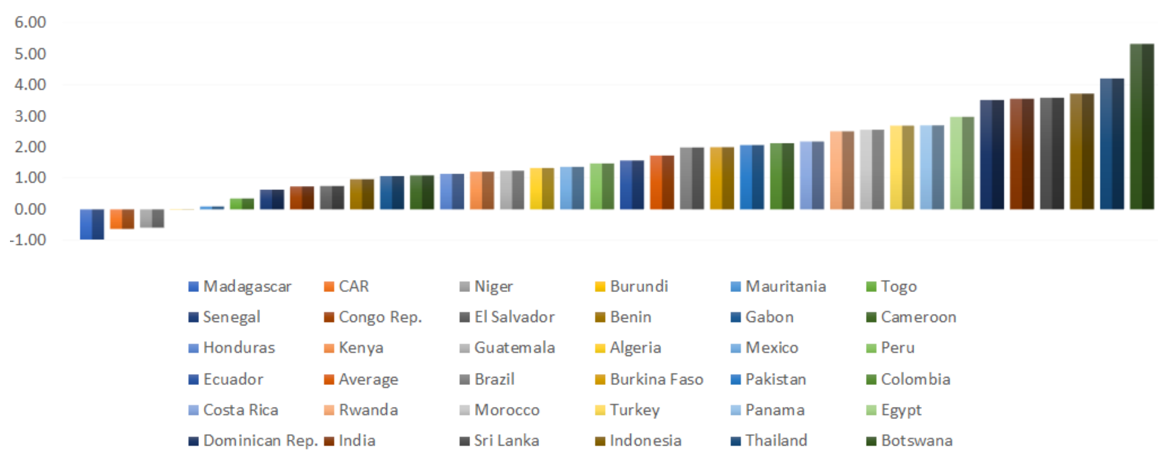

Figure C 2: Average Growth in GDP per Capita in 35 Low- and Middle-Income Countries Since 1970

External Borrowing Can Boost Investment

The figure below shows investment to GDP in a simulated "country" starting with GDP per capita below its long-run average. Investment to GDP is shown from the stochastic growth model simulation with external borrowing vs. without external borrowing. As can be seen in Figure C 3, allowing for external borrowing boosts investment and therefore contributes to economic growth.

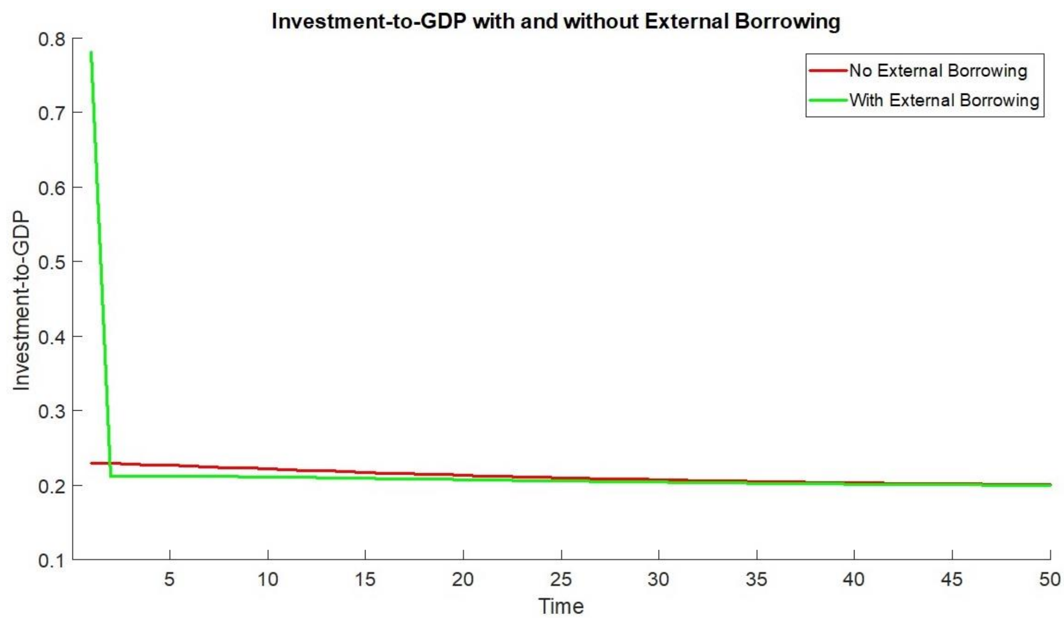

Figure C 3: Investment-to-GDP With and Without External Borrowing

Growth Regression Model Estimation Results - Detailed

The tables below show the estimated coefficients from the different regression models presented in Chapter 3. The results show that the signs of the coefficients are in line with what is expected by theory. That is, for investment and trade the sign is positive. In contrast, for government expenditure and inflation the sign is negative. Finally, for initial GDP per capita, the sign is negative which is in line with conditional convergence.

Table C 1: Estimation Results (Model 1 and Model 2 – Benchmark X_{it})

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	-0.017***	-0.001
Log (initial real GDP)	-0.131	-0.433***
Investment/GDP	0.114***	0.128***

Table C 2: Estimation Results (Model 1 and Model 2 – More Regressors)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	-0.017***	-0.001
Log (initial real GDP)	-0.184	-0.339*
Investment / GDP	0.104***	0.111***
Govt expenditure / GDP	-0.097***	-0.061*
Trade Openness	0.009	0.016
Inflation	-0.001	-0.000

Table C 3: Estimation Results (Model 3 and Model 4 – Benchmark X_{it})

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}} > 49\%$	-0.012***	0.003
$\frac{b_{\text{it}}}{y_{it}} < 49\%$	0.011	0.026**
Log (initial real GDP)	-0.210	-0.529***
Investment/GDP	0.118***	0.133***

Table C 4: Estimation Results (Model 3 and Model 4 – More Regressors)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}} > 49\%$	-0.012***	0.003
$\frac{b_{\text{it}}}{y_{it}} < 49\%$	0.009	0.026**
Log (initial real GDP)	-0.264	-0.445**
Investment / GDP	0.105***	0.116***
Govt expenditure / GDP	-0.092***	-0.059
Trade Openness	0.010*	0.017
Inflation	-0.001	-0.000

Table C 5: Estimation Results (Model 5 and Model 6 – Benchmark X_{it} – t=5)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.022*	0.043***
$interact$	-0.038***	-0.040***
Investment/GDP	0.112***	0.108***
Log (initial real GDP)	-0.033	-0.358**

Table C 6: Estimation Results (Model 5 and Model 6 – Benchmark X_{it} – t=5)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.020*	0.043***
$interact$	-0.036***	-0.041***
Log (initial real GDP)	-0.080	-0.231
Investment / GDP	0.102***	0.093***
Govt expenditure / GDP	-0.088***	-0.068*
Trade Openness	0.008	0.012
Inflation	-0.001	-0.000

Table C 7: Estimation Results (Model 5 and Model 6 – Benchmark X_{it} – t=5 –Lagged b/y)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.035***	0.054***
$interact$	-0.045***	-0.044***
Investment/GDP	0.112***	0.111***
Log (initial real GDP)	-0.018	-0.360**

Table C 8: Estimation Results (Model 5 and Model 6 – More Regressors – t=5 –Lagged b/y)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.033***	0.053***
$interact$	-0.043***	-0.044***
Log (initial real GDP)	-0.058	-0.242
Investment / GDP	0.106***	0.098***
Govt expenditure / GDP	-0.100***	-0.059*
Trade Openness	0.006	0.009
Inflation	-0.001	-0.000

Table C 9: Estimation Results (Model 5 and Model 6 – Benchmark X_{it} – t=3)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.014	0.033***
$interact$	-0.031***	-0.034***
Investment/GDP	0.130***	0.144***
Log (initial real GDP)	-0.013	-0.464***

Table C 10: Estimation Results (Model 5 and Model 6 – More Regressors – t=3)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.017*	0.035***
$interact$	-0.033***	-0.036***
Log (initial real GDP)	0.014	-0.346***
Investment / GDP	0.127***	0.138***
Govt expenditure / GDP	-0.087***	-0.056*
Trade Openness	0.002	0.003
Inflation	-0.003***	-0.003***

Table C 11: Estimation Results (Model 5 and Model 6 – Benchmark X_{it} – t=7)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.031**	0.047***
$interact$	-0.045***	-0.043***
Log (initial real GDP)	-0.117	-0.448***
Investment/GDP	0.107***	0.094***

Table C 12: Estimation Results (Model 5 and Model 6 – More Regressors – t=7)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.029**	0.049***
$interact$	-0.043***	-0.044***
Log (initial real GDP)	-0.133	-0.344*
Investment / GDP	0.101***	0.087***
Govt expenditure / GDP	-0.076**	-0.052
Trade Openness	0.005	0.005
Inflation	-0.002	-0.002

New Sample

As mentioned, I repeat the estimation with a new sample in which the starting date is 1994 (shorter time period), so that I have five 5-year time periods. In this sample, more countries have their data available. Therefore, the number of countries included in the new sample is 82, as opposed to 35 when the starting data is 1970 (the benchmark sample).

The purpose of repeating the estimation using a different sample and therefore a different mix of countries and a different time period covered is to check whether the results and the main conclusion are sensitive to the choice of countries included and time period covered. Results are shown in Table C 13 and Table C 14 below (Tables C 15 and C16 present the detailed results). Results are in line with those from models' estimation using data from the benchmark (1970) sample. That is, even with a different mix of countries and time period, $\hat{\beta}_2$ is positive and significant and $\hat{\beta}_3$ is negative and significant.

Table C 13: Estimated $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ – Benchmark $\boldsymbol{X_{it}}$ – Model 5 and Model 6 (New Sample)

	Pooled OLS	FE
$\hat{\beta}_2$	0.081***	0.091***
$\hat{\beta}_3$	-0.090***	-0.090***

Table C 14: Estimated $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ – More Regressors – Model 5 and Model 6 (New Sample)

	Pooled OLS	FE
$\hat{\beta}_2$	0.077***	0.089***
$\hat{\beta}_3$	-0.087***	-0.088***

Table C 15: Estimation Results (Model 5 and Model 6 – Benchmark X_{it} – New Sample)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.081***	0.091***
interact	-0.090***	-0.090***
Log (initial real GDP)	-0.041	-0.129
Investment/GDP	0.129***	0.153***

Table C 16: Estimation Results (Model 5 and Model 6 – More Regressors – New Sample)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.077***	0.089***
$interact$	-0.087***	-0.088***
Log (initial real GDP)	-0.044	-0.340
Investment / GDP	0.119***	0.139***
Govt expenditure / GDP	-0.081**	0.040
Trade Openness	0.010**	0.023**
Inflation	-0.001	-0.000

Growth Regression Model Estimation Results Using Simulated Data

The tables below show the regression estimation results along with the predicted change in economic growth from a 1pp change in external debt-to-income when estimating regression model parameters using the data generated from simulating the stochastic growth model with external borrowing shown in section 3.3.

Table C 17: Estimated β_2 and β_3 Using Simulated Data (Model 5 and Model 6)

	Pooled OLS	FE
$\hat{\beta}_2$	0.029***	0.025***
$\hat{\beta}_3$	-0.026**	-0.021*

Table C 18: Predicted Change in growth From 1pp increase in b/y Using Estimates From Table C 17

Lagged-to-Average GDP per Capita	$\frac{\partial growth}{\partial (b/y)}$ - Pooled OLS	$\frac{\partial growth}{\partial (b/y)}$ - FE
0.25	0.023	0.020
0.50	0.016	0.015
0.75	0.010	0.009
1.00	0.003	0.004
1.25	-0.004	-0.001
1.50	-0.010	-0.007
1.75	-0.017	-0.012

Table C 19: Estimation Results (Model 5 and Model 6 – Benchmark X_{it} – Simulated Data)

Explanatory Variable	**Pooled OLS**	**FE**
$\frac{b_{\text{it}}}{y_{it}}$	0.029***	0.025***
interact	-0.026**	-0.021*
Log (initial real GDP)	-4.548***	-2.942***
Investment/GDP	0.158***	0.095***

Curriculum Vitae

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