No 2015-31 – December

Working Paper

CEPII

Excess Finance and Growth: Don't Lose Sight of Expansions !

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Highlights

- We propose a growth cycle accounting procedure to estimate the long-run elasticity between growth and finance.
- This procedure links long-run growth to the duration and growth rate of expansions and recessions.
- The elasticity between financial and economic growth rates is positive for a complete business cycle, even if high financial growth makes recessions more severe.
- This elasticity may turn negative if one considers the persistent effects of financial growth on the expansion of the subsequent cycle.

Abstract

Accompanying the great recession, a recent empirical literature casts doubt on the existence of a positive relationship between economic and financial growth pointing out the economic costs of excessive financial growth. We show however that if one considers the complete growth cycle, that is by including expansions into a growth cycle accounting procedure, the elasticity between financial and economic growth rates is positive for most financial series, even if high financial growth makes recessions more severe. This elasticity should be however adjusted downward, and may even turn negative, if one considers the persistent effects of financial growth on the expansion of the subsequent cycle. This effect can explain the pattern of economic growth observed during and after financial bubbles.

Keywords

Growth, Business Cycles, Finance, Financial Cycles, Bubbles.

JEL

E32, E44.

Working Paper

CEPII

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CEPII Working Paper
Contributing to research in international economics

Editorial Director:
Sébastien Jean

Production:
Laure Boivin

No ISSN: 1293-2574

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Excess Finance and Growth: Don't Lose Sight of Expansions !

Thomas Grjebine,* and Fabien Tripier†

"How long has it been since the American economy enjoyed reasonable growth, from a reasonable unemployment rate, in a financially sustainable way? The answer is that is has been really quite a long time, certainly more than half a generation". Summers (2015)

"We may be an economy that needs bubbles just to achieve something near full employment". Krugman (2013)

1. Introduction

The "Secular Stagnation" debate launched by Summers (2013) and Krugman (2013) has recently revived the attention on the difficulties to conciliate economic growth with financial stability. They raise in particular the question of what would have been growth during the last thirty years in developed economies without financial and housing bubbles. This debate highlights the complexity of the interactions between economic growth and finance, which has been alternatively pointed out as a key driver of economic growth and a major source of amplification of economic crisis. This paper proposes a new empirical methodology, labeled growth cycle accounting, which provides an unified framework to estimate and compare these different effects. Even if high financial growth makes recessions more severe, the elasticity between finance and growth for a complete business cycle is positive because of the key role played by expansions. This positive elasticity should however be adjusted downward by the excessive development of finance inherited from previous expansions. Hence, don't lose sight of expansions!

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If the two faces of finance, key driver of economic growth and major source of instability are well known, quite surprisingly, they are based on stylized facts established in distinct frameworks, with separate data and empirical tools. A large empirical literature on long-run growth has been developed in the tradition of King and Levine (1993) after the precursory contributions of Goldsmith (1969) and McKinnon (1973). The starting point of this literature is to regress long-run growth for a panel of country on a set of variables among which one of them measures the initial state of development of the financial sector and the other are control variables. This literature concluded on the existence of a positive and significant relationship between average growth and various measures of financial development, see Levine (1997), even if recent studies have challenged the robustness of this conclusion as Cecchetti and Kharroubi (2012), Rousseau and Wachtel (2011, 2015) or Arcand et al. (2015). To take into account the time-varying behavior of the financial sector, these studies estimate dynamic panels using window of several years (generally five years) to eliminate business cycle fluctuations.

Another recent literature focuses precisely on business cycle fluctuations to identify the links between financial development and economic crisis. Actually, they do not consider all business cycle fluctuations, but they focus instead on the recessions' characteristics, that is the probability of occurrence, the severity, and the duration. Drehmann et al. (2012) show that financial cycle peaks are very closely associated with financial crises and business cycle recessions are much deeper when they coincide with the contraction phase of the financial cycle; Claessens et al. (2012) that the duration and amplitude of recessions are higher when they occur with financial disruptions; Jordà et al. (2013) that the severity of recessions is amplified by the intensity of financial development; and Schularick and Taylor (2012) that the credit ratio is a good predictor of financial crisis[1]. In this literature, less attention is given to economic expansions, which however determine the long-run growth when cumulated over the cycles of an economy.

To sum up, the literature on growth does not consider the specificity of business cycle phases

[1]See also Borio et al. (2013) who develop measures of potential output and output gaps in which financial factors play a central role.

while the literature on recessions does not take into account the economic growth process associated with the expansion phases. In this article, we fill the gap between these two strands of the literature by providing a unified empirical framework, which we call a growth cycle accounting. This framework allows to decompose the long-run elasticity between finance and growth as the sum of business cycle elasticities. If this methodology is not suitable to identify causal relationships, as actually most previous quoted references, it aims at identifying the regular pattern of interactions between economic and financial growth both in the short- and the long-run. Our paper complements recent attempts in the literature to balance the various interactions between finance and growth. Ranciere et al. (2006) develop a setup to decompose the effects of financial liberalization on economic growth and on the incidence of crises. To do so, they introduce crisis events into standard growth regressions augmented with financial variables. This setup allows to compare the direct effect of financial liberalization on growth, which is close to the one identified by Levine (1997) and others, and the indirect effect, which is negative and results from the occurrence of financial crises[2]. In a similar manner, Bonfiglioli (2008) studies the effects of financial globalization on investment and productivity growth by controlling for indirect effects on banking and currency crisis.

The key point of our approach is that we do not split series into trend and cyclical components by removing a trend from original series to get the classical cycle. Instead, we study the growth cycle which is defined by the analysis of turning points (known as peaks and troughs) between expansion and recession phases.[3] The interest of this set-up is to link the long-run economic growth to the properties of business cycles. Indeed, the long-run growth of an economy is equal to the average growth observed

[2]Rancière and Tornell (2015) develop a two-sector model consistent with these empirical facts in which financial liberalization may increase growth, but leads to more crises and costly bailouts.

[3]Gadea Rivas and Perez-Quiros (2015) study the relations between credit and growth both during expansion and recession phases, as we do, but with a different objective. The authors' objective is to assess the ability of credit-based indicators to forecast efficiently the recessions. They show the poor performances of credit-based indicators in out of sample prediction of crisis because of the procyclical behavior of credit, which increases during expansion.

for all growth cycles of this economy. Then, it is possible to get insights for long-run economic growth by analysing the properties of growth cycles – it is not the case for classical cycles which are by construction independent on the trend of long-run growth. Therefore, instead of looking directly at the relationship between long-run growth and finance, we investigate the relationship between growth cycles and finance and then draw some conclusions for long-run growth. To do that, we show that the elasticity between long-run growth and finance can be expressed as the sum of elasticities associated with the growth cycle properties – hence, the label *growth cycle accounting* proposed for this methodology. The finance-growth elasticity in the long-run can be viewed as the cumulative of finance-growth interactions within each cycle through two channels: (i) the growth channel, associated with the difference in the growth rates between the expansion and recession phases, and (ii) the duration channel, associated with the difference in the durations of the expansion and recession phases. The procedure allows to assess the statistical significativity of each channel and to quantify their relative importances to provide a global picture of the finance-growth interactions. The growth cycle accounting procedure is also of interest to study the interactions between financial and the volatility of economic growth.

The application of the growth cycle accounting methodology requires an empirical measure for finance. The recent empirical literature uses measures of financial activities around the peaks of economic activity to assess their interactions with economic growth during the recessions, see Drehmann et al. (2012), Claessens et al. (2012), Schularick and Taylor (2012), and Jordà et al. (2013). Because we want to balance these interactions with what happens during expansions, we follow these authors and consider measures of financial activities at the peaks of business cycles. More precisely, we consider the growth rate of financial series during the expansion phase for each growth cycle taken in deviation with the mean of growth observed for all business cycles, as in Jordà et al. (2013), and label this measure "excess finance". To take into account the persistent effects of financial growth during one growth cycle on the subsequent cycles, we also include in our study the initial value of the financial series at the beginning of each growth cycle. The growth cycle accounting procedure is applied to a panel of 25 countries over the period 1970-2015. Business cycles are defined by the identification of turning points in the real GDP per capita for each country. We take house prices as the benchmark for the financial series. Results are then compared with other series related to the housing sector, namely the price to rent and price to income series and with series related to the credit market, namely real credit and credit to GDP ratio for the private sector as a whole or only for households.

Following Arcand et al. (2015), we control for endogeneity of our regression models using the estimators developed by Rigobon (2003) and Lewbel (2012) that allow to identify causal relationships through heteroskedasticity. In the presence of heteroskedasticity in the regression's residual, this methodology allows identifying causal relationships even in the absence of external instruments. We show that our results are robust to controlling for endogeneity with this technique.

Our first result is that the long-run elasticity between economic and excess finance is positive. For example, for house prices, the elasticity is equal to 14.7%[4]. This elasticity is the sum of the elasticities linked to the growth channel (12.4%) and the duration channel (1.9%). Looking at the growth channel, the elasticity is positive during the expansion (20.1%) and turns negative during the recession phase (-7.7%).[5] This result is close to that of Ranciere et al. (2006) and Bonfiglioli (2008) who conclude that the direct positive effect of financial development on growth outweighs the indirect and negative effect associated with crisis occurrence. However, this result does not take into account the persistent effects of excess finance on subsequent cycles trough the initial value of financial series. Actually, we show that the long-run elasticity between economic growth and the initial value of financial series is negative for all series. This result is of importance because is suggests that positive elasticity within business cycles should be adjusted downward by persistence effects between growth cycles. This situation can be interpreted as

[4] This number should be interpreted as follows: a 1% excess finance is associated in the data with a variation of 0.14 points of percentage of annual growth in the long run.

[5]The sum of these two elasticities is the value of the growth channel (12.4%).

a hysteresis phenomenon – see Blanchard et al. (2015) and Galí (2015) for recent contributions on the importance of the concept of hysteresis to understand the full consequences of recessions. We use our regression results to simulate the pattern of economic growth associated with financial bubbles defined as the alternation of highly positive and negative financial growth rates with persistent effects. Our results show that financial bubbles are characterized by a long phase of expansion together with high economic growth. They are ended by a more severe recession, as already well documented in the literature, but are also followed by a depressed growth cycle characterized by low economic growth and a short expansion phase.

The rest of the paper proceeds as follows. In Section 2, we describe the growth cycle accounting procedure. We show in particular that the finance-growth elasticity in the long-run can be viewed as the cumulative of finance-growth interactions within each cycle through two channels, the growth channel and the duration channel. We show implications for volatility and we present the case of financial bubbles. In Section 3, we present our empirical methodology. In Section 4, we present the results, both for the regressions and the growth cycle accounting procedure. We also propose simulations of GDP patterns depending on variations in excess finance. Finally, as robustness, we present the results for seven other measures of excess finance.

2. The Growth Cycle Accounting Procedure

This section describes the growth cycle accounting procedure.

2.1. Growth Cycle

We consider a panel of n countries indexed by $i = 1, ..., n$ and $t = 1, ..., T_i$ where t is a quarter and T_i the number of observations of the series for the country i. In the time domain, the real GDP per capita is denoted $Y_{i,t}$, which quarterly annual growth rate is denoted $g_{i,t} \equiv \log (Y_{i,t}/Y_{i,t-4})$.

To implement the growth cycle accounting procedure, the series should be defined in the dimension of economic cycles and not only in the time domain. For each country i, we observe $c = 1, ..., C_i$ cycles. For each cycle c, $s = 1, ..., \tau_c$ stands for the quarter of the cycle and τ_c for the duration of the cycle. The cycle c can itself be decomposed into two business cycle phases: the expansion and the recession. In the remainder, we use the following notation: x^{ph} refers to the value of the series x for the business cycle phase ph, which can take two values $ph = \{ex, re\}$ where ex stands for expansion and re for recession. The duration of the growth cycle satisfies $\tau_c = \tau_c^{ex} + \tau_c^{re}$ where τ_c^{ex} is the duration of the expansion phase and τ_c^{re} the duration of the recession phase. The peak of a typical business cycle is reached as of time τ_c^{ex}, which is the end of the expansion phase and the beginning of the recession phase, one quarter after. The trough of the cycle corresponds to the period $(\tau_c^{ex} + \tau_c^{re})$, which is the end of the recession and the start of the next cycle, one quarter after. The phase ph represents the share $\pi^{ph} = \tau_c^{ph}/\tau_c$ of the duration of the cycle c.

$$\pi^{ph} \equiv \frac{\tau_c^{ph}}{\tau_c^{ex} + \tau_c^{re}}, \text{ for } ph = \{ex, re\} \tag{1}$$

In the cycle dimension, $Y_{i,c,s}$ denotes the real GDP per capita observed during the quarter s of the cycle c in country i, which quarterly annual growth rate is denoted $g_{i,c,s} \equiv \log(Y_{i,c,s}/Y_{i,c,s-4})$.

The average growth rate of the real GDP for the panel of countries is denoted g and defined as

$$g \equiv \frac{1}{n}\sum_{i=1}^{n} g_i \tag{2}$$

where g_i denotes the average growth for the economy i. In the time domain, the average growth of a country is calculated as $g_i \equiv (1/T_i)\sum_{t=1}^{T_i} g_{i,c}$ without taking into account the business cycle. The interest of the cycle dimension, is to take into account potential differences between expansion and recession business cycle phases. To do so, the average growth rate of the country i, namely g_i, is calculated as the average of growth rates for each cycle c, which is denoted $g_{i,c}$, using the formula

$$g_i \equiv \frac{1}{C_i}\sum_{c=1}^{C^i} g_{i,c} \tag{3}$$

where $g_{i,c}$ can be expressed as the average of the growth rates during the expansion and recession phases, respectively denoted $g_{i,c}^{ex}$ and $g_{i,c}^{re}$, weighted by the share of each business cycle phase in the full duration of the cycle, namely π^{ex} and π^{re} respectively, that is

$$g_{i,c} \equiv \pi^{ex}_{i,c} g^{ex}_{i,c} + \pi^{re}_{i,c} g^{re}_{i,c} \tag{4}$$

where the averages of growth rates for each business cycle phase are defined as follows.

$$g^{ex}_{i,c} \equiv \frac{1}{\tau^{ex}_{i,c}} \sum_{s=1}^{\tau^{ex}_{i,c}} g^{ex}_{i,c,s}, \text{ and } g^{re}_{i,c} \equiv \frac{1}{\tau^{re}_{i,c}} \sum_{s=\tau^{ex}_{i,c}+1}^{\tau_{i,c}} g^{re}_{i,c,s} \tag{5}$$

These definitions of growth are used hereafter to compute the elasticity of growth with respect to financial series.

2.2. Financial Properties of Growth Cycles

As for the real GDP per capita, we define financial series in the cycle dimension: $F_{i,c,s}$ denotes the value of the financial series F measured for the quarter s of the cycle c in country i. We do not consider herein the specific cycles of the financial series. Then, the timing of expansion and recession of business cycle phases is the same as for the real GDP per capita. Actually, we are interested by the properties of growth cycles in terms of financial activities. For each financial series considered, the state of financial activies is defined by its excess growth during the expansion phase

$$\phi^{ex}_{i,c} \equiv \frac{\log\left(F_{i,c,\tau^{ex}_{i,c}} / F_{i,c,0}\right)}{\tau^{ex}_{i,c}} - \widetilde{\phi}^{ex} \tag{6}$$

which is the quarterly average growth rate of F during the expansion phase in deviation with $\widetilde{\phi}^{ex}$, the average of growth rates for all the cycles of all the countries of the panel, namely

$$\widetilde{\phi}^{ex} \equiv \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_i} \sum_{c=1}^{C_i} \frac{\log\left(F_{i,c,\tau^{ex}_{i,c}} / F_{i,c,0}\right)}{\tau^{ex}_{i,c}} \tag{7}$$

We then use this definition of excess finance to measure the links between financial and growth cycle.

2.3. The Finance-Growth Elasticities

The semi-elasticity of long-run growth rate g with respect to the measure of excess finance ϕ^{ex} is given by the following first order partial derivative

$$\varepsilon^{g}_{\phi^{ex}} \equiv \frac{\partial g}{\partial \phi^{ex}} \tag{8}$$

Since both g and ϕ^{ex} are the log of "gross" growth rates of real GDP per capita and the financial series, $\varepsilon^{g}_{\phi^{ex}}$ is the semi-elasticity between these two rates and the elasticity between these two "gross" rates. For simplicity, we use the term elasticity for $\varepsilon^{g}_{\phi^{ex}}$ in the remainder while keeping in mind that it concerns the "gross" rates of series. Using (1), (2) and (3), the long-run growth rate is

$$g = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{C_i}\sum_{c=1}^{C^i}\left(\pi^{ex}_{i,c}g^{ex}_{i,c} + \pi^{re}_{i,c}g^{re}_{i,c}\right) \tag{9}$$

where the number of countries n and of cycles by countries C_i are independant on the value of financial series. Then, using (9), the elasticity $\varepsilon^{g}_{\phi^{ex}}$ defined by (8) is equal to

$$\varepsilon^{g}_{\phi^{ex}} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{C_i}\sum_{c=1}^{C^i}\left[\frac{\partial g^{ex}_{i,c}}{\partial \phi^{ex}}\frac{\tau^{ex}_{i,c}}{\tau^{ex}_{i,c}+\tau^{re}_{i,c}} + \frac{\partial g^{re}_{i,c}}{\partial \phi^{ex}}\frac{\tau^{ex}_{i,c}}{\tau^{ex}_{i,c}+\tau^{re}_{i,c}} + \left(\frac{\partial \tau^{ex}_{i,c}}{\partial \phi^{ex}}\tau^{re}_{i,c} - \frac{\partial \tau^{re}_{i,c}}{\partial \phi^{ex}}\tau^{ex}_{i,c}\right)\frac{g^{ex}_{i,c}-g^{re}_{i,c}}{\left(\tau^{ex}_{i,c}+\tau^{re}_{i,c}\right)^2}\right] \tag{10}$$

where $\partial g^{ph}_{i,c}/\partial \phi^{ex}$ are the elasticities of growth with respect to excess finance for each business cycle phase $ph = \{ex, re\}$ of the growth cycle. Using (5) these partial derivatives are

$$\frac{\partial g^{ex}_{i,c}}{\partial \phi^{ex}} = \frac{1}{\tau^{ex}_{i,c}}\sum_{s=1}^{\tau^{ex}_{i,c}}\frac{\partial g^{ex}_{i,c,s}}{\partial \phi^{ex}}, \text{ and } \frac{\partial g^{re}_{i,c}}{\partial \phi^{ex}} = \frac{1}{\tau^{re}_{i,c}}\sum_{s=\tau^{ex}_{i,c}+1}^{\tau_{i,c}}\frac{\partial g^{re}_{i,c,s}}{\partial \phi^{ex}} \tag{11}$$

since the durations are assumed to be constant when the partial derivatives of $g^{ph}_{i,c}$ with respect to ϕ^{ex} are computed for $ph = \{ex, re\}$. We use two kinds of regression to quantify the terms present in the equation (10) of the long-run elasticity. First regressions consider the growth rate during business cycle phases as a dependent variable and the second regressions consider the duration of business cycle phases as a dependent variable.

Growth regressions are estimated with the standard OLS estimator using the following specification

$$g^{ph}_{i,c,s} = c^{ph}_{g} + f^{ph}_{g,i} + \alpha^{ph}_{g}\phi^{ex} + \gamma^{ph}_{g}X^{g}_{i,c,s} + \varepsilon_{i,c,f} \tag{12}$$

for each phase $ph = \{ex, re\}$. In this regression, c_g^{ph} is the constant term, $f_{g,i}^{ph}$ a country-fixed effect, $X_{i,c,s}^{g}$ is a set of controls for both business cycles and growth, and α_g^{ph} the coefficient of interest that measures the elasticity between growth and excess finance during the business cycle phase $ph = \{ex, re\}$. Using, (12) the elasticity of growth with respect to excess finance during the business cycle phase ph writes

$$\frac{\partial g_{i,c}^{ph}}{\partial \phi^{ex}} = \frac{1}{\tau_{i,c}^{ph}} \sum_{s=1}^{\tau_{i,c}^{ph}} \alpha_g^{ph} = \alpha_g^{ph} \tag{13}$$

for $ph = \{ex, re\}$.

Duration regressions are estimated with the Accelerated Failure-Time (AFT) specification of the Weibull model developed for duration data with covariates. Assuming that the duration τ^{ph} of the business cycle phase $ph = \{ex, re\}$ has a Weibull distribution, the logarithm of duration τ^{ph} can be estimated using the following specification

$$\log\left(\tau_{i,c}^{ph}\right) = c_\tau^{ph} + f_{\tau,i}^{ph} + \alpha_\tau^{ph}\phi^{ex} + \gamma_g^{ph} X_{i,c}^{\tau} + z_{i,c}^{ph} \tag{14}$$

where $z_{i,c}^{ph}$ has an extreme-value distribution scaled by the inverse of the shape parameter of the Weibull distribution, denoted p^{ph}. In this regression, c_τ^{ph} is the constant term, $f_{\tau,i}^{ph}$ a country-fixed effect, $X_{i,c,s}^{\tau}$ is a set of controls for both business cycles and growth, and α_τ^{ph} the coefficient of interest. Using (14), the (semi-)elasticity of the duration of the business cycle phase ph with respect to excess finance is

$$\frac{\partial \tau_{i,c}^{ph}}{\partial \phi^{ex}} = \alpha_\tau^{ph} \tau_{i,c}^{ph} \tag{15}$$

for $ph = \{ex, re\}$.

The elasticity defined by (10) becomes

$$\varepsilon_{\phi^{ex}}^{g} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{C_i}\sum_{c=1}^{C^i}\left[\alpha_g^{ex}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right) + \alpha_g^{re}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right) + \left(\alpha_\tau^{ex}-\alpha_\tau^{re}\right)\frac{\tau_{i,c}^{ex}\tau_{i,c}^{re}}{\left(\tau_{i,c}^{ex}+\tau_{i,c}^{re}\right)^2}\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)\right] \tag{16}$$

given the outcomes of the regressions (13) and (15), details are provided in the appendix A. Then, since the regression coefficients do not depend on the country i or the cycle c, the equation (16) becomes

$$\varepsilon^{g}_{\phi^{ex}} = \alpha^{ex}_{g}\frac{1}{n}\sum_{i=1}^{n}\frac{1}{C_i}\sum_{c=1}^{C^i}\pi^{ex}_{i,c} + \alpha^{re}_{g}\frac{1}{n}\sum_{i=1}^{n}\frac{1}{C_i}\sum_{c=1}^{C^i}\pi^{re}_{i,c} + \alpha^{ex}_{\tau}\frac{1}{n}\sum_{i=1}^{n}\frac{1}{C_i}\sum_{c=1}^{C^i}\sigma^{ex}_{i,c} + \alpha^{re}_{\tau}\frac{1}{n}\sum_{i=1}^{n}\frac{1}{C_i}\sum_{c=1}^{C^i}\sigma^{ex}_{i,c} \tag{17}$$

The new variable $\sigma_{i,c}$ is defined as follows

$$\sigma_{i,c} \equiv \pi^{ex}_{i,c}\pi^{re}_{i,c}\left(g^{ex}_{i,c} - g^{re}_{i,c}\right) \tag{18}$$

This variable provides a measure the gap in growth rates between the two business cycle phases, namely $(g^{ex}_{i,c} - g^{re}_{i,c})$, weighted by the relative duration of business cycle phases, $\pi^{ex}_{i,c}$ and $\pi^{re}_{i,c}$. Considering the historical mean of $\pi^{ex}_{i,c}$, $\pi^{re}_{i,c}$, and $\sigma_{i,c}$ for all cycles of the panel, the elasticity given by (17) becomes

$$\varepsilon^{g}_{\phi^{ex}} = \underbrace{\alpha^{ex}_{g} \times \widetilde{\pi}^{ex} + \alpha^{re}_{g} \times \widetilde{\pi}^{re}}_{\text{Growth Channel}} + \underbrace{(\alpha^{ex}_{\tau} - \alpha^{re}_{\tau}) \times \widetilde{\sigma}}_{\text{Duration Channel}} \tag{19}$$

where $\widetilde{x}$ denotes the historical mean of the series $x_{i,c}$ for $x = \{\pi^{ex}, \pi^{re}, \sigma\}$.

The long-run elasticity of growth with respect to excess finance is the sum of three elements which are directly associated with business cycle properties. The sum of the first two elements constitutes the growth channel since it depends on the elasticities of growth during business cycle phases with respect to excess finance, namely α^{ex}_{g} and α^{re}_{g}, which are weighted by the relative shares of expansions and recessions in the business cycle duration, namely $\widetilde{\pi}^{ex}$ and $\widetilde{\pi}^{re}$. The third element constitutes the duration channel since it depends on the elasticities of business cycle phase durations with respect to excess finance, namely α^{ex}_{τ} and α^{re}_{τ}, and the weighted gap in the growth rates, which is measured by $\widetilde{\sigma}$. The duration channel does not exist if at least one of these three conditions is satisfied

1. the duration of business cycle phases are not correlated with excess finance: $\alpha^{ex}_{\tau} = \alpha^{re}_{\tau} = 0$;
2. the duration of business cycle phases are correlated with excess finance, but the elasticity is the same for the two business cycle phases: $(\alpha^{ex}_{\tau} - \alpha^{re}_{\tau}) = 0$;
3. the duration of business cycle phases are correlated with excess finance, with different elasticities for the two business cycle phases, but the weighted gap in growth rates between the two business cycle phases is nil: $\widetilde{\sigma} = 0$.

2.4. Implications for Volatility

The growth cycle accounting approach can also be used to study the implications of the properties of business cycles on the volatility of the economy. We measure the volatility by the variance of the quarterly annual growth of real GDP per capita, which is denoted $\mathrm{var}(g)$ for all the panel and defined as follows

$$\mathrm{var}(g) \equiv \frac{1}{n}\sum_{i=1}^{n} \mathrm{var}(g_i) \tag{20}$$

where $\mathrm{var}(g_i)$ is the variance of growth g_i for each country i of the panel. Using the definition (3) of growth in country i, the variance $\mathrm{var}(g_i)$ is equal to

$$\mathrm{var}(g_i) \equiv \mathrm{var}\left(\frac{1}{C_i}\sum_{c=1}^{C^i} g_{i,c}\right) = \frac{1}{C_i}\left(\sum_{c=1}^{C^i} \mathrm{var}(g_{i,c}) + \sum_{c\neq c'} \mathrm{cov}(g_{i,c}, g_{i,c'})\right) \tag{21}$$

that is the average value of variances observed for all cycles c of country i, namely $\mathrm{var}(g_{i,c})$, plus the covariance of growth rates between cycles, namely $\mathrm{cov}(g_{i,c}, g_{i,c'})$ for $c \neq c'$. As done in the previous section for the average of growth, see (4), the variance of growth can be decomposed into contributions of each business cycle phase as follows

$$\mathrm{var}(g_{i,c}) = \pi_{i,c}^{ex}\mathrm{var}\left(g_{i,c}^{ex}\right) + \pi_{i,c}^{re}\mathrm{var}\left(g_{i,c}^{re}\right) + \pi_{i,c}^{ex}\pi_{i,c}^{re}\left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2 \tag{22}$$

Details are provided in the appendix B. The variance of growth during the cycle c in country i is the sum of (i) the variances of growth during each business cycle phase, namely $\mathrm{var}\left(g_{i,c}^{ph}\right)$ for $ph = \{ex, re\}$, weighted by the relative duration of business cycle phases, namely $\pi_{i,c}^{ph}$ for $ph = \{ex, re\}$, and of (ii) the squared-gap of growth rates between expansion and recession phases, namely $\left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2$, also weighted by the relative duration of business cycle phases, namely $\pi_{i,c}^{ex}\pi_{i,c}^{re}$.

As for the average growth, regressions are estimated for the standard deviation of growth with an OLS estimator using the following specification

$$\mathrm{sd}\left(g_{i,c}^{ph}\right) = c_{sd}^{ph} + f_{sd,i}^{ph} + \alpha_{sd}^{ph}\phi^{ex} + \gamma^{sd}X_{i,c}^{\tau} + \widetilde{\epsilon}_{i,c} \tag{23}$$

for each phase $ph = \{ex, re\}$. Notice that, following the tradition in the literature regressions are estimated for the standard deviation of growth and not for the variance. In this regression, c_{sd}^{ph} is the constant term, $f_{sd,i}^{ph}$ a country-fixed effect, $X_{i,c}^{\tau}$ is a set of controls for both business cycles and growth, and α_{sd}^{ph} the coefficient of interest. The semi-elasticity of the standard deviation of growth during the business cycle phase ph with respect to excess finance is deduced from regression (23) as

$$\frac{\partial \mathrm{sd}\left(g_{i,c}^{ph}\right)}{\partial \phi^{ex}} = \alpha_{sd}^{ph} \tag{24}$$

Then, using (20), (21), (22), and (24), the semi-elasticity of the variance of growth with respect to excess finance can be decomposed as follows

$$\begin{aligned} \frac{\partial \mathrm{var}\left(g\right)}{\partial \phi^{ex}} &= \underbrace{\alpha_{sd}^{ex} \times \frac{2}{n} \sum_{i=1}^{n} \frac{1}{C_i} \sum_{c=1}^{C^i} \pi_{i,c}^{ex} \mathrm{sd}\left(g_{i,c}^{ex}\right) + \alpha_{sd}^{re} \times \frac{2}{n} \sum_{i=1}^{n} \frac{1}{C_i} \sum_{c=1}^{C^i} \pi_{i,c}^{re} \mathrm{sd}\left(g_{i,c}^{re}\right)}_{\text{Volatility Channel}} \qquad (25) \\ & \underbrace{+\left(\alpha_g^{ex} - \alpha_g^{re}\right) \times \sum_{i=1}^{n} \frac{1}{C_i} \sum_{c=1}^{C^i} \pi_{i,c}^{ex} \pi_{i,c}^{re} 2 \left(g_{i,c}^{ex} - g_{i,c}^{re}\right)}_{\text{Growth Channel}} \\ & \underbrace{+\left(\alpha_\tau^{ex} - \alpha_\tau^{re}\right) \times \sum_{i=1}^{n} \frac{1}{C_i} \sum_{c=1}^{C^i} \pi_{i,c}^{ex} \pi_{i,c}^{re} \left[\mathrm{var}\left(g_{i,c}^{ex}\right) - \mathrm{var}\left(g_{i,c}^{re}\right) + \left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2 \left(1 - 2\pi_{i,c}^{ex}\right)\right]}_{\text{Duration Channel}} \end{aligned}$$

Details are provided in the appendix C. The volatility channel is associated with the variances of growth for each phase of the business cycles. It is the weighted average of semi-elasticities of the standard deviation of growth during each business cycle phase, namely α_{sd}^{ph} for $ph = \{ex, re\}$, weighted by the relative duration of business cycle phases, namely $\pi_{i,c}^{ph}$ for $ph = \{ex, re\}$. Even if these semi-elasticities are nil, that is $\alpha_{sd}^{ex} = \alpha_{sd}^{re} = 0$, the variance of growth may be linked to excess finance through the two other channels associated with the properties of business cycles: the growth channel and the duration channel. The growth channel is associated with the volatility of the economy induced by the switch between two business cycle phases characterized by different average growth rates. Indeed, this channel does not exist if the growth rates are equal in the two business cycle phases, $g_{i,c}^{ex} = g_{i,c}^{re}$, or have the same elasticity with respect to excess finance, $\alpha_g^{ex} = \alpha_g^{re}$. The duration channel is associated with the volatility of the economy induced by the frequency of switch between the two business cycle phases. This channel does not exist if the variance and the mean of growth rates are identical in the two business cycle phases, that is both $\mathrm{var}\left(g_{i,c}^{ex}\right) = \mathrm{var}\left(g_{i,c}^{re}\right)$ and $g_{i,c}^{ex} = g_{i,c}^{re}$, or the elasticities of the business cycle phases with respect to excess finance are equal, $\alpha_T^{ex} = \alpha_T^{re}$.

To quantify the relative importance of these three channels for all the panel of countries, we use the results of the regressions (12), (14), and (23) to get numerical values of the coefficients $\alpha_g^{ph}, \alpha_T^{ph}$, and α_{var}^{ph}, respectively, for $ph = \{ex, re\}$. Historical data are used to compute the average values of the terms that multiplied these regression coefficients in (26).

2.5. Persistent Effects of Excess Finance and The Case of Financial Bubbles

In the previous sections, the interactions between economic growth and financial growth were considered within the same business cycle. However, current economic growth may also be related with past financial growth through persistent effects. We now take into account this phenomenon, which may be important to understand the consequences of financial bubbles.

Financial bubble is a very large concept to describe situations in which market prices diverge lastingly from their fundamental or equilibrium values in such a way that market corrections should occur to restore market equilibrium. In our data, financial growth is defined for financial series that try to capture such divergence, as the price-to-rent ratio and credit-to-ouput. However, it is hard to distinguish in the data the fluctuations of theses series that result from structural shifts of the economy from those that result from purely bubble/speculative behaviors. Nevertheless, our methodology can be informative to characterize the pattern of economic growth associated with a financial bubble. Once again, we do not measure here the causal impact of a financial bubble on economic growth, but we identify the joint behavior of economic and financial growth during business cycles. A financial bubble during the cycle $\widetilde{c}$ is defined as follows

$$\phi_c^{ex} = \begin{cases} \varepsilon & \text{, if } c = \widetilde{c} \\ -\varepsilon & \text{, if } c = \widetilde{c} + 1 \\ 0 & \text{otherwise} \end{cases} \tag{26}$$

where ε is the size of the bubble. The symmetry of financial growth during cycles $\widetilde{c}$ and $(\widetilde{c}+1)$ ensures the full adjustment of the bubble for future cycles $c > (\widetilde{c}+1)$. In addition to the negative financial growth during the cycle $(\widetilde{c}+1)$, the value of the financial series at the begining of this cycle is also impacted by the bubble since

$$\phi_{\widetilde{c}+1}^0 = \phi_{\widetilde{c}}^0 + \phi_{\widetilde{c}}^{ex} \tag{27}$$

where $\phi_{\widetilde{c}}^0$ is the inital value of the financial series, that is for the quarter 0 of the cycle $\widetilde{c}$. If economic growth during the cycle $\widetilde{c}+1$ is correlated with $\phi_{\widetilde{c}}^0$, it means that financial growth during the previous cycle, namely $\phi_{\widetilde{c}}^{ex}$, has persistent effects for subsequent cycles. This situation can be interpreted as a hysteresis phenomenon.

Hysteresis is a popular concept to depict situations in which the consequences of an action persist even when this action is finished. In previous sections, the action considered was an excess in the growth rate of financial series. The various measures of elasticity provided tried to capture the links between this excess development of finance and the business cycle during which this excess occurred. However, this excess can also have links with future cycles due to the hysteresis phenomenon. For example, an excessive growth of house prices during a cycle can lead to a high house price level at the beginning of the new cycle. In this case, even if housing prices are constant during this new cycle, the consequences of the previous cycle are still present through the initial value of housing prices. To take into account this possibility, we systemically consider in our regressions (12), (14), and (23) the initial value of the financial series $\phi_{i,c}^0 \equiv F_{i,c,0}$ among the controls $X_{i,c,s}^g$ and $X_{i,c}^\tau$.

The elasticity of growth with respect to a financial bubble B during cycle c is then defined as the sum of the elasticities of economic growth with respect to a positive and a negative financial growth rates, augmented with the elasticity with respect the inital condition of the financial series.

$$\varepsilon_B^g \equiv \varepsilon \frac{\partial g}{\partial \phi^{ex}} + \underbrace{\varepsilon \frac{\partial g}{\partial \phi^0}}_{\text{Persistent Effect}} - \varepsilon \frac{\partial g}{\partial \phi^{ex}} \tag{28}$$

Our previous regressions can be used to compute each of these terms. For long-run economic growth, the first and third terms cancel naturally each other because financial growth is symmetric and only the persistent effect (namely the second term) remains. However, the interest of our methodology is to show the implications for business cycles, notably in terms of durations of business cycle phases.

3. Data

This section presents the financial and macroeconomic series used to apply the growth cycle accounting procedure.

Financial Series. House price series are taken from the *International House Price Database* published by the Federal Reserve Bank of Dallas. Series are quoted in real terms and begin in first quarter 1975. Price to income ratios and Price to rent ratios are extracted from *OECD Housing Prices Database*. Price to income ratios are defined as the nominal house price divided by nominal disposable income per head. Price to rent ratio is the nominal house price divided by rent price. These quarterly series are available for the period 1970Q1-2014Q2. For credit series, we use BIS database entitled "Long series on credit to private non-financial sectors" which provides a measure of the total credit distributed to the non-financial corporations in nominal terms at the quarterly frequency for a large set of countries over the last decades. The definition of total credit used by the BIS is large and encompasses the credit provided by domestic banks and all other sectors of the economy including the non-residents. Credit is measured both as an index in real terms and as a ratio of GDP. The first measure is referred to as "Real Credit" and the second as "Credit to GDP" in the remainder of the paper. We use also the BIS database to build series of Credit to Households. This variable is measured both as an index in real terms and as a ratio of GDP (respectively "Households Credit" and "Households Credit to GDP"). All the variables used in this paper are described in Table B.13.

Excess Finance. Following Jordà et al. (2013), we construct a measure of excess finance build-up during the previous boom: the rate of change in the series of finance, in deviation from its mean, and calculated from the previous trough to the subsequent peak. We use real house prices as the main specification for measuring "excess finance". As noticed by Jordà et al. (2014), housing finance has come to play a central role in the modern macroeconomy. Results are robust using other measures of excess housing developments such as price-to-income ratios or price-to-rent ratios. We use also measures of excess credit such as Real Credit, Credit to GDP, Real Households Credit, Households Credit to GDP, or a qualitative measure such as the financial reform index. Table B.1 provides the descriptive statistics of excess finance for our set of financial series.

Peaks and troughs. We apply the algorithm of Harding and Pagan (2002)[6] to identify local maxima (peaks) and minima (troughs) in the log-levels of real GDP per capita in each country of our panel. A cycle is composed of two phases: the expansion phase starts after a trough and ends at the peak which initiates the recession phases up to the next trough. The parameters of the algorithm are fixed such that a full cycle and each of its phase must last at least 4 quarters and 2 quarters, respectively. We identify in our series 249 peaks and 228 troughs. We only consider complete business cycles, that is a business cycle with an expansion and a recession. We thus keep 228 GDP cycles. Table B.2 provides the descriptive statistics of growth cycles.

[6]This algorithm constitutes a quarterly implementation of the original algorithm of Bry and Boschan (1971) for monthly series.

4. Results

We first present in this section the results for the regressions and the growth cycle accounting procedure. We then propose simulations of GDP patterns depending on variations in excess finance. Finally, as robustness, we present the results for seven other measures of excess financial growth.

4.1. Regression results

GDP growth. Table 1 shows elasticity between House Prices (Excess) and real GDP growth. We start with no controls in the first columns and add controls moving to the right in the table. For a house price excess of 1%, GDP increases by 0.269 points of percentage during expansions (column (1)). As expected, the intensity of the housing boom during the expansion phase is closely associated with the severity of the recession phase. A 1% excess in house prices growth during the expansion is associated with a reduction of GDP growth by 0.303 points of percentage (column (2)). We control these results using the traditional determinants of long-run growth used in the literature, among them the state of development of the country at the beginning of each business cycle, the state of development of the financial sector measured with the credit to GDP ratio at the beginning of each business cycle, population growth and the average years of schooling of population aged 25 and over (see in particular Levine (1997) or more recently Cecchetti and Kharroubi (2012)). Results confirm the positive elasticity during the expansion and the negative elasticity during the recession (columns (4) and (5)). Excess financial growth and economic growth move together both during expansions and recessions, but in opposite direction. For the expansion phases, this is consistent with the well-known procyclical behaviour of finance and, for the recession phases, it confirms the recent results reported by Drehmann et al. (2012), Claessens et al. (2012) and Jordà et al. (2013).

Table 1 shows another interesting result on the interactions between finance and growth when it comes to the initial condition. The coefficient of the initial value of house prices is negative for the two business cycle phases, the expansion and recession (columns (1)-(2)). This result seems in contradiction with the literature on long-run growth which tries precisely to show that the initial state of financial development is a good predictor for future economic growth, see Levine (1997). However, we consider a very specific initial condition, namely the value of house prices at the end of the previous cycle, which is the inheritance of the previous cycle. Then, starting a new cycle with a high level of house prices is associated with a low economic growth, not only during the new expansion phase, but also during the next recession. This effect holds even if we introduce the controls for economic growth in columns (4)-(5). This result can be related with the concept of "Debt Supercycle" developed by Rogoff (2015) according to which the inheritance of excessive development of finance in the past can lead to long-lasting low economic growth (see also Lo and Rogoff (2015)). This result could also be linked to the notion of deleveraging crisis formalized by Eggertsson and Krugman (2012). They present a new Keynesian model of debt-driven slumps – that is, situations in which an overhang of debt on the part of some agents, who are forced into rapid deleveraging, is depressing aggregate demand.

Duration. In Table 2, we employ the Weibull regression model to investigate the role of "excess finance" as a determinant of the duration of the different phases of business cycles (Section 2.3). In line with the literature, results of our regressions first show a positive duration dependence (P(Weibull distribution parameter)> 1) (columns (1) to (6)), which implies that an expansion (recession) is more likely to end the longer it lasts (see in particular Claessens et al. (2012)). We then show that large excess house prices are associated with a longer duration of expansions (column (1)) while they are not significantly correlated with the duration of the recession in the case of excess house prices (column (2)). These results are robust using the controls (columns (4) and (5)). The coefficient of the initial value of house prices is negative and significantly different from zero (column (2)) but it is no longer significant when controls are introduced (column (5).

To our knowledge, the identification of a link between finance and expansion duration is a new

Table 1 – Excess House Prices and GDP growth

	(1) GDP (OLS)	(2) GDP (OLS)	(3) GDP (OLS)	(4) GDP (OLS)	(5) GDP (OLS)	(6) GDP (OLS)
House Prices(Excess)	0.269***	-0.303**	0.121	0.368***	-0.298***	0.222***
	(0.0460)	(0.147)	(0.0757)	(0.0522)	(0.0922)	(0.0478)
House Prices[0]	-0.000218***	-0.000179**	-0.000239***	-0.000194***	-0.000242***	-0.000250***
	(2.79e-05)	(8.78e-05)	(4.62e-05)	(4.74e-05)	(8.14e-05)	(4.33e-05)
Schooling				0.000581	-0.000991	-0.000171
				(0.000504)	(0.00103)	(0.000490)
Credit/GDP[0]				-0.00542**	0.0124***	0.00486*
				(0.00276)	(0.00472)	(0.00250)
Population				-0.855***	-1.120***	-1.248***
				(0.165)	(0.262)	(0.147)
GDP capita[0]				-4.52e-09***	-8.39e-10	-5.19e-09***
				(7.11e-10)	(2.37e-09)	(7.06e-10)
Constant	0.0380***	0.0111*	0.0337***	0.0463***	0.0221***	0.0421***
	(0.00203)	(0.00652)	(0.00338)	(0.00412)	(0.00804)	(0.00393)
Observations	2,310	764	3,074	1,809	633	2,442
R^2	0.050	0.010	0.011	0.121	0.084	0.083
Number of countries	22	22	22	20	20	20
Period	Expansion	Recession	Cycle	Expansion	Recession	Cycle

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. GDP is GDP per capita annual growth. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle.

contribution to the literature. This result was previously suggested by Terrones et al. (2009) which show with summary statistics that duration of the expansion is longer for business cycles with financial crisis with no clear predictions for the economic growth. Jordà et al. (2013) suggest also with descriptive statistics that the duration of expansion is longer for expansions with high excess credit than for expansions with low excess credit. The literature on the links between financial cycles and business cycles do not focus on the duration of expansions. They study recessions and recoveries. For instance, Claessens et al. (2012) examine how the growth of asset prices prior to the recession correlates with the recession's duration. In their regressions, the increase in house prices prior to the recession is significantly positively related with the recession's duration, while equity price growth does not have a significant correlation. They do not study the duration of expansions since the amplitude of a recovery is measured over a fixed period of four quarters. Further research would be needed to explain the positive link between finance and expansion duration. In Section 5, we propose alternative explanations of this correlation.

Volatility. In Table 3, we measure the links between excess house prices and the volatility of real GDP per capita. We use as a measure of volatility the standard deviation of the quarterly growth rate of real GDP per capita. A higher value of excess finance is associated with a higher volatility during the recession phase (column (2)). Results during the recession phase remain significant using the controls (column (5)). This result echoes that of Cecchetti (2008) that finds that housing booms increase the volatility of growth. However, the absence of significant coefficients for the expansion phase for both the excess growth and the initial value of house prices may seem surprising given the large literature devoted to the issue of macroeconomic (in)stability associated with financial development. It is worth remembering here that we consider the volatility of growth within business cycle phases, which is only one of the three channels of interactions between excess finance and growth volatility, see Section 2.

It is interesting to notice that results on GDP growth, duration or volatility do not depend on the period considered. In particular, results do not change when splitting the sample into two periods, before

Table 2 – Excess House Prices and Duration

	(1)	(2)	(3)	(4)	(5)	(6)
	Duration	Duration	Duration	Duration	Duration	Duration
	(Weibull)	(Weibull)	(Weibull)	(Weibull)	(Weibull)	(Weibull)
House Prices (Excess)	19.39***	6.025	17.65***	20.54***	7.685	18.70***
	(4.588)	(4.770)	(3.913)	(5.699)	(6.400)	(4.773)
House Prices[0]	-0.00164	-0.00458**	-0.00179	-0.00640**	-0.00524	-0.00595**
	(0.00223)	(0.00211)	(0.00177)	(0.00315)	(0.00332)	(0.00249)
Schooling				-0.0911*	-0.0695	-0.0785**
				(0.0484)	(0.0470)	(0.0366)
Credit/GDP[0]				-0.208	0.139	-0.146
				(0.177)	(0.189)	(0.135)
Population				71.08	9.613	55.01
				(76.20)	(59.64)	(57.01)
GDP capita[0]				1.46e-07**	-8.96e-08	1.22e-07**
				(6.55e-08)	(5.81e-08)	(5.35e-08)
Observations	155	155	155	108	108	108
Number of countries	22	22	22	20	20	20
P (Weibull distribution para.)	1.225	1.333	1.528	1.311	1.368	1.685
Period	Expansion	Recession	Cycle	Expansion	Recession	Cycle

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "Duration" stands for the duration (in quarters) of each phase of the business cycle.

and after 1990 (see Table B.12 in the Appendix).

Endogeneity. The previous regressions show significant correlation between excess finance and growth even if we control for country fixed-effects and other determinants of economic growth as originally done by King and Levine (1993). However, as emphasized by Beck (2008), OLS estimators may not be consistent because of the omitted variable bias, the reverse causation from growth to excess finance, and measurement issues of variables. Instrumental Variables (IV) have been extensively used in the growth-finance literature to overcome the biases of OLS estimators notably by instrumenting financial depth with legal origin in cross-country analysis (Levine (1998), Levine (1999)) or by using lagged variables as internal instruments in dynamic panel analysis (Beck et al. (2000)). In this paper, we follow the strategy recently proposed by Arcand et al. (2015) who use an identification strategy based on the presence of heteroskedasticity in the regression's residual. The interest of this methodology originally developed by Rigobon (2003) and Lewbel (2012) is to improve the identification of causal relationships even in the absence of external instruments[7].

To explain the identification strategy, we follow the exposition of Lewbel (2012) and its application in the finance-growth literature by Arcand et al. (2015). Let Y_1 and Y_2 be observed endogenous variables, with Y_1 the GDP growth and Y_2 the excess finance, X a vector of explanatory variables, and $\varepsilon = (\varepsilon_1, \varepsilon_2)$ unobserved errors. The standard growth regression is specified as follows

$$Y_1 = \beta_1 X + \gamma_1 Y_2 + \varepsilon_1 \tag{29}$$

where an endogeneity issue arises because of reverse causation from growth to excess finance according to

$$Y_2 = \beta_2 X + \gamma_2 Y_1 + \varepsilon_2 \tag{30}$$

[7] As explained by Beck (2008), the challenge with external instruments "is to identify the economic mechanisms through which the instrumental variables influence the endogenous variable – financial development – while at the same time assuring that the instruments are not correlated with growth directly."

Table 3 – Excess House Prices and Volatility

	(1)	(2)	(3)	(4)	(5)	(6)
	Volatility	Volatility	Volatility	Volatility	Volatility	Volatility
	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)
House Prices(Excess)	-1.417	15.95**	7.721	1.061	20.56***	9.843
	(6.517)	(6.415)	(5.168)	(8.647)	(7.338)	(6.016)
House Prices[0]	-1.44e-05	-0.00428	-0.000673	-0.0109	0.00413	-0.000248
	(0.00434)	(0.00427)	(0.00344)	(0.00885)	(0.00751)	(0.00616)
Schooling				-0.148	0.0607	-0.0226
				(0.148)	(0.125)	(0.103)
Credit/GDP[0]				1.403**	-0.605	0.247
				(0.567)	(0.481)	(0.394)
Population				74.26	54.65	98.44
				(119.6)	(101.5)	(83.22)
GDP capita[0]				-2.38e-08	-1.89e-08	1.56e-07
				(2.08e-07)	(1.76e-07)	(1.44e-07)
Constant	1.881***	2.536***	2.410***	2.051**	1.629*	1.839***
	(0.336)	(0.331)	(0.267)	(0.993)	(0.843)	(0.691)
Observations	155	155	155	108	108	108
R^2	0.000	0.056	0.018	0.093	0.144	0.098
Number of countries	22	22	22	20	20	20
Period	Expansion	Recession	Cycle	Expansion	Recession	Cycle

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita.

The exogenous regressors X should satisfy here the minimal assumption that $E(\varepsilon X) = 0$. Lewbel (2012) demonstrated that the structural model parameters, namely the β, remain unidentified under the standard homoskedasticity assumption that $E(\varepsilon\varepsilon'|X)$ is constant. However, the structural model parameters may be identified given some heteroskedasticity, in particular if $\operatorname{cov}\left(X, \varepsilon_j^2\right) \neq 0$, for $j = 1, 2$, and $\operatorname{cov}(Z, \varepsilon_1\varepsilon_2) \neq 0$ for an observed Z, where Z can be a subset of X. Arcand et al. (2015) suggest to use $X\varepsilon_2$ as an instrument for Y_2.[8]

Table 4 reports the estimates of the models of Tables 1 (columns (4), (5), and (6)) and 3 (columns (4), (5), (6)) using identification through heteroskedasticity (Rigobon (2003), Lewbel (2012))[9]. As in the OLS estimations of Table 1, we find a positive relationship between House Prices (Excess) and GDP growth during the expansion (column (1)) and a negative one during the recession (column (2)). As in Table 3, we find that a higher value of excess finance is associated with a higher volatility during the recession phase (column (5)). The coefficients associated with House Prices (Excess) are precisely estimated, suggesting that $\operatorname{cov}(X, \varepsilon_2^2)$ is not close to zero and the Hansen's J test fails to reject the overidentifying restrictions at the 5% confidence level.

4.2. Growth Cycle Accounting

Regression results show several interactions between excess finance and the characteristics of the expansions and recessions, namely their growth rates, durations, and volatilities. This section uses the growth cycle accounting procedure to determine the implications of these interactions on the long-run economic growth and volatility. To do so, we apply the formulas presented in Section 2 for the estimates of the coefficients α_x^{ph} which are significantly different form zero at the 10% level, otherwise the zero value is

[8] This is a good instrument because the assumption that $cov(X, \varepsilon_1\varepsilon_2) = 0$ guarantees that $X\varepsilon_2$ is uncorrelated with ε_1, and the presence of heteroskedasticity ($cov(X, \varepsilon_2^2) \neq 0$) guarantees that $X\varepsilon_2$ is correlated with ε_2 and thus with Y_2. Using the stata function ivreg2h.do, we use the instrument $(Z - \mathrm{E}(Z))\,\varepsilon_2$ as originally suggested by Lewbel (2012).

[9] We cannot use the same methodology for the Weibull regression model we use in Table 2. In this section, we thus choose to focus on controlling the endogeneity of the OLS regressions.

Table 4 – Correcting for Endogeneity

	(1) GDP growth (IV)	(2) GDP growth (IV)	(3) GDP growth (IV)	(4) Volatility (IV)	(5) Volatility (IV)	(6) Volatility (IV)
House Prices (Excess)	0.285***	-0.540**	0.155**	22.10	22.41**	25.05***
	(0.0608)	(0.244)	(0.0701)	(13.79)	(9.564)	(8.835)
House Prices[0]	-0.000190***	-0.000269***	-0.000198***	-0.00613	0.00455	0.00318
	(5.76e-05)	(9.08e-05)	(4.84e-05)	(0.0106)	(0.00953)	(0.00682)
Schooling	-0.000351	-0.00182	-0.000533	-0.231	0.0535	-0.0824
	(0.000529)	(0.00112)	(0.000480)	(0.170)	(0.137)	(0.120)
Credit/GDP[0]	-0.00323	0.0150***	0.00241	1.510***	-0.596	0.324
	(0.00378)	(0.00535)	(0.00313)	(0.487)	(0.689)	(0.278)
Population	-0.606	-5.720***	-2.888***	-29.64	45.54	23.36
	(0.843)	(1.564)	(0.793)	(115.0)	(82.33)	(78.55)
GDP capita[0]	-3.79e-09***	-3.29e-09*	-4.63e-09***	-2.08e-08	-1.86e-08	1.58e-07**
	(1.04e-09)	(1.73e-09)	(9.49e-10)	(1.02e-07)	(1.19e-07)	(6.82e-08)
Observations	1,909	514	2,423	108	108	108
Hansen J Stat.	4.347	6.145	0.346	1.899	8.031	3.068
p-value	0.361	0.189	0.987	0.754	0.0905	0.546
Period	Boom	Recession	Cycle	Expansion	Recession	Cycle

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is GDP per capita annual growth. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita. The causal effect of House Prices (Excess) is identified using identification through heteroskedasticity (Lewbel (2012)).

imposed, where $ph = \{ex, re\}$ and $x = \{g, T, sd\}$.

In Table 5, we measure GDP growth elasticity with respect to house prices (excess). Column (10) reports the long-run elasticity as the sum of the growth channel (columns (4) to (6)) and the duration channel (columns (7) to (9)). Concerning the growth channel, the total elasticity is equal to 12.38% (column (6)), a number that is the sum of the elasticities during the expansion (that is 20.08%, column (4)) and the recession (that is -7.70%, column (5)). The value of $\tilde{\pi}^{ex}$ introduced in equation (19) for our panel is 0.745, that is economies are in average three quarters of the time in expansion and one quarter of the time in recession. This explains why the growth channel is positive even if the negative coefficient of excess finance for recessions in Table 1 is larger in absolute value than the positive coefficient of excess finance for expansions. The gap between the growth channel and the long-run elasticity is explained by the duration channel, which is equal to 1.88% (column (7)) and therefore accounts for almost 13% of the long-run elasticity. The duration channel is positive because excess finance is associated with longer duration of expansion and as the economic growth is in average higher in expansions than in recessions – the corresponding rates are 2.19% and -0.11%.

We then measure the elasticity of growth volatility with respect to house prices (excess). Higher economic growth occurs with a more volatile economic growth mainly because of the volatility channel during the recession phases, suggesting a trade-off between economic growth on volatility. It is interesting to notice that the duration channel during expansion reduces GDP volatility (columns (7)). Actuallty, the term in bracket of the equation (26), that multiplies the coefficient α_{τ}^{ex} is negative because the gap in the average growth rates of the two business cycle phases is not zero and the variance of output growth is higher in recessions than in expansions (respectively 46.91% and 10.09%).

Table 5 – Elasticity between House Prices (Excess) and Growth, House Prices (Excess) and Volatility

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Vol(ex)	Vol(re)	Vol(tot)	Gr(ex)	Gr(re)	Gr(tot)	Du(ex)	Du(re)	Du(tot)	Total
Growth				20.08	-7.70	12.38	1.88	0.00	1.88	14.27
Volatility	0.00	0.71	0.71	0.00	0.00	0.00	-0.35	0.00	-0.35	0.36

Notes: "Growth" is GDP growth elasticity with respect to house prices (excess). "Volatility" is volatility of output growth with respect to house prices (excess). "Vol(ex)", "Vol(re)", "Vol(tot)" are the volatility channels during expansion, recession and in the long-run. "Gr(ex)", "Gr(re)", "Gr(tot)" are the GDP growth channels during expansion, recession and in the long-run. "Du(ex)", "Du(re)", "Du(tot)" are the duration channels during expansion, recession and in the long-run. "Total" is the long-run elasticity.

4.3. Simulating Growth Pattern for Various Excess Finance

In Figure 1, we simulate GDP patterns depending on variations in excess house prices as described in Section 2.5. The interest of these simulations is to exhibit the role of direct interactions (between excess finance and growth) and indirect interactions (through persistent effects on the initial values of financial series).

To start, we consider only the direct interactions between excess finance and growth. Figure 1A shows output paths for growth cycles with high excess house prices (corresponding to the mean value of excess house prices plus one standard deviation), for the mean value of excess house prices, and for low excess house prices (mean minus one standard deviation). GDP growth is larger during the expansion for high excess house prices. The duration of the expansion is also longer for high excess house prices. Total GDP growth is thus much larger with high excess house prices than with low excess house prices, even if growth is lower during recessions with high excess finance.

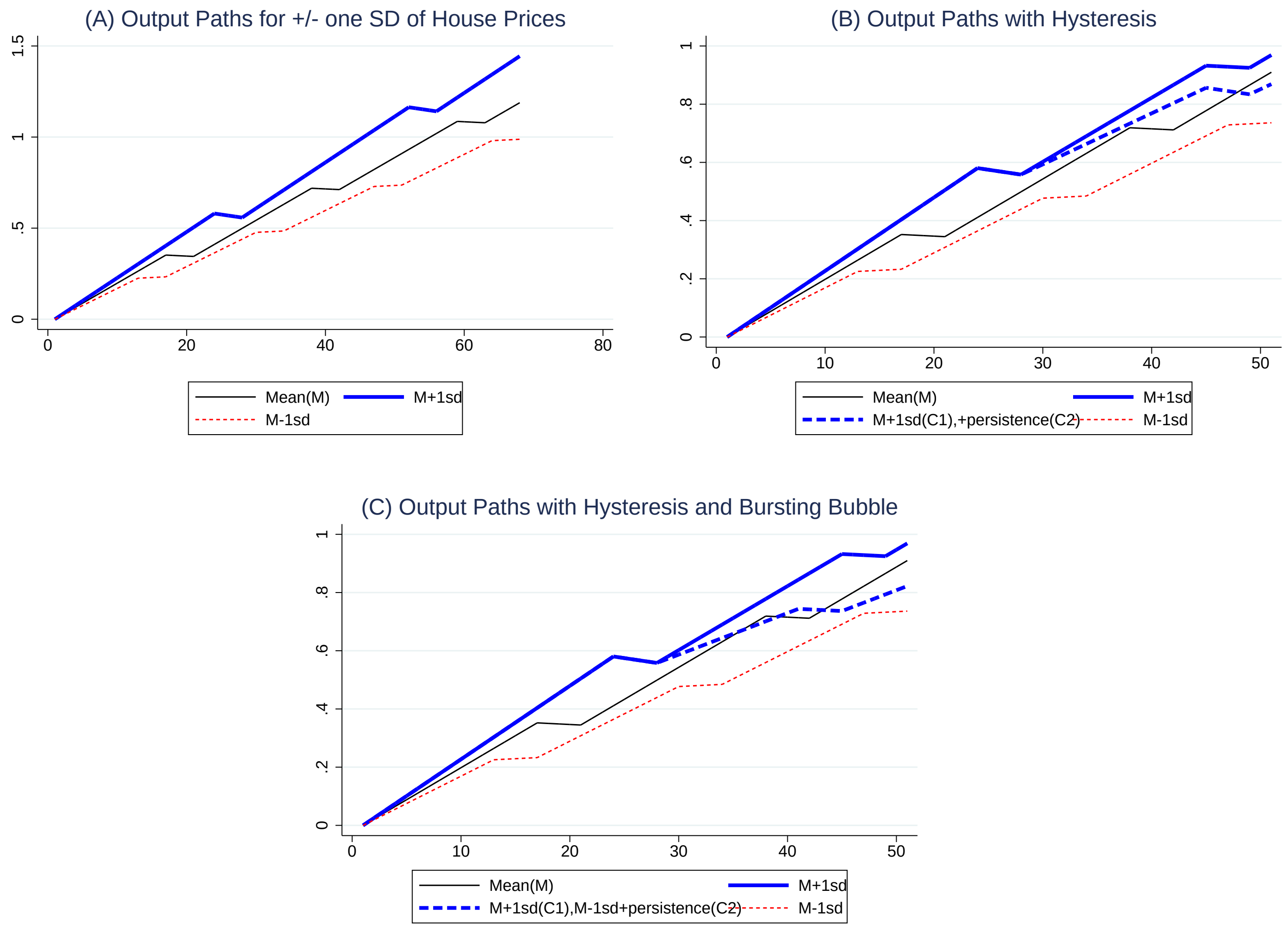
Then, we take into account the persistent effects of excess finance by considering that the initial value of the financial series for the second cycle is impacted by the excess finance of the first cycle as specified in equation (27). Figure 1B reproduces the three output patterns of Figure 1A and adds the case of high excess finance with this persistent effect. Following a growth cycle with a high excess house prices, GDP growth is reduced in the following cycle because of the high initial value of house prices. The initial value of house prices (that is the value of house prices at the beginning of each business cycle) is indeed negatively correlated with GDP growth (Table 1). At the end of the first cycle, output is higher in the high excess finance case, but it is not necessary the case at the end of the subsequent cycles. Indeed, for this simulation, the solid blue lines overtakes the dotted blue line at the end of the period.

Finally we consider output paths in the case of a bursting bubble as defined by equation (26). More precisely, Figure 1C shows the case of a first cycle with a high excess house prices followed by a cycle with persistent effects linked to the initial values of house prices and a low excess house prices (Mean minus one standard deviation) – the three benchmark paths of the Figure 1A are also reproduced. This corresponds to a bursting bubble. GDP growth is much reduced in this case because of the combination in the second cycle of low house prices growth and a high initial value of house prices. This situation is close to numerous examples of growth during and after financial bubbles (as recently observed in Spain). The interest of our methodology is to generate such patterns using estimates of growth-finance interactions through the growth and duration channels as well as the persistent effects of financial growth.

4.4. Robustness: Alternative measures of finance

We choose as the main specification house price excess. As robustness checks, we use seven other measures of excess finance growth such as price-to-income ratios, price-to-rent ratios, real credit, credit to GDP, real households credit, households credit to GDP or a qualitative measure such as the financial reform index .

Figure 1 – SIMULATION OF OUTPUT PATHS FOR VARIATIONS IN EXCESS HOUSE PRICES



Notes: Figure 1A shows output paths for business cycles with high excess house prices (corresponding to the mean value of excess house prices plus one standard deviation ("M+1sd", *in blue*), for the mean value of excess house prices ("M", *in black*), and for low excess house prices (mean minus one standard deviation, *in red*). Figure 1B reproduces the three output patterns of Figure 1A and adds the case of high excess finance with a persistent effect in cycle 2 ("C2", *Blue dash-line*). Figure 1C shows the case of a first cycle ("C1") with a high excess house prices followed by a cycle with persistent effects on the initial values of house prices and a low excess house prices (Mean minus one standard deviation, "M-1sd+persistence(C2)", *Blue dash-line*) – the three benchmark paths of the Figure 1A are also reproduced. We show coefficients that are significantly different form zero at the 10% level, otherwise the zero value is imposed.

Regression results for seven alternative measures. The correlation between excess dinance and GDP growth is very robust in expansion and recession for the seven alternative measures. Price-to-income ratios (excess), price-to-rent ratios (excess), real credit (excess), credit to GDP (excess), real households credit (excess), households credit to GDP (excess) and the financial reform index are all associated with higher GDP growth during the expansion and lower growth during the recession (columns (1) and (2) of Tables B.3, B.4, B.5, B.6, B.7, B.8, B.9).

Concerning duration, the seven different measures of excess finance growth indicate a strongly positive and significant correlation between excess finance growth and the duration of the expansion phase (columns (3) of Tables B.3, B.4, B.5, B.6, B.7, B.8, B.9). We find also a positive and significant correlation between excess finance growth and the duration of the recession in the case of the price-to-income ratios and credit to GDP (column (9) of Tables B.3 and B.6).

Concerning volatility, there is positive and significant correlation between excess finance and the volatility of recession in the cases of price-to-income ratios, price-to-rent ratios, real credit and the financial reform index (column (6) of Tables B.3, B.4, B.5, B.9). The regression is not significant in the case of expansion (column (5) of B.3, B.4, B.5, B.9), except for credit to GDP, real households credit and households credit to GDP where we find a negative correlation between excess finance and volatility (column (5) of Tables B.6, B.7, B.8).

Growth Cycle Accounting for seven other measures. In Table B.10, we compute GDP growth elasticity with respect to the eight measures of excess finance growth. Column (10) reports the long-run elasticity as the sum of the growth channel (columns (4) to (6)) and the duration channel (columns (7) to (9)). For seven out of the eight measures of excess finance, the long-run elasticity is positive. This is the case for house prices, price-to income ratio, price-to-rent ratio, real credit, real households credit, households credit to GDP and Financial reforms (the only exception is credit to GDP). For these seven measures, the elasticity for the growth channel during the expansion phases is positive, with a number higher than the economic growth during the recession phase. The growth channel, defined as the sum of these two elasticities, is equal to 12% for house prices, 20% for the price-to-income ratio, 19% for the price-to-rent ratio, 18% for real credit, 16% for real households credit, 11% for households credit to GDP. Concerning the duration channel, the elasticity is positive for all the measures of excess finance, with a range of results going from 0.4% (financial reforms) to 3.3% (real credit). The total long-run elasticity is positive for all the measures, except credit to GDP.

In Table B.11, we compute GDP volatility elasticity with respect to the eight measures of excess finance growth. Contrary to GDP growth, the sign of the total elasticity depends on the measure considered. For house prices and real credit, total elasticity is positive. For the six other measures, this elasticity is negative. It is thus not possible to conclude that higher economic growth occurs with a more volatile economic growth.

Simulations of Growth Patterns. We simulate the patterns of output growth for various values of excess finance using the estimation results for real credit, and households credit (see Figures A.1, A.2 and A.3). The properties exhibited for house prices are shared with these financial series. Indeed, as for house prices, a high value of excess finance is associated with higher growth in longer expansions during the first cycle but growth may be reduced in the subsequent cycle if one considers persistent effects and bubble burst (eg negative excess finance).

5. Concluding Remarks

We propose in this paper a new accounting procedure to study the interactions between excess financial growth and economic growth. We show that the finance-growth elasticity in the long-run can be viewed as the cumulative of finance-growth interactions within each cycle through a growth channel and a duration channel. Our empirical analysis delivers three key properties of the interactions between finance and growth.

1. Recessions are more severe after episodes of high excess finance.

2. High excess finance occurs with a high output growth rate during a long expansion phase.

3. High initial value of financial series at the beginning of a cycle is associated with a low output growth during the expansion and recession of this cycle.

The first property is nowadays well-known and constitutes the focus of the literature on finance and growth, see in particular Drehmann et al. (2012), Claessens et al. (2012) and Jordà et al. (2013). The third property is also of importance since it can be related with the concept of "Debt Supercycle" developed by Rogoff (2015) according to which the inheritance of excessive development of finance in the past can lead to long-lasting low economic growth. This result could also be linked to the notion of deleveraging crisis formalized by Eggertsson and Krugman (2012). Concerning the second property, the identification of a link between finance and expansion duration is a new contribution to the literature. It is interesting to notice that this property suggests a different pattern from the one described by Ranciere et al. (2008) in which financial liberalization leads to higher long-run growth but also to more crises, implying shorter expansions. In our paper, high excess finance is accompanied by a longer duration of expansions. Several mechanisms could explain this property. A first interpretation could be based on the procyclical behaviour of finance as stated by the financial accelerator mechanism developed by Bernanke et al. (1999). Indeed, an improvement of the fundamentals of the economic leads to more both growth and financial activities. A second interpretation could be based on the "time is different" syndrome developed by Reinhart and Rogoff (2008). A long expansion may be a favorable context for the development of beliefs at the origin of excessive developments of financial activities. A third interpretation could be that bubbles in the expansion phase can play as a shock absorber. An oil shock could be for example more easily absorbed in a country when growth is fed by a bubble. Hence, we conclude that further research would be needed to investigate the links between the duration of expansion and excess finance, in particular the sense of causality and economic mechanisms behind the relationship.

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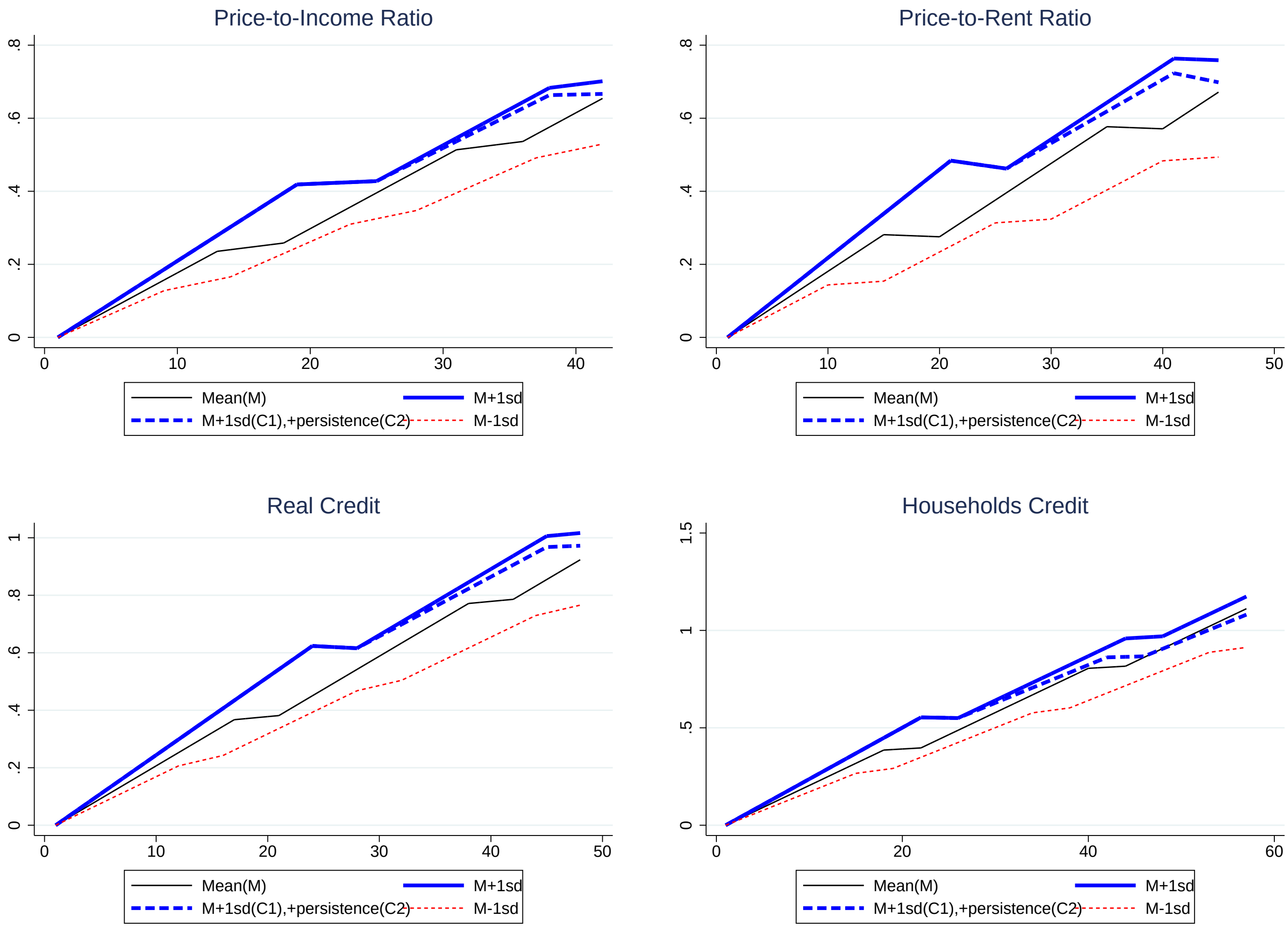
Appendix

A. Figures

Figure A.1 – SIMULATION OF OUTPUT PATHS FOR VARIATIONS IN EXCESS FINANCIAL SERIES

Notes: Figures A.1 shows output paths for business cycles with high excess financial growth (corresponding to the mean value of excess financial growth plus one standard deviation ("M+1sd", *in blue*), for the mean value of excess financial growth ("M", *in black*), and for low excess financial growth (mean minus one standard deviation, *in red*). We show the results for excess price-to-income ratio, excess price-to-rent ratio, excess real credit and excess households credit. We show coefficients that are significantly different form zero at the 10% level, otherwise the zero value is imposed.

Figure A.2 – SIMULATION OF OUTPUT PATHS WITH HYSTERESIS



Notes: Figures A.2 reproduce the three output patterns of Figure A.1 and adds the case of high excess finance with a persistent effect in cycle 2 ("C2", *Blue dash-line*). We show the results for excess price-to-income ratio, excess price-to-rent ratio, excess real credit and excess households credit. We show coefficients that are significantly different form zero at the 10% level, otherwise the zero value is imposed.

Figure A.3 – SIMULATION OF OUTPUT PATHS WITH HYSTERESIS AND BURSTING BUBBLE

Notes: Figures A.3 show the case of a first cycle ("C1") with a high excess financial growth followed by a cycle with persistent effects on the initial values of excess finance and a low excess financial growth (Mean minus one standard deviation, "M-1sd+persistence(C2)", *Blue dash-line*) – the three benchmark paths of the Figure A.1 are also reproduced. We show the results for excess price-to-income ratio, excess price-to-rent ratio, excess real credit and excess households credit. We show coefficients that are significantly different form zero at the 10% level, otherwise the zero value is imposed.

B. Tables

Table B.1 – Summary Statistics: Financial Series

	(1) N	(2) Mean	(3) Median	(4) Min	(5) Max
House Prices(Excess)	3,074	1.19e-10	0.00115	-0.0832	0.0591
Price-Income ratio(Excess)	2,761	0	-3.61e-05	-0.0357	0.0287
Price-Rent ratio(Excess)	2,997	-8.71e-11	0.00110	-0.0826	0.0319
Real Credit(Excess)	3,636	-4.51e-10	0.000295	-0.0297	0.0270
Credit/GDP(Excess)	3,696	-8.34e-11	9.41e-05	-0.0400	0.0227
Households Credit(Excess)	2,518	7.67e-10	-0.00159	-0.0302	0.0327
Households Credit/GDP(Excess)	2,518	-1.30e-10	-0.00111	-0.0433	0.0323

Table B.2 – Summary Statistics: Growth Cycles

	(1) N	(2) Mean	(3) Median	(4) Min	(5) Max
Duration Boom	228	14.61	11	2	67
Duration Cycle	228	18.18	15	3	70
Duration Recession	228	3.566	3	1	23

Table B.3 – Price/Income

	(1)	(2)	(3)	(4)	(5)	(6)
	GDP growth	GDP growth	Duration	Duration	Volatility	Volatility
	(OLS)	(OLS)	(Weibull)	(Weibull)	(OLS)	(OLS)
Price Income(Excess)	0.372***	-0.304***				
	(0.0585)	(0.101)				
Price Income[0]	-9.51e-05***	-0.000228***	0.00123	-0.00335	-0.00165	-0.00193
	(3.52e-05)	(6.57e-05)	(0.00211)	(0.00228)	(0.00563)	(0.00586)
Price Income(Excess)			32.18***	10.45*	4.317	8.478
			(6.724)	(5.812)	(8.317)	(8.670)
Constant	0.0283***	0.0248***			2.007***	1.864***
	(0.00316)	(0.00588)			(0.518)	(0.540)
Observations	2,064	697	151	151	151	151
R^2	0.026	0.026			0.003	0.009
Number of countries	24	24	24	24	24	24
P (Weibull distribution para.)			1.266	1.349		
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is real GDP growth per capita. "Duration" stands for the duration (in quarters) of each phase of the business cycle. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.4 – Price/Rent

	(1) GDP growth (OLS)	(2) GDP growth (OLS)	(3) Duration (Weibull)	(4) Duration (Weibull)	(5) Volatility (OLS)	(6) Volatility (OLS)
Price Rent(Excess)	0.352***	-0.268*				
	(0.0485)	(0.143)				
Price Rent[0]	-0.000137***	-0.000255**	-0.000184	-0.00226	-0.00269	-0.00286
	(3.08e-05)	(0.000104)	(0.00188)	(0.00182)	(0.00467)	(0.00497)
Price Rent(Excess)			24.68***	5.154	4.041	10.00
			(5.297)	(4.088)	(6.374)	(6.776)
Constant	0.0312***	0.0190**			2.067***	2.330***
	(0.00246)	(0.00844)			(0.389)	(0.413)
Observations	2,237	760	161	161	161	161
R-squared	0.039	0.011			0.006	0.021
Number of countries	25	25	25	25	25	25
P (Weibull distribution para.)			1.263	1.347		
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is real GDP growth per capita. "Duration": duration (in quarters) of each phase of the business cycle. "Volatility": standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.5 – Real Credit

	(1)	(2)	(3)	(4)	(5)	(6)
	GDP growth	GDP growth	Duration	Duration	Volatility	Volatility
	(OLS)	(OLS)	(Weibull)	(Weibull)	(OLS)	(OLS)
Credit(Excess)	0.440***	-0.572***				
	(0.0596)	(0.107)				
Credit[0]	-0.000185***	-0.000165***	-0.000930	0.000232	0.000990	0.000387
	(1.74e-05)	(3.02e-05)	(0.00193)	(0.00171)	(0.00265)	(0.00245)
Credit(Excess)			33.94***	9.007	-10.28	25.10***
			(7.292)	(6.348)	(9.336)	(8.627)
Constant	0.0331***	0.0123***			1.795***	1.727***
	(0.000960)	(0.00181)			(0.158)	(0.146)
Observations	2,794	842	180	180	180	180
R-squared	0.103	0.048			0.013	0.060
Number of countries	24	24	24	24	24	24
P (Weibull distribution para.)			1.330	1.300		
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is real GDP growth per capita. "Duration" stands for the duration (in quarters) of each phase of the business cycle. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.6 – Credit/GDP

	(1)	(2)	(3)	(4)	(5)	(6)
	GDP growth	GDP growth	Duration	Duration	Volatility	Volatility
	(OLS)	(OLS)	(Weibull)	(Weibull)	(OLS)	(OLS)
Credit/GDP(Excess)	0.136**	-0.714***				
	(0.0646)	(0.108)				
Credit/GDP[0]	-0.0157***	-0.0113***	0.00179	0.0200	0.211	-0.121
	(0.00133)	(0.00230)	(0.119)	(0.0957)	(0.205)	(0.198)
Credit/GDP(Excess)			38.46***	12.70**	-17.94*	14.71*
			(7.077)	(6.243)	(9.182)	(8.847)
Constant	0.0420***	0.0166***			1.574***	1.863***
	(0.00159)	(0.00282)			(0.251)	(0.241)
Observations	2,828	868	186	186	186	186
R-squared	0.062	0.058			0.040	0.025
Number of countries	24	24	24	24	24	24
P (Weibull distribution para.)			1.301	1.306		
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is real GDP growth per capita. "Duration" stands for the duration (in quarters) of each phase of the business cycle. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.7 – Real Households Credit

	(1)	(2)	(3)	(4)	(5)	(6)
	GDP growth	GDP growth	Duration	Duration	Volatility	Volatility
	(OLS)	(OLS)	(Weibull)	(Weibull)	(OLS)	(OLS)
Households Credit(Excess)	0.318***	-0.304***				
	(0.0660)	(0.116)				
Households Credit[0]	-0.000236***	-0.000105***	-0.00621***	-0.000638	0.00292	-0.00320
	(2.09e-05)	(3.50e-05)	(0.00228)	(0.00178)	(0.00318)	(0.00307)
Households Credit(Excess)			16.18**	0.119	-20.81**	10.49
			(7.849)	(6.411)	(10.21)	(9.854)
Constant	0.0358***	0.00845***			1.595***	1.934***
	(0.00115)	(0.00223)			(0.203)	(0.196)
Observations	1,973	545	117	117	117	117
R-squared	0.139	0.020			0.080	0.040
Number of countries	22	22	22	22	22	22
P (Weibull distribution para.)			1.364	1.459		
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is real GDP growth per capita. "Duration" stands for the duration (in quarters) of each phase of the business cycle. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.8 – Households Credit/GDP

	(1) GDP growth (OLS)	(2) GDP growth (OLS)	(3) Duration (Weibull)	(4) Duration (Weibull)	(5) Volatility (OLS)	(6) Volatility (OLS)
Households Credit/GDP(Excess)	0.264***	-0.349***				
	(0.0694)	(0.119)				
Households Credit/GDP[0]	-0.0459***	-0.0138**	-0.130	0.106	0.738	-0.866
	(0.00382)	(0.00623)	(0.316)	(0.239)	(0.609)	(0.595)
Households Credit/GDP(Excess)			34.92***	4.596	-23.40**	1.055
			(8.361)	(6.681)	(10.22)	(9.976)
Constant	0.0447***	0.00894***			1.412***	2.127***
	(0.00177)	(0.00315)			(0.303)	(0.296)
Observations	1,973	545	117	117	117	117
R-squared	0.104	0.020			0.087	0.025
Number of countries	22	22	22	22	22	22
P (Weibull distribution para.)			1.325	1.460		
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is real GDP growth per capita. "Duration" stands for the duration (in quarters) of each phase of the business cycle. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.9 – Financial Reforms

	(1) GDP growth (OLS)	(2) GDP growth (OLS)	(3) Duration (Weibull)	(4) Duration (Weibull)	(5) Volatility (OLS)	(6) Volatility (OLS)
Financial Reforms(Excess)	0.0298***	-0.000922				
	(0.00482)	(0.0119)				
Financial Reforms(Excess)			3.920***	1.081	0.145	1.125***
			(0.825)	(0.772)	(0.143)	(0.164)
Constant	0.0201***	0.00600***			1.832***	1.585***
	(0.000736)	(0.00132)			(0.0205)	(0.0236)
Observations	1,681	600	124	124	2,281	2,281
R-squared	0.023	0.000			0.000	0.020
Number of countries	22	22	22	22	22	22
P (Weibull distribution para.)			1.316	1.222		
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "GDP growth" is real GDP growth per capita. "Duration" stands for the duration (in quarters) of each phase of the business cycle. "Volatility" is the standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.10 – Elasticity between Growth and Excess Finance

	(1) Growth(ex)	(2) Growth(re)	(3) Growth(tot)	(4) Dura(ex)	(5) Dura(re)	(6) Dura(tot)	(7) Total
House Prices	20.08	-7.70	12.38	1.88	0.00	1.88	14.27
Price to Income	27.77	-7.73	20.04	3.12	-1.01	2.11	22.15
Price to Rent	26.29	-6.82	19.47	2.40	0.00	2.40	21.87
Real Credit	32.84	-14.52	18.32	3.30	0.00	3.30	21.61
Credit to GDP	10.14	-18.15	-8.01	3.73	-1.23	2.50	-5.50
Households Credit	23.73	-7.73	16.00	1.57	0.00	1.57	17.57
Households Credit to GDP	19.72	-8.86	10.86	3.39	0.00	3.39	14.25
Financial Reforms	2.22	0.00	2.22	0.38	0.00	0.38	2.60

Notes: We measure GDP growth elasticity with respect to the various measures of excess financial growth. "Growth(ex)", "Growth(re)", "Growth(tot)" are the GDP growth channels during expansion, recession and in the long-run. "Dura(ex)", "Dura(re)", "Dura(tot)" are the duration channels during expansion, recession and in the long-run. "Total" is the long-run elasticity.

Table B.11 – Elasticity between Volatility and Excess Finance

	(1) Vol(ex)	(2) Vol(re)	(3) Vol(tot)	(4) Gr(ex)	(5) Gr(re)	(6) Gr(tot)	(7) Du(ex)	(8) Du(re)	(9) Du(tot)	(10) Total
House Prices	0.00	0.71	0.71	0.00	0.00	0.00	-0.35	0.00	-0.35	0.36
Price to Income	0.00	0.00	0.00	0.00	0.00	0.00	-0.58	0.19	-0.39	-0.39
Price to Rent	0.00	0.00	0.00	0.00	0.00	0.00	-0.45	0.00	-0.45	-0.45
Real Credit	0.00	1.11	1.11	0.00	0.00	0.00	-0.61	0.00	-0.61	0.50
Credit to GDP	-2.75	0.65	-2.09	0.00	0.00	0.00	-0.70	0.23	-0.47	-2.56
Real HH Credit	-3.19	0.00	-3.19	0.00	0.00	0.00	-0.29	0.00	-0.29	-3.48
HH Credit to GDP	-3.58	0.00	-3.58	0.00	0.00	0.00	-0.63	0.00	-0.63	-4.21
Financial Reforms	0.00	0.05	0.05	0.00	0.00	0.00	-0.07	0.00	-0.07	-0.02

Notes: We measure volatility of output growth with respect to the various measures of excess financial growth. "Vol(ex)", "Vol(re)", "Vol(tot)" are the volatility channels during expansion, recession and in the long-run. "Gr(ex)", "Gr(re)", "Gr(tot)" are the GDP growth channels during expansion, recession and in the long-run. "Du(ex)", "Du(re)", "Du(tot)" are the duration channels during expansion, recession and in the long-run. "Total" is the long-run elasticity. "HH Credit" means households credit.

Table B.12 – House Prices: splitting the sample before/after 1990

	(1)	(2)	(3)	(4)	(5)	(6)
<=**1990**	GDP growth	GDP growth	Duration	Duration	Volatility	Volatility
House Prices(Excess)	0.255***	-0.183*				
	(0.0642)	(0.104)				
House Prices[0]	-0.000143	-0.000309	0.00646**	-0.00342	0.00865	-0.00619
	(9.23e-05)	(0.000197)	(0.00282)	(0.00393)	(0.0154)	(0.0156)
House Prices(Excess)			17.43***	12.63*	2.678	19.72**
			(4.958)	(6.516)	(8.071)	(8.199)
Constant	0.0339***	0.0232*			1.577*	2.412**
	(0.00593)	(0.0120)			(0.929)	(0.944)
Observations	988	298	74	74	74	74
R^2	0.028	0.016			0.007	0.123
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

	(1)	(2)	(3)	(4)	(5)	(6)
>**1990**	GDP growth	GDP growth	Duration	Duration	Volatility	Volatility
House Prices(Excess)	0.235***	-0.494				
	(0.0863)	(0.311)				
House Prices[0]	-0.000297***	-0.000224	-0.0141***	-0.00302	0.00606	0.000832
	(3.50e-05)	(0.000145)	(0.00407)	(0.00299)	(0.00766)	(0.00633)
House Prices(Excess)			19.29*	-1.933	-6.327	30.83**
			(11.50)	(6.549)	(16.34)	(13.49)
Constant	0.0435***	0.0116			1.146*	2.358***
	(0.00274)	(0.0116)			(0.679)	(0.561)
Observations	1,322	466	81	81	81	81
R^2	0.069	0.009			0.018	0.088
Period	Expansion	Recession	Expansion	Recession	Expansion	Recession

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Country fixed effects included. "Excess" stands for excess financial growth. "[0]" indicates the level at the beginning of each business cycle. "GDP growth" is real GDP growth per capita. "Duration": duration (in quarters) of each phase of the business cycle. "Volatility": standard deviation of the quarterly growth rate of Real GDP per capita.

Table B.13 – Variables definitions

Variables (Abbreviation)	Sources	Variable description
Total credit (Total credit)	BIS Long series on credit to the private non-financial sector	Credit to non-financial private sector (Borrowing sector: Private non-financial sector that is resident in the economy, Lending sector: All sectors), National currency , Quarterly.
Households Credit (Households Credit)	BIS Long series on credit to the private non-financial sector	Credit to non-financial private sector – Credit to Non-financial Corporations, National currency , Quarterly.
Gross domestic product (GDP)	OECD, Quarterly National Accounts	National currency, volume estimates, OECD reference year, annual levels, seasonally adjusted, Quarterly.
Population (Population)	OECD, Historical population data and projections	Population, 15-64, Persons, thousands.
GDP per capita (GDP per capita)	OECD	GDP/Population 15-64, Quarterly.

Variables (Abbreviation)	Sources	Variable description
House Prices (House Prices)	International House Prices Database, Federal Reserve Bank of Dallas	Residential property prices, real terms, Quarterly
Price-to-Income Ratio (Price-to-Income)	OECD Housing Prices Database	Nominal House Price divided by nominal disposable income per head, Quarterly
Price-to-Rent Ratio (Price-to-Rent)	OECD Housing Prices Database	Nominal House Price divided by Rent price, Quarterly
Schooling (Schooling)	Barro and Lee (2013), International Human Development Indicators	Average years of schooling of population aged 25 and over
Financial Reforms (Financial Reforms)	IMF, 2008 (Abiad et al, 2008)	Financial Reform Index, normalized to be between 0 and 1.
Bank crisis (Bank crisis)	GFDD (Laeven and Valencia, 2013)	Dummy variable for the presence of banking crisis (1=banking crisis, 0=none).

C. Computation of Elasticities

A. Elasticity of growth w.r.t. to excess finance

Let us first define the elasticity of relative duration w.r.t. to excess finance. The first order partial derivative of $\pi_{i,c}^{ex}$ w.r.t. to ϕ^{ex} is

$$\frac{\partial \pi_{i,c}^{ex}}{\partial \phi^{ex}} = \frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \tag{A.1}$$

then,

$$\frac{\partial \pi_{i,c}^{ex}}{\partial \phi^{ex}} = \frac{\partial \ \tau_{i,c}^{ex}}{\partial \phi^{ex}} \frac{1}{\tau_{i,c}^{ex} + \ \tau_{i,c}^{re}} \pi_{i,c}^{re} - \frac{\partial \tau_{i,c}^{re}}{\partial \phi^{ex}} \frac{1}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \pi_{i,c}^{ex} \tag{A.2}$$

The first order partial derivative of $\pi_{i,c}^{re}$ w.r.t. to ϕ^{ex} is

$$\frac{\partial \pi_{i,c}^{re}}{\partial \phi^{ex}} = \frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \tag{A.3}$$

then,

$$\frac{\partial \pi_{i,c}^{re}}{\partial \phi^{ex}} = \frac{\partial \tau_{i,c}^{re}}{\partial \phi^{ex}} \frac{1}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \pi_{i,c}^{ex} - \frac{\partial \tau_{i,c}^{ex}}{\partial \phi^{ex}} \frac{1}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \pi_{i,c}^{re} \tag{A.4}$$

Then, we show how to get the expression of $\varepsilon_{\phi^{ex}}^{g}$ given by equation (10) using the definition (9) of growth, which is

$$g = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_i} \sum_{c=1}^{C^i} \left[\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} g_{i,c}^{ex} + \frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} g_{i,c}^{re} \right] \tag{A.5}$$

The first order derivative of the first term of g w.r.t. to ϕ^{ex} is

$$\frac{\partial g}{\partial \phi^{ex}} = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_i} \sum_{c=1}^{C^i} \left[\frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} g_{i,c}^{ex} \right) + \frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} g_{i,c}^{ex} \right) \right] \tag{A.6}$$

The first term of (A.6) is

$$\frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} g_{i,c}^{ex} \right) = \frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\mathcal{T}_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \times g_{i,c}^{ex} + \frac{\partial g_{i,c}^{ex}}{\partial \phi^{ex}} \times \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \tag{A.7}$$

where $\frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right)$ is given by (A.2), then (A.7) becomes

$$\begin{aligned} \frac{\partial}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} g_{i,c}^{ex} \right) \quad = \quad & \frac{\partial \tau_{i,c}^{ex}}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \frac{g_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \\ & - \frac{\partial \tau_{i,c}^{re}}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \frac{g_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) + \frac{\partial g_{i,c}^{ex}}{\partial \phi^{ex}} \left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \end{aligned} \tag{A.8}$$

The second term of (A.6) is

$$\frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}} g_{i,c}^{re}\right)=\frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{re}}{\mathcal{T}_{i,c}^{ex}+\tau_{i,c}^{re}}\right) \times g_{i,c}^{re}+\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right) \times \frac{\partial g_{i,c}^{re}}{\partial \phi^{ex}} \tag{A.9}$$

where $\frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)$ is given by (A.4), then (A.9) becomes

$$\begin{aligned}\frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}} g_{i,c}^{re}\right) \quad = \quad & \frac{\partial \tau_{i,c}^{re}}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}} \frac{g_{i,c}^{re}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right) \\ & -\frac{\partial \tau_{i,c}^{ex}}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}} \frac{g_{i,c}^{re}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)+\frac{\partial g_{i,c}^{re}}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)\end{aligned} \tag{A.10}$$

The sum of (A.8) and (A.10) is

$$\begin{aligned}& \frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}} g_{i,c}^{ex}\right)+\frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\mathcal{T}_{i,c}^{ex}+\tau_{i,c}^{re}} g_{i,c}^{ex}\right) \\ = \; & \frac{\partial g_{i,c}^{ex}}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)+\frac{\partial g_{i,c}^{re}}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)+\left(\frac{\partial \tau_{i,c}^{ex}}{\partial \phi^{ex}} \tau_{i,c}^{re}-\frac{\partial \tau_{i,c}^{re}}{\partial \phi^{ex}} \tau_{i,c}^{ex}\right) \frac{g_{i,c}^{ex}-g_{i,c}^{re}}{\left(\tau_{i,c}^{ex}+\tau_{i,c}^{re}\right)^{2}}\end{aligned} \tag{A.11}$$

that is the term in the sum defined by equation (10). Using (13) and (15), (A.11) becomes

$$\begin{aligned}& \frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}} g_{i,c}^{ex}\right)+\frac{\partial}{\partial \phi^{ex}}\left(\frac{\tau_{i,c}^{ex}}{\mathcal{T}_{i,c}^{ex}+\tau_{i,c}^{re}} g_{i,c}^{ex}\right) \\ = \; & \alpha_{g}^{ex}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)+\alpha_{g}^{re}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)+\left(\alpha_{\tau}^{ex}-\alpha_{\tau}^{re}\right) \frac{\tau_{i,c}^{ex} \tau_{i,c}^{re}}{\left(\tau_{i,c}^{ex}+\tau_{i,c}^{re}\right)^{2}}\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)\end{aligned} \tag{A.12}$$

Introducing this expression into (A.6) gives

$$\begin{aligned}\frac{\partial g}{\partial \phi^{ex}} \quad = \quad & \alpha_{g}^{ex} \times \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_{i}} \sum_{c=1}^{C^{i}}\left(\frac{\tau_{i,c}^{ex}}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\right)+\alpha_{g}^{re} \times \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_{i}} \sum_{c=1}^{C^{i}}\left[\left(\frac{\tau_{i,c}^{re}}{\tau_{i,c}^{ex}+\mathcal{T}_{i,c}^{re}}\right)\right] \\ & +\left(\alpha_{\tau}^{ex}-\alpha_{\tau}^{re}\right) \times \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_{i}} \sum_{c=1}^{C^{i}}\left[\frac{\tau_{i,c}^{ex} \tau_{i,c}^{re}}{\left(\tau_{i,c}^{ex}+\tau_{i,c}^{re}\right)^{2}}\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)\right]\end{aligned} \tag{A.13}$$

using the definition of $\pi_{i,c}^{ph}=\tau_{i,c}^{ph} / \left(\tau_{i,c}^{ex}+\tau_{i,c}^{re}\right)$ and $\sigma_{i,c}=\pi_{i,c}^{ex} \pi_{i,c}^{re}\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)$, it becomes

$$\begin{aligned}\frac{\partial g}{\partial \phi^{ex}} \quad = \quad & \alpha_{g}^{ex} \times \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_{i}} \sum_{c=1}^{C^{i}} \pi_{i,c}^{ex}+\alpha_{g}^{re} \times \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_{i}} \sum_{c=1}^{C^{i}} \pi_{i,c}^{re} \\ & +\left(\alpha_{\tau}^{ex}-\alpha_{\tau}^{re}\right) \times \frac{1}{n} \sum_{i=1}^{n} \frac{1}{C_{i}} \sum_{c=1}^{C^{i}} \sigma_{i,c}\end{aligned} \tag{A.14}$$

and, finally, using the $\widetilde{x}$ symbol to denote historical mean of series x, it is

$$\frac{\partial g}{\partial \phi^{ex}}=\alpha_{g}^{ex} \times \widetilde{\pi}^{ex}+\alpha_{g}^{re} \times \widetilde{\pi}^{re}+\left(\alpha_{\mathcal{T}}^{ex}-\alpha_{\tau}^{re}\right) \times \widetilde{\sigma} \tag{A.15}$$

B. Definition of the Variance of Growth

The variance of growth during the cycle c in country i is defined as follows

$$\mathrm{var}\left(g_{i,c}\right) \equiv \frac{1}{\tau_{i,c}} \sum_{s=1}^{\tau_{i,c}} \left(g_{i,c,s} - \widetilde{g}_{i,c}\right)^2 \tag{B.1}$$

Using the definition of business cycle phases, it is

$$\mathrm{var}\left(g_{i,c}\right) = \frac{1}{\tau_{i,c}} \left[\sum_{s=1}^{\tau_{i,c}^{ex}} \left(g_{i,c,s} - \widetilde{g}_{i,c}\right)^2 + \sum_{s=1+\tau_{i,c}^{ex}}^{\tau_{i,c}} \left(g_{i,c,s} - \widetilde{g}_{i,c}\right)^2\right] \tag{B.2}$$

Introducing the average values of growth rate per business cycle phases ph, namely $g_{i,c}^{ph}$ for $ph = \{ex, re\}$, it becomes

$$\mathrm{var}\left(g_{i,c}\right) = \frac{1}{\tau_{i,c}} \left[\sum_{s=1}^{\tau_{i,c}^{ex}} \left[\left(g_{i,c,\int} - g_{i,c}^{ex}\right) + \left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)\right]^2 + \sum_{s=1+\tau_{i,c}^{ex}}^{\tau_{i,c}} \left[\left(g_{i,c,s} - g_{i,c}^{re}\right) + \left(g_{i,c}^{re} - \widetilde{g}_{i,c}\right)\right]^2\right] \tag{B.3}$$

The first term of (B.3) is

$$\sum_{s=1}^{\tau_{i,c}^{ex}} \left[\left(g_{i,c,s} - g_{i,c}^{ex}\right) + \left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)\right]^2 = \sum_{s=1}^{\tau_{i,c}^{ex}} \left[\left(g_{i,c,s} - g_{i,c}^{ex}\right)^2 + \left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)^2 + 2\left(g_{i,c,s} - g_{i,c}^{ex}\right)\left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)\right] \tag{B.4}$$

then,

$$\begin{aligned} & \sum_{s=1}^{\tau_{i,c}^{ex}} \left[\left(g_{i,c,s} - g_{i,c}^{ex}\right) + \left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)\right]^2 \\ = \; & \tau_{i,c}^{ex} \left[\underbrace{\frac{1}{\tau_{i,c}^{ex}} \sum_{s=1}^{\tau_{i,c}^{ex}} \left(g_{i,c,s} - g_{i,c}^{ex}\right)^2}_{=\mathrm{var}\left(g_{i,c}^{ex}\right)} + 2\left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right) \underbrace{\frac{1}{\tau_{i,c}^{ex}} \sum_{s=1}^{\tau_{i,c}^{ex}} g_{i,c,s}}_{=g_{i,c}^{ex}} + \left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)^2 - 2g_{i,c}^{ex}\left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)\right] \end{aligned} \tag{B.5}$$

and finally

$$\sum_{s=1}^{\tau_{i,c}^{ex}} \left[\left(g_{i,c,s} - g_{i,c}^{ex}\right) + \left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)\right]^2 = \tau_{i,c}^{ex} \mathrm{var}\left(g_{i,c}^{ex}\right) + \tau_{i,c}^{ex}\left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)^2 \tag{B.6}$$

The second term of (B.3) is

$$\sum_{s=1+\tau_{i,c}^{ex}}^{\tau_{i,c}} \left[\left(g_{i,c,s} - g_{i,c}^{re}\right) + \left(g_{i,c}^{re} - \widetilde{g}_{i,c}\right)\right]^2 = \tau_{i,c}^{re} \mathrm{var}\left(g_{i,c}^{re}\right) + \tau_{i,c}^{re}\left(g_{i,c}^{re} - \widetilde{g}_{i,c}\right)^2 \tag{B.7}$$

following similar calculus. Using (B.6) and (B.7), (B.3) becomes

$$\operatorname{var}(g_{i,c}) = \frac{1}{\tau_{i,c}}\left[\tau_{i,c}^{ex}\operatorname{var}\left(g_{i,c}^{ex}\right) + \tau_{i,c}^{ex}\left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)^2 + \tau_{i,c}^{re}\operatorname{var}\left(g_{i,c}^{re}\right) + \tau_{i,c}^{re}\left(g_{i,c}^{re} - \widetilde{g}_{i,c}\right)^2\right] \tag{B.8}$$

Then, introducing the variables π^{ph}, it becomes

$$\operatorname{var}(g_{i,c}) = \pi_{i,c}^{ex}\operatorname{var}\left(g_{i,c}^{ex}\right) + \pi_{i,c}^{re}\operatorname{var}\left(g_{i,c}^{re}\right) + \pi_{i,c}^{ex}\left(g_{i,c}^{ex} - \widetilde{g}_{i,c}\right)^2 + \pi_{i,c}^{re}\left(g_{i,c}^{re} - \widetilde{g}_{i,c}\right)^2 \tag{B.9}$$

The last step is to suppress $\widetilde{g}_{i,c}$ form this expression, using

$$\widetilde{g}_{i,c} \equiv \pi_{i,c}^{ex}g_{i,c}^{ex} + \pi_{i,c}^{re}g_{i,c}^{re} \tag{B.10}$$

then

$$\operatorname{var}(g_{i,c}) = \pi_{i,c}^{ex}\operatorname{var}\left(g_{i,c}^{ex}\right) + \pi_{i,c}^{re}\operatorname{var}\left(g_{i,c}^{re}\right) + \pi_{i,c}^{ex}\left(\left(1-\pi_{i,c}^{ex}\right)g_{i,c}^{ex} - \pi_{i,c}^{re}g_{i,c}^{re}\right)^2 + \pi_{i,c}^{re}\left(\left(1-\pi_{i,c}^{re}\right)g_{i,c}^{re} - \pi_{i,c}^{ex}g_{i,c}^{ex}\right)^2 \tag{B.11}$$

since $\pi_{i,c}^{re} + \pi_{i,c}^{ex} = 1$, it becomes

$$\operatorname{var}(g_{i,c}) = \pi_{i,c}^{ex}\operatorname{var}\left(g_{i,c}^{ex}\right) + \pi_{i,c}^{re}\operatorname{var}\left(g_{i,c}^{re}\right) + \pi_{i,c}^{ex}\left(\pi_{i,c}^{re}\right)^2\left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2 + \pi_{i,c}^{re}\left(\pi_{i,c}^{ex}\right)^2\left(g_{i,c}^{re} - g_{i,c}^{ex}\right)^2 \tag{B.12}$$

and finally,

$$\operatorname{var}(g_{i,c}) = \pi_{i,c}^{ex}\operatorname{var}\left(g_{i,c}^{ex}\right) + \pi_{i,c}^{re}\operatorname{var}\left(g_{i,c}^{re}\right) + \pi_{i,c}^{ex}\pi_{i,c}^{re}\left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2 \tag{B.13}$$

C. Elasticity of the Variance of Growth w.r.t. Excess Finance

The first order partial derivative of $\operatorname{var}(g_{i,c})$ w.r.t. to ϕ^{ex} is

$$\begin{aligned}\frac{\partial\operatorname{var}(g_{i,c})}{\partial\phi^{ex}} &= \frac{\partial\pi_{i,c}^{ex}}{\partial\phi^{ex}}\operatorname{var}\left(g_{i,c}^{ex}\right) + \pi_{i,c}^{ex}\frac{\partial\operatorname{var}\left(g_{i,c}^{ex}\right)}{\partial\phi^{ex}} + \frac{\partial\pi_{i,c}^{re}}{\partial\phi^{ex}}\operatorname{var}\left(g_{i,c}^{re}\right) + \pi_{i,c}^{re}\frac{\partial\operatorname{var}\left(g_{i,c}^{re}\right)}{\partial\phi^{ex}} \\ &+ \left[\frac{\partial\left(\pi_{i,c}^{ex}\pi_{i,c}^{re}\right)}{\partial\phi^{ex}}\left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2 + \pi_{i,c}^{ex}\pi_{i,c}^{re}\frac{\partial\left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2}{\partial\phi^{ex}}\right]\end{aligned} \tag{C.1}$$

The first order partial derivative of $\operatorname{var}\left(g_{i,c}^{ph}\right)$ w.r.t. to ϕ^{ex} is

$$\frac{\partial\operatorname{var}\left(g_{i,c}^{ph}\right)}{\partial\phi^{ex}} = 2\frac{d\operatorname{sd}\left(g_{i,c}^{ph}\right)}{\partial\phi^{ex}}\operatorname{sd}\left(g_{i,c}^{ph}\right) \tag{C.2}$$

using the definition of the variance: $\mathrm{var}\left(g_{i,c}^{ph}\right) \equiv \mathrm{sd}\left(g_{i,c}^{ph}\right)^2$. The first order partial derivative of $\pi_{i,c}^{ex}$ w.r.t. to ϕ^{ex} is given by (A.2), which becomes

$$\frac{\partial \pi_{i,c}^{ex}}{\partial \phi^{ex}} = \frac{1}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \left(\alpha_\tau^{ex} \frac{\tau_{i,c}^{ex} \tau_{i,c}^{re}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} - \alpha_\tau^{re} \frac{\tau_{i,c}^{re} \tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \tag{C.3}$$

using (15), and then,

$$\frac{\partial \pi_{i,c}^{ex}}{\partial \phi^{ex}} = \pi_{i,c}^{ex} \pi_{i,c}^{re} \left(\alpha_\tau^{ex} - \alpha_\tau^{re} \right) \tag{C.4}$$

The first order partial derivative of $\pi_{i,c}^{re}$ w.r.t. to ϕ^{ex} is is given by (A.4), which becomes

$$\frac{\partial \pi_{i,c}^{re}}{\partial \phi^{ex}} = \frac{1}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \left(\alpha_\tau^{re} \frac{\tau_{i,c}^{re} \tau_{i,c}^{ex}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} - \alpha_\tau^{ex} \frac{\tau_{i,c}^{ex} \tau_{i,c}^{re}}{\tau_{i,c}^{ex} + \tau_{i,c}^{re}} \right) \tag{C.5}$$

using (15), and then,

$$\frac{\partial \pi_{i,c}^{re}}{\partial \phi^{ex}} = \pi_{i,c}^{ex} \pi_{i,c}^{re} \left(\alpha_\tau^{re} - \alpha_\tau^{ex} \right) \tag{C.6}$$

or equivalently,

$$\frac{\partial \pi_{i,c}^{re}}{\partial \phi^{ex}} = -\pi_{i,c}^{ex} \pi_{i,c}^{re} \left(\alpha_\tau^{ex} - \alpha_\tau^{re} \right) = -\frac{\partial \pi_{i,c}^{ex}}{\partial \phi^{ex}} \tag{C.7}$$

The first order partial derivative of $\left(\pi_{i,c}^{ex} \pi_{i,c}^{re}\right)$ w.r.t. to ϕ^{ex} is

$$\frac{\partial \left(\pi_{i,c}^{ex} \pi_{i,c}^{re}\right)}{\partial \phi^{ex}} = \frac{\partial \pi_{i,c}^{ex}}{\partial \phi^{ex}} \pi_{i,c}^{re} + \frac{\partial \pi_{i,c}^{re}}{\partial \phi^{ex}} \pi_{i,c}^{ex} \tag{C.8}$$

using (C.7) and $\pi_{i,c}^{re} = 1 - \pi_{i,c}^{ex}$, it becomes

$$\frac{\partial \left(\pi_{i,c}^{ex} \pi_{i,c}^{re}\right)}{\partial \phi^{ex}} = \frac{\partial \pi_{i,c}^{ex}}{\partial \phi^{ex}} \left(1 - 2\pi_{i,c}^{ex}\right) \tag{C.9}$$

and using (C.4)

$$\frac{\partial \left(\pi_{i,c}^{ex} \pi_{i,c}^{re}\right)}{\partial \phi^{ex}} = \pi_{i,c}^{ex} \pi_{i,c}^{re} \left(1 - 2\pi_{i,c}^{ex}\right) \left(\alpha_\tau^{ex} - \alpha_\tau^{re} \right) \tag{C.10}$$

The first order partial derivative of $\left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2$ w.r.t. to ϕ^{ex} is

$$\frac{\partial \left(g_{i,c}^{ex} - g_{i,c}^{re}\right)^2}{\partial \phi^{ex}} = 2 \left(\frac{\partial g_{i,c}^{ex}}{\partial \phi^{ex}} - \frac{\partial g_{i,c}^{re}}{\partial \phi^{ex}} \right) \left(g_{i,c}^{ex} - g_{i,c}^{re}\right) \tag{C.11}$$

Using (13), it becomes

$$\frac{\partial\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)^2}{\partial\phi^{ex}}=2\left(\alpha_g^{ex}-\alpha_g^{re}\right)\left(g_{i,c}^{ex}-g_{i,c}^{re}\right) \tag{C.12}$$

Finally, (C.1) becomes

$$\begin{aligned}\frac{\partial\mathrm{var}\left(g_{i,c}\right)}{\partial\phi^{ex}}&=\pi_{i,c}^{ex}\times 2\frac{d\mathrm{sd}\left(g_{i,c}^{ex}\right)}{\partial\phi^{ex}}\mathrm{sd}\left(g_{i,c}^{ex}\right)+\pi_{i,c}^{re}\times 2\frac{d\mathrm{sd}\left(g_{i,c}^{re}\right)}{\partial\phi^{ex}}\mathrm{sd}\left(g_{i,c}^{re}\right)\\&+\pi_{i,c}^{ex}\pi_{i,c}^{re}\mathrm{var}\left(g_{i,c}^{ex}\right)\left(\alpha_\tau^{ex}-\alpha_\tau^{re}\right)-\pi_{i,c}^{ex}\pi_{i,c}^{re}\mathrm{var}\left(g_{i,c}^{re}\right)\left(\alpha_\tau^{ex}-\alpha_\tau^{re}\right)\\&+\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)^2\pi_{i,c}^{ex}\pi_{i,c}^{re}\left(1-2\pi_{i,c}^{ex}\right)\left(\alpha_\tau^{ex}-\alpha_\tau^{re}\right)+\pi_{i,c}^{ex}\pi_{i,c}^{re}2\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)\left(\alpha_g^{ex}-\alpha_g^{re}\right)\end{aligned} \tag{C.13}$$

using (C.4), (C.6), and (C.12), and then

$$\begin{aligned}\frac{\partial\mathrm{var}\left(g_{i,c}\right)}{\partial\phi^{ex}}&=\pi_{i,c}^{ex}\times 2\frac{d\mathrm{sd}\left(g_{i,c}^{ex}\right)}{\partial\phi^{ex}}\mathrm{sd}\left(g_{i,c}^{ex}\right)+\pi_{i,c}^{re}\times 2\frac{d\mathrm{sd}\left(g_{i,c}^{re}\right)}{\partial\phi^{ex}}\mathrm{sd}\left(g_{i,c}^{re}\right)\\&+\pi_{i,c}^{ex}\pi_{i,c}^{re}\left[\mathrm{var}\left(g_{i,c}^{ex}\right)-\mathrm{var}\left(g_{i,c}^{re}\right)+\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)^2\left(1-2\pi_{i,c}^{ex}\right)\right]\left(\alpha_\tau^{ex}-\alpha_\tau^{re}\right)\\&++\pi_{i,c}^{ex}\pi_{i,c}^{re}2\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)\left(\alpha_g^{ex}-\alpha_g^{re}\right)\end{aligned} \tag{C.14}$$

Using (22), it becomes

$$\begin{aligned}\frac{\partial\mathrm{var}\left(g_{i,c}\right)}{\partial\phi^{ex}}&=\pi_{i,c}^{ex}\times 2\alpha_{sd}^{ex}\mathrm{sd}\left(g_{i,c}^{ex}\right)+\pi_{i,c}^{re}\times 2\alpha_{sd}^{re}\mathrm{sd}\left(g_{i,c}^{re}\right)+\pi_{i,c}^{ex}\pi_{i,c}^{re}2\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)\left(\alpha_g^{ex}-\alpha_g^{re}\right)\\&+\pi_{i,c}^{ex}\pi_{i,c}^{re}\left[\mathrm{var}\left(g_{i,c}^{ex}\right)-\mathrm{var}\left(g_{i,c}^{re}\right)+\left(g_{i,c}^{ex}-g_{i,c}^{re}\right)^2\left(1-2\pi_{i,c}^{ex}\right)\right]\left(\alpha_\tau^{ex}-\alpha_\tau^{re}\right)\end{aligned} \tag{C.15}$$

The last step is to take the historical average of this first order partial derivative to get equation 22 assuming here that the covariance $\mathrm{cov}\left(g_{i,c},g_{i,c'}\right)$ is not related to ϕ^{ex} consistently with the next Section D.

D. Definition of the Covariance of Growth

Using the definitions (4) and (5), growth during the cycle c in country i is

$$g_{i,c}\equiv\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\left(\sum_{s=1}^{\tau_{i,c}^{ex}}g_{i,c,s}^{ex}+\sum_{s=\tau_{i,c}^{ex}+1}^{\tau_{i,c}}g_{i,c,s}^{re}\right) \tag{D.1}$$

The covariance between $g_{i,c}$ and $g_{i,c'}$ is defined as

$$\mathrm{cov}\left(g_{i,c},g_{i,c'}\right)\equiv\mathrm{E}\left[\left(g_{i,c}-\mathrm{E}\left(g_{i,c}\right)\right)\left(g_{i,c'}-\mathrm{E}\left(g_{i,c'}\right)\right)\right] \tag{D.2}$$

where the expected value for growth is

$$\begin{aligned}\mathrm{E}\left(g_{i,c}\right) &= \mathrm{E}\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\left[\tau_{i,c}^{ex}\left(c_g^{ex}+F_{g,i}^{ex}+\alpha_g^{ex}\phi^{ex}\right)+\sum_{\int=1}^{\tau_{i,c}^{ex}}\gamma_g^{ph}X_{i,c,s}^{g}+\sum_{s=1}^{\tau_{i,c}^{ex}}\varepsilon_{i,c,s}\right.\\ &\left.+\tau_{i,c}^{re}\left(c_g^{re}+F_{g,i}^{re}+\alpha_g^{re}\phi^{ex}\right)+\sum_{s=\tau_{i,c}^{ex}+1}^{\tau_{i,c}}\gamma_g^{re}X_{i,c,s}^{g}+\sum_{\int=\tau_{i,c}^{ex}+1}^{\tau_{i,c}}\varepsilon_{i,c,s}\right]\end{aligned}$$

using the regressions (12). Then, the gap between $g_{i,c}$ and its expected value is the weigthed sum of shocks

$$g_{i,c}-\mathrm{E}\left(g_{i,c}\right)=\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\left(\sum_{s=1}^{\tau_{i,c}^{ex}}\varepsilon_{i,c,s}+\sum_{s=\tau_{i,c}^{ex}+1}^{\tau_{i,c}}\varepsilon_{i,c,\int}\right) \tag{D.3}$$

The covariance defined by (D.2) is then

$$\begin{aligned}\operatorname{cov}\left(g_{i,c},g_{i,c'}\right) &= \mathrm{E}\left[\left(\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\sum_{\int=1}^{\tau_{i,c}^{ex}}\varepsilon_{i,c,s}+\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\sum_{s=\tau_{i,c}^{ex}+1}^{\tau_{i,c}}\varepsilon_{i,c,\int}\right)\right.\\ &\left.\times\left(\frac{1}{\tau_{i,c'}^{ex}+\tau_{i,c'}^{re}}\sum_{s=1}^{\tau_{i,c'}^{ex}}\varepsilon_{i,c',s}+\frac{1}{\tau_{i,c'}^{ex}+\tau_{i,c'}^{re}}\sum_{s=\tau_{i,c'}^{ex}+1}^{\tau_{i,c'}}\varepsilon_{i,c',s}\right)\right]\end{aligned}$$

and

$$\begin{aligned}&\operatorname{cov}\left(g_{i,c},g_{i,c'}\right) \qquad \text{(D.4)}\\ &= \mathrm{E}\left[\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\frac{1}{\tau_{i,c'}^{ex}+\tau_{i,c'}^{re}}\sum_{s=1}^{\tau_{i,c}^{ex}}\varepsilon_{i,c,s}\sum_{\int=1}^{\tau_{i,c'}^{ex}}\varepsilon_{i,c',s}+\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\frac{1}{\tau_{i,c'}^{ex}+\tau_{i,c'}^{re}}\sum_{s=1}^{\tau_{i,c}^{ex}}\varepsilon_{i,c,\int}\sum_{s=\tau_{i,c'}^{ex}+1}^{\tau_{i,c'}}\varepsilon_{i,c',s}\right.\\ &\left.+\left(\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\frac{1}{\tau_{i,c'}^{ex}+\tau_{i,c'}^{re}}\sum_{s=\tau_{i,c}^{ex}+1}^{\tau_{i,c}}\varepsilon_{i,c,s}\sum_{s=1}^{\mathcal{T}_{i,c'}^{ex}}\varepsilon_{i,c',s}+\frac{1}{\tau_{i,c'}^{ex}+\tau_{i,c'}^{re}}\frac{1}{\tau_{i,c}^{ex}+\tau_{i,c}^{re}}\sum_{s=\mathcal{T}_{i,c}^{ex}+1}^{\tau_{i,c}}\varepsilon_{i,c,s}\sum_{s=\tau_{i,c'}^{ex}+1}^{\tau_{i,c'}}\varepsilon_{i,c',s}\right)\right]\end{aligned}$$

Since residuals $\varepsilon_{i,c,s}$ are assumed to be iid with a zero mean, they satisfy $\mathrm{E}\left(\varepsilon_{i,c,\int}\right)=\mathrm{E}\left(\varepsilon_{i,c',s}\right)=0$ with $\operatorname{cov}\left(\varepsilon_{i,c,s},\varepsilon_{i,c',s}\right)=0$, which imply $\operatorname{cov}\left(g_{i,c},g_{i,c'}\right)=0$ in (D.2).