LIST OF ABBREVIATIONS

AR1	Autoregressive of order 1
AR2	Autoregressive of order 2
ASEAN	Association of Southeast Asian Nations
BGP	Balanced growth path
CIA	Cash–in–advance
CPI	Consumer Price Index
CNTS	Cross–national time–series data
CRRA	Constant relative risk aversion
CRS	Constant returns to scale
CSV	Costly state verification
DGE	Dynamic General Equilibrium
ELG	Export–led growth
ESTAR	Exponential smooth transition autoregressive
FE	Fixed effects
FE-IV	Fixed effect instrumental variables
FGLS	Feasible generalised least squares
FOC	First order condition
GDP	Gross Domestic Product
GDPPC	Gross Domestic Product per capita
GMM	Generalised method of moments
IT	Inflation Targeting
IV	Instrumental variables
KOF	Konjunkturforschungsstelle
LHS	Left hand side
LSTAR	Logistic smooth transition autoregressive
MIMIC	Multiple indicators multiple causes
MIU	Money–in–utility function
MPK	Marginal product of Capital
MTE	Modified total electricity
OECD	Organisation for Economic Co–operation and Development

OLG	Overlapping generations
OLS	Ordinary Least Squares
PCA	Principal component analysis
PPP	Purchasing power parity
PWT	Penn World Tables
R&D	Research and Development
RE	Rational Expectations
RHS	Right hand side
SEM	Structural equation model
USD	United States dollar
WDI	World Development Indicators
WGI	World Governance Indicators

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CHAPTER 1 INTRODUCTION

> "It is no crime to be ignorant of economics, which is, after all, a specialized discipline and one that most people consider to be a 'dismal science'. But it is totally irresponsible to have a loud and vociferous opinion on economic subjects while remaining in this state of ignorance." - Murray N. Rothbard[1]

1.1 PROBLEM STATEMENT

The topics studied in this thesis are of importance to any economy, but more so to an emerging economy like South Africa. The thesis will not only aim to obtain optimal policy responses in the presence of such distortions (deviations from the traditional Neoclassical world), but will also analyse the effects of these distortions on the growth and welfare of the economy.

This thesis aims to study and report on specific findings related to specific conditions in the characterised economies, and does not attempt to provide clarity on all topics, however relevant these topics may be. We do not provide detailed limitations to this study here, but rather discuss these in the relevant chapters and specifically, in Chapter 6 where some concluding remarks are offered.

[1] *The Death Wish of the Anarcho–Communists* (1970)

1.2 RESEARCH OBJECTIVE AND QUESTIONS

1.2.1 Research Objective One

Using a standard overlapping generations monetary production economy, faced with endogenously determined tax evasion by heterogeneous agents in the economy, we provide a theoretical model that indicates that both a lower (higher) level of financial development and a higher (lower) level of inflation leads to a bigger (smaller) shadow economy. These findings are empirically tested within a panel econometric framework, using data collected for 150 countries over the period 1980 – 2009 to enable a broad generalisation of the results. The results support the developed theoretical model, even after having accounted for the differences in the levels of economic development, the level of institutional quality that includes different tax regimes and regulatory frameworks, central bank participation in the economy as well as different macroeconomic policies.

1.2.2 Research Objective Two

Conventional models of social status purport a positive inflation-growth relationship, and attribute this empirical contradiction to the presence of a consumer's desire for social status. These models are dominated by a substitution effect of money holdings for capital holdings, as an increase in the inflation rate due to money growth raises the cost of holding money and depresses the real money holdings. Using a monetary endogenous growth model, the effects of wealth-induced social status on long-run growth is reconsidered. The analysis is enhanced through the addition of a competitive banking sector that intermediates the available capital in the economy, subject to a mandatory cash reserve requirement. The cash reserve requirement creates a wedge between the deposit rate and the loan rate. While the real loan rate is tied with the constant marginal product of capital, the real deposit rate is negatively related to the rate of inflation. This leads to another, opposing substitution effect of deposit holdings for real money holdings and hence, increases the cost of holding deposits as inflation increases. The consolidated theoretical model described herein supports a diverse range of theoretical findings, contingent on the presence of wealth effects or the spirit of capitalism, using a simpler and more tractable framework that accounts for the role of the banking system in monetary policy decision outcomes. Significantly, as long as the mandatory reserve requirement imposed on the banking system by the monetary authority exceeds a (small) critical value, an increase in the money growth rate will lead to a decrease in the long-run growth rate of the economy.

1.2.3 Research Objective Three

Using an augmented two-sector endogenous growth model for a small, open economy characterised by human capital accumulation and productive government expenditure, we analyse the nature of the relationship between openness and growth. External openness enters the human capital accumulation function directly. Productive government expenditure affects human capital accumulation, relying on seigniorage revenue as finance where seigniorage is itself dependent on the level of openness. The findings indicate two, opposing effects of openness on growth - a direct effect of openness on growth through knowledge spillovers that affect human capital accumulation, and an indirect effect of decreasing seigniorage revenue on growth through decreasing productive government expenditure on human capital. We discuss conditions under which the openness-growth curve can be concave/convex, without specifying theoretical functional forms or values to unknown parameters in the model to provide concise theoretical results. Rather, drawing samples of exact model-match countries over 1980 – 2011, we rely on a semi-parametric, data-driven empirical approach to provide empirical impetus to the theoretical outcomes reported. We show the relationship between openness and growth is non-linear. Specifically, inverted U–shaped. The results suggest that openness only has a positive impact on the growth-rate until a certain threshold–level, thereafter, the effect is negative.

1.2.4 Research Objective Four

We implement two different monetary policies – an inflation targeting policy as well as a cash reserve requirement – in a monetary endogenous growth overlapping generations model characterized by production lags and analyse the growth dynamics that emerge from this framework. The growth process is endogenized by allowing productive government expenditure on infrastructure, complementing the lagged private capital input. In the presence of these monetary policies, we show that multiple equilibria emerge along different growth paths, with the low-growth (high-growth) equilibrium being unstable (stable) and locally determinate (locally indeterminate). In addition, we highlight the possibility of convergent or divergent endogenous fluctuations and even topological chaos around the high-growth equilibrium in the growth path where the monetary authority follows a high inflation targeting regime.

Conversely, when the monetary authority follows a low inflation targeting regime, oscillations do not occur around either the low-growth or high-growth equilibrium. Moreover, a strictly non-negative cash reserve requirement is a necessary and sufficient condition to initiate the growth process.

1.3 RESEARCH CONTRIBUTION

1.3.1 Research Contribution One

Using a monetary OLG stochastic production economy, characterised by endogenous tax evasion, we provide a novel theoretical explanation that both lower financial sector development as well as higher inflation (as proxied through the money growth rate) leads to a bigger shadow economy, and; second, with the theoretical analysis presented yielding an empirically-testable equation (albeit not in the sense of a one-to-one correspondence) relating tax evasion with financial development and inflation, we test the validity of the theoretical implications using a panel of 150 countries for the period 1980 to 2009, based on a newly-constructed dataset of shadow economy estimates by Elgin and Öztunali (2012).

To the best of our knowledge, this chapter is a first attempt at providing a simultaneous theoretical explanation of how both (lower) financial development and (higher) inflation may lead to (higher) tax evasion and therefore, to the observance of a (bigger) shadow economy, and also empirically corroborates the theoretical claims.

1.3.2 Research Contribution Two

We provide a novel and simple explanation of the effects of monetary growth on economic growth that is empirically consistent in the face of the mixed evidence on the inflation–growth nexus.

To our knowledge, the model presented is the first attempt at explaining how the money growth rate together with cash reserve requirements – in a similar vein as the reserve requirement coordinating arrangement proposed by Barnett (2005) – affect the outcome of an endogenous monetary model in the presence of the spirit of capitalism or wealth–induced social status. More specifically, this chapter brings the importance of the banking literature, especially cash reserve requirements, to bear upon the inflation–growth relationship, which in the presence of social status in an endogenous growth model was found to be positive and hence, inconsistent with the empirical literature. In other words, through the explicit modelling of the banking sector in an otherwise standard endogenous growth model with spirit of capitalism, we are able to obtain the empirically consistent negative relationship between growth and inflation under certain very plausible conditions on the cash reserve requirements.

1.3.3 Research Contribution Three

Contrary to the assertion by von Mises (1919) in his influential political economy works, almost 100 years on the empirical evidence on the relationship between general openness and economic growth remains mixed, at best.

Against this backdrop, the objectives of this chapter are twofold: First, we use a two–sector Lucasian (1988) (human capital) endogenous growth model applied to a small, open economy characterized by *productive* government expenditure and external openness in the human capital accumulation function, to provide a novel and consolidated theoretical explanation of the existence of such a non–linear relationship between openness and growth; and, second, with the theoretical analysis presented yielding an empirically–testable equation relating openness with human capital and economic growth, we test the validity of the theoretical implications using a panel of 176 countries for the period 1980 – 2012 combining semi–parametric methods in the vein of Vaona and Schiavo (2007) with a spline regression function in the vein of Verardi and Dibarsy (2012). We augment this combined analysis with the inclusion of a new index of openness constructed by Dreher (2006).

1.3.4 Research Contribution Four

From the perspective of inflation targeting monetary policy, our theoretical results in this chapter have very important implications. While gestation lags are part of any production process, irrespective of whether we consider either developed or developing economies, they are of greater importance and more likely to occur in the latter set of countries. Hence, our model is perhaps more evident of developing nations pursuing inflation targeting monetary policy, contingent on production lags in the investment process.

Consequently, we show that central banks in developing countries should be exceptionally careful in deciding on their inflation targets. Inflation targets should be chosen based on the structural parameters of the model, and independent of any pressure from groups, such as the labour unions. Under external pressures, it is more likely that the inflation target will be relatively less stringent, and likely to be higher. As we show, in such a scenario, uncertain growth dynamics like fluctuations and even chaos are likely to emerge. What is of even greater concern is that these uncertain fluctuations will occur around the high-growth path; which, though indeterminate, is the stable equilibrium.

1.4 OVERVIEW OF STUDY

This thesis was compiled from four different research papers, all of which have been prepared as original research work and have been submitted to various peer–reviewed academic journals. Three of these papers have been published, with the fourth currently under Revise and Resubmit.

Chapter One provides the broad introduction to this thesis. In Chapter Two, the theoretical and empirical analysis and findings on Research Objective One is presented. Chapter Three details the theoretical work in support of Research Objective Two. Both the theoretical and empirical analysis focussed on Research Objective Three is included in Chapter Four. Chapter Five contains the last of the research papers, in support of Research Objective Four.

Concluding remarks are presented in Chapter Six of this thesis.

CHAPTER 2 TAX EVASION, FINANCIAL DEVELOPMENT AND INFLATION: THEORY AND EMPIRICAL EVIDENCE

[1]

2.1 INTRODUCTION

"To think of shadows is a serious thing." - Victor Hugo[2]

Recent empirical evidence provided by Bose, Capasso and Wurm (2012) show that an improvement in the development of the banking sector is associated with a smaller shadow economy. The findings of Bose et al. (2012) corroborate indicative theoretical results reported by Blackburn, Bose and Capasso (2012) that a less-developed financial sector corresponds to the observance of a bigger shadow economy. Blackburn et al. (2012) studied the relationship between the underground economy and financial development in a model of tax evasion and bank intermediation. In their model, agents with heterogeneous skills seek loans in order to undertake risky investment projects, with asymmetric information between borrowers and lenders implying a menu of loan contracts that induce self-selection in a separating equilibrium. Given these contracts, agents choose how much of their income

[1] This chapter has been published as: Bittencourt, M., Gupta, R., and Stander, L. (2014). Tax evasion, financial development and inflation: Theory and empirical evidence. *Journal of Banking and Finance*, 41, 194-208. We would like to thank two anonymous referees for many helpful comments that tremendously improved the quality of the paper. However, any remaining errors are solely mine.

[2] *Les Misérables* (1862)

to declare by trading off their incentives to offer collateral against their disincentives to comply with tax obligations. The main implication of the analysis is that the marginal net benefit of income disclosure increases with the level of financial development. Thus, as with the empirical observation made by Bose et al. (2012), the paper shows that the lower is the stage of such development, the higher is the incidence of tax evasion and the greater is the size of the underground economy. Furthermore, Gupta and Ziramba (2010) using an overlapping generations (OLG) monetary endogenous growth model, whereby government transfers affect young-age income, show that inflation - besides the usual suspects like fiscal policy (Dabla-Norris and Feltenstein, 2005), penaly rates (Schneider, 1994), probability of being detected (Schneider and Enste, 2000) and degree of corruption (Cerqueti and Coppier, 2011) - affect the degree of tax evasion. Specifically, they indicate a negative relationship between inflation and the fraction of income reported.

Against this backdrop, the objectives of this paper are twofold: First, using a monetary OLG stochastic production economy, characterised by endogenous tax evasion, we provide a novel theoretical explanation that both lower financial sector development as well as higher inflation (money growth rate) lead to a bigger shadow economy, and; second, with the theoretical analysis presented yielding an empirically-testable equation (albeit not in the sense of a one-to-one correspondence) relating tax evasion with financial development and inflation, we test the validity of the theoretical implications using a panel of 150 countries for the period 1980 to 2009, based on a newly-constructed dataset of shadow economy estimates by Elgin and Öztunali (2012).[3] To the best of our knowledge, this paper is not only the first attempt at providing a simultaneous theoretical explanation of how both (lower) financial development and (higher) inflation may lead to (higher) tax evasion and therefore, to the observance of a (bigger) shadow economy,[4] but also empirically corroborate the theoretical claims.

At this stage, it is important to put into context the importance of our theoretical result that monetary

[3]Note that the shadow economy estimates of Elgin and Öztunali (2012) is obtained from a calibrated dynamic general equilibrium model for various countries over different periods.

[4]We concede that tax evasion and shadow economy are not necessarily synonymous, but contend that measures of the shadow economy are systematically used in the literature as a proxy for the level of tax evasion (Alm, 2012). The use of tax evasion as a substitute for the shadow economy also resonates with the adopted definition of the shadow economy in this paper, and facilitates the theoretical approach followed. Moreover, following Gupta (2005) it can be shown that $\frac{TE}{Y} = SE * \tau$, where $\frac{TE}{Y}$ is tax evasion as a percentage of gross domestic product (GDP), SE is a measure of the shadow economy and τ is a parameter measuring taxes paid as a percentage of GDP.

policies (money growth rate and cash-reserve requirements held by financial intermediaries[5]) could also affect the level of tax evasion. Gupta (2008) and Gupta and Ziramba (2009) point out that studies (such as Roubini and Sala-i-Martin (1995), Gupta (2005) and Holman and Neanidis (2006)) which analyse optimal (growth- and/or welfare-maximising) mix of fiscal policy and monetary policy suffer from the Lucas (1976) critique, by treating tax evasion exogenously. Gupta (2008) and Gupta and Ziramba (2009) reached such conclusions by developing growth models with tax evasion being a behavioural decision (as also pointed out theoretically by Atolia (2003), Chen (2003) and Arana (2004)) to indicate that the level of tax evasion is dependant on the tax and penalty rates. Given this, following a change in the degree of tax evasion, the tax and the penalty rates are not available to the policy maker to respond optimally to such a change, since clearly changes in these policy variables would affect the level of tax evasion further. Thus, Gupta (2008) and Gupta and Ziramba (2009) study optimal monetary policy response following changes in the degree of tax evasion emanating from not only movements in the structural parameters of the model, but also variations in the tax and penalty rates.[6] Now, with tax evasion also affected by monetary policy, it would imply that the studies of Gupta (2008) and Gupta and Ziramba (2009) are not immune to the Lucas (1976) critique either. In summary, studies that analyse optimal (growth- and/or welfare-maximising) monetary policy and fiscal policy following a change in the degree of tax evasion are likely to lead to non-optimal policy outcomes, since changes in the policy parameters in response to the change in the level of tax evasion (arising from changes in the structural parameters affecting the degree of evasion) would change the degree of tax evasion further.

The rest of the paper is organised as follows: Section 2.2 describes the economic setting for our analysis; Sections 2.3 and 2.4, respectively, defines the competitive equilibrium, solves the model for the optimal degree of the shadow economy and discusses the empirical evidence obtained from our dataset against the current background to the observance of the shadow economy.

[5]Note that, the cash-reserve requirements have been long viewed as a measure of financial repression, since higher the cash reserve requirements, lesser the loans available to a bank to lend out for investment/production purposes. For a detailed discussion along these lines, refer to Gupta (2005, 2008) and Gupta and Ziramba (2009, 2010).

[6]See Koreshkova (2006) for a similar analysis relating inflation and the underground economy, where the shadow economy is modelled by distinguishing between a formal and informal production structure, instead of endogenous tax evasion.

2.2 THE ECONOMIC SETTING

Time is divided into discrete segments and indexed by $t = 1, 2, \ldots$. The principal economic activities are: (i) entrepreneurs who live for two periods, receive a positive young-age endowment of W_1 and consume only when old. When the cost of undertaking an investment project exceeds the current endowment of entrepreneurs, they require external finance. To obtain the external finance, entrepreneurs have to offer collateral to the banks and thus have to decide what portion of their income to declare in order to increase the probability of obtaining external finance. This external finance is provided by the banks according to the terms and conditions of optimal loan contracts; (ii) each two-period lived overlapping generations depositor receives a young-age endowment of $0 \leq W_2 \leq 1$ and an old-age endowment of $0 \leq W_3 \leq 1$. The depositors consume in both periods. The young-age consumer evades a portion of the tax-liability, with the tax evasion being determined endogenously to maximize utility, and the remainder is allocated either towards young-age consumption or deposited in the banks, for future old-age consumption; (iii) the banks operate in a competitive environment and perform a pooling function by collecting the deposits from the consumers and lending it out to the entrepreneurs after meeting an obligatory cash reserve requirements; and (iv) there is an infinitely-lived consolidated government which meets its non-productive expenditure by taxing income, generating seigniorage income and setting a penalty for tax evasion when caught. The government also controls its two main policy instruments, namely money growth rate and the reserve requirement. The government balances its budget on a period-by-period basis. There is a continuum of each type of economic agent with unit mass.

We introduce ex-post moral hazard into the economy due to banks facing a costly state verification (CSV) problem since entrepreneurs can declare bankruptcy even when they are not. The principal outcome of those investment projects of the entrepreneurs, financed via bank loans, is essentially private information to the entrepreneur. If banks are willing to incur some monitoring cost, they can observe the same outcome. Note that the size of CSV is used here as a "proxy" for the efficiency of the financial system. In line with Di Giorgio (1999) and Gupta (2005), it is reasonable to assume that a more developed financial system will have a lower CSV.

2.2.1 Entrepreneurs

Entrepreneurs live for two periods, receive an initial endowment of W_1, undertake some type of investment and only consume in the second period. They have access to a simple investment technology such that by investing one unit of the consumption good at t, either $\alpha > 1$ units are produced at $t+1$ with probability of q or 0 units are produced with probability of $1-q$. Capital investment undertaken by the entrepreneur, K_t, is limited by the availability of funding to the entrepreneurs. Hence:

$$K_t = W_1 + l_t \tag{2.1}$$

where $l_t = \frac{L_t}{p_t}$ and L_t is the nominal quantity of loans that entrepreneurs can obtain from the banks. If the investment activity of the entrepreneur is successful, the cost of external finance obtained at time point t that is repaid to the bank, is a gross interest rate of $1+i_{lt+1}$. If the investment activity is not successful, resulting in the entrepreneur declaring bankruptcy, nothing is repaid to the bank. The level of output produced by the entrepreneur at time point $t+1$ with probability q, is then:

$$y_{t+1} = \alpha K_t \tag{2.2}$$

or 0 with probability $1-q$. Thus, the entrepreneur's consumption in the second period, C^e_{t+1} depends on the initial endowment of W_1; the yield of the investment, α; the cost of the external finance obtained from the banks, $1+i_{lt+1}$ and the probability of success, q. Taking $1+\pi_{t+1} = \frac{p_{t+1}}{p_t}$, the gross inflation rate and replacing ((2.1)) into ((2.2)), the entrepreneur's problem is precisely defined as:

$$C^e_{t+1} = \alpha(W_1 + l_t) - (1+i_{lt+1})\frac{l_t}{1+\pi_{t+1}} \tag{2.3}$$

with probability of q or

$$C^e_{t+1} = 0 \tag{2.4}$$

with probability of $1-q$. As the outcome of the entrepreneur's problem is intertwined with the outcome of the bank's problem, the problem will not be explicitly solved here but rather as part of the bank's problem.

2.2.2 Depositors

All depositors have the same preferences, so there is a representative agent in each period. Depositors receive an initial young-age endowment of W_2 and an old-age endowment of W_3, respectively. Both age-type endowments obey $0 \le W_2, W_3 \le 1$, and we assume that $\sum_{i=1}^{3} W_i = 1$. Thus, at time point t, there are two coexisting generations of young-age and old-age depositors. N people are born at each time point $t = 1$. At time point $t = 1$, there exist N people in the economy called the initial old, who live for only one period and at each time point $t = 1$, N people are born (the young generation) and N people are beginning the second period of their life (the old generation). Note, the population N here is assumed to be constant, therefore N is normalized to 1.

The government sets a tax of rate τ on the young-age endowment received by the depositor, which can be evaded - at a cost[7] - with a given probability of σ. Thus, for the potential evader, there exists the possibility of two tax states: 'success' (getting away with evasion) or 'failure' (being discovered and incurring a penalty) with the probability of $1-\sigma$. The depositor knows *ex-ante* the probability of getting caught, $1-\sigma$ and the size of the penalty, θ but cannot avoid or insure against the risk of being caught. Let β_t be the fraction of income evaded in period t and let τ be the income tax rate at t. If the evader is discovered of evading an amount of income equal to $\beta_t W_2$, then the depositor has to pay a penalty on the unreported income in the same period t, but at a rate of θ, where $\theta > \tau$. So on receiving the endowment and in order to maximise his utility, the young-age depositor decides on: his consumption in both periods; β_t, the fraction of income to evade as well as d_t, the amount deposited at the bank (or his savings decision). After making his decisions, the *ex-post* tax state is revealed to the depositor. If the tax state is 'failure', the penalty is paid out of his savings.

Formally, the depositor must solve the following two-period problem:

$$\max_{c_{yt},\beta_t,d_t,c^1_{ot+1},c^2_{ot+1}} U = u(c_y) + \rho\sigma u(c^1_{ot+1}) + \rho(1-\sigma)u(c^2_{ot+1}) \tag{2.5}$$

subject to:

$$p_t c_{yt} + p_t d_t \leq [\beta_t + (1-\beta_t)(1-\tau)]p_t W_2 \tag{2.6}$$

$$p_{t+1}c^1_{ot+1} \leq (1+i_{dt+1})[d_t - \delta W_2]p_t + p_{t+1}W_3 \tag{2.7}$$

$$p_{t+1}c^2_{ot+1} \leq (1+i_{dt+1})[d_t - \theta\beta W_2 - \delta W_2]p_t + p_{t+1}W_3 \tag{2.8}$$

$$0 \leq \beta_t \leq 1 \tag{2.9}$$

where $u(.) = log(.)$; $1+i_{dt+1}$ is the gross nominal interest rate received in period t on deposits held by the banks; d_t are real deposits; c_{yt} is real young-age consumption; c^1_{ot+1} and c^2_{ot+1} is real old-age

[7]The cost of evasion is not limited to only paying a penalty imposed by the government when the evader is caught, but it also includes cost of possible litigation, being excluded from certain public goods and even some social cost being regarded as a tax evader. For this model, however we will only consider a penalty as imposed by the government. The transaction cost that evading households incur, like hiring legal representatives or paying bribes to officials (Gupta and Ziramba, 2009) is accounted for through the depositor's old-age consumption function.

consumption in tax states 'success' or 'failure', respectively; ρ is the discount factor and δ represents the transaction cost that households incur to evade taxes. For clarity, (2.6) is the feasible first-period budget constraint, while (2.7) and (2.8) are the second-period budget constraint in the tax state where the depositor evades taxes successfully and where the depositor is discovered and incurs a penalty, respectively. The constraint in (2.9) is self-evident. In equilibrium, budget constraints (2.6) to (2.8) hold with equality since the depositor's utility function is increasing in consumption in each period. We define $1 + r_{dt+1} = \frac{1+i_{dt+1}}{1+\pi_{t+1}}$ as being the gross real interest rate on deposits held at banks. Solving the depositor's two-period utility maximisation problem yields the following first-order conditions (FOC):

$$d_t : u'(c_{yt}) = \rho(1 + r_{dt+1})[\sigma u'(c^1_{ot+1}) + (1 - \sigma)u'(c^2_{ot+1})] \tag{2.10}$$

$$\beta_t : \tau_t u'(c_{yt}) \le \rho\theta_t(1 - \sigma)[1 + r_{dt+1}]u'(c^2_{ot+1}) \tag{2.11}$$

$$\tau_t u'(c_{yt}) = \rho\theta_t(1 - \sigma)[1 + r_{dt+1}]u'(c^2_{ot+1})$$

$$\tau_t u'(c_{yt}) \ge \rho\theta_t(1 - \sigma)[1 + r_{dt+1}]u'(c^2_{ot+1})$$

for $\beta_t = 0$, $0 \le \beta_t \le 1$ and $\beta_t = 1$, respectively. From the series of first order conditions for β_t in (2.11), the left-hand side of the equation represents the marginal benefit of tax evasion and the right-hand side the marginal cost of tax evasion. The FOC's for the depositor imply that when the marginal cost of tax evasion exceeds the marginal benefit, there is no incentive for tax evasion so that $\beta_t = 0$. Conversely, when the marginal benefit of tax evasion exceeds the marginal cost, there is no incentive to declare any income so that $\beta_t = 1$. When the marginal benefit of tax evasion is equal to the marginal cost of tax evasion, there exist a range of plausible tax evasion parameters, such that $0 \le \beta_t \le 1$. However, for this interior solution to realise, it is required that $\tau_t > \theta_t(1 - \sigma)$ or that the regular tax rate is higher than the prospective penalty[8].

2.2.3 Financial intermediaries

There exist a finite number of risk-neutral banks in this economy,[9] which we assume to behave competitively and are all subject to an obligatory cash reserve requirement, γ_t set by the government.

[8] Both Atolia (2009) and Sandmo (2012) provide a detailed account for this requirement.

[9] There are two specific reasons as to why banks exist: (i) Banks competitively provide a simple pooling function along the lines described in Bryant and Wallace (1980), since we assume that capital is illiquid and is created in large minimum denominations; and (ii) We also assume that it is relatively more cost-effective for the banks to design contracts for the verification of the state of the firms than for the individual consumers/depositors.

This assumption assures that all banks levy the same cost on their loans, the gross nominal interest rate of $1 + i_{lt}$. In each period t, banks accept deposits and extend loans to risk-neutral entrepreneurs, subject to γ_t with the goal of maximising their profits. A simplifying assumption that deposits are one-period contracts assures a gross nominal deposit rate of $1 + i_{dt}$. Banks receive interest income from loans to entrepreneurs and meet their interest obligations to depositors at the end of the period. Because entrepreneurs have an incentive to declare bankruptcy even if their investment projects are successful, banks face a costly state verification problem, and hence offer a financing contract to entrepreneurs detailing the conditions of intermediation. Part of the conditions is that monitoring will take place if bankruptcy is declared. It is assumed that banks adopt a stochastic monitoring technology *à la* Bernanke and Getler (1989).

We denote λ as the number of times a misreporting entrepreneur can be discovered, with V the corresponding punishment. We use the revelation principle[10] to derive the optimal solution to the following financial contract based on the given structure. Formally, banks wish to maximise the following profit function:

$$\max_{i_l,L,V} \Pi_{Bt} = \frac{P_{t-1}}{P_t}[q(1+i_{lt})l_{t-1} + m_{t-1} - \lambda(1-q)cl_{t-1} - (1+i_{dt})d_{t-1}] \tag{2.12}$$

subject to:

$$l_{t-1} + m_{t-1} \leq d_{t-1} \tag{2.13}$$

$$m_{t-1} \geq \gamma_{t-1}d_{t-1} \tag{2.14}$$

$$q[p_t\alpha(W_1 + l_{t-1}) - p_{t-1}(1+i_{lt})l_{t-1}] \geq p_t q\alpha W_1 \tag{2.15}$$

$$q[p_t\alpha(W_1 + l_{t-1}) - p_{t-1}(1+i_{lt})l_{t-1}] \geq qp_t[\alpha(W_1 + l_{t-1}) - \lambda V] \tag{2.16}$$

$$p_t V \leq p_t\alpha(W_1 + l_{t-1}) \tag{2.17}$$

$$0 \leq \lambda \leq 1 \tag{2.18}$$

where Π_{Bt} is the bank's profit at time point t; l_{t-1} is loans provided to entrepreneurs in period $t-1$; m_{t-1} is the bank's holding of fiat money; c is the bank's proportional cost for the monitoring technology and d_{t-1} is the deposits held by depositors at the bank in period $t-1$. The constraints (2.13) to (2.18) are explained as follows: (2.13) is the feasibility condition in order for the bank to satisfy its balance sheet; (2.14) is the legal reserve requirement obligating the bank's holding of fiat money; the 'participation constraint' ensuring that entrepreneurs accept the financing contract is given by (2.15); (2.16) is the

[10]This induces entrepreneurs to truthfully report the outcome of their investment activity to the bank, as it is not more profitable to misreport the outcome, as reported in more detail in Myerson (1979).

'incentive constraint' compelling entrepreneurs to not misreport the outcome of successful investment activities; (2.17) is the 'limited liability' constraint imposing a maximum penalty on entrepreneurs who misreport. Again, (2.18) is self-evident.

Solving the optimal contract for the financial intermediary requires (2.15) to be binding, leading to $\alpha = \frac{1+i^*_{lt}}{1+\pi_t}$. Incentive compatibility in (2.16) then requires $\lambda V = \alpha l_{t-1}$. Since the profit of the bank, Π_{Bt} decreases as monitoring increases, banks will set λ to its minimum such that (2.16) holds. Consequently, $0 < \lambda^* < 1$ and V is then set to its maximum, which from (2.17) implies that $V^* = \alpha(W_1 + l_{t-1})$. This also ensures that (2.18) is binding. Then, assuming that entrepreneurs have no incentive to misreport because misreporting the actual outcome of the investment activity does not yield a higher expected profit to the entrepreneur, we ensure that (2.16) is binding and $\lambda^* = \frac{l^*_{t-1}}{W_1+l^*_{t-1}}$. A competitive banking sector is characterised by free entry, which drives profits to zero. Thus, in equilibrium, based on the zero profit condition and that banks loan out all their available resources when $\alpha q > c$, we have that (2.13) and (2.14) also bind and hence, $l^*_{t-1} = (1-\gamma_{t-1})(d_{t-1})$. Besides from being an equilibrium condition, this also highlights the repressive nature of the obligatory reserve requirement in that it leads to sub-optimal functioning of the financial intermediary market.

So, given that $\alpha q > c$, the optimal financing contract is summarised as:

$$
\begin{aligned}
(i) &\quad l^*_{t-1} = (1-\gamma_{t-1})d_{t-1} \\
(ii) &\quad \alpha^* = \frac{1+i^*_{lt}}{1+\pi_t} \\
(iii) &\quad \lambda^* = \frac{l^*_{t-1}}{W_1 + l^*_{t-1}} \\
(iv) &\quad V^* = \alpha^*(W_1 + l^*_{t-1})
\end{aligned}
$$

2.2.4 Government

An infinity-lived consolidated government purchases g_t units of consumption goods, and government expenditure is assumed to be non-productive. The government finances its consumption expenditure through the collection of taxes, seigniorage income and penalty income that it levies on the unsuccessful depositor evading taxes. The government budget constraint is formally given by:

$$g_t = (1-\beta_t)\tau_t W_2 + \frac{M_t - M_{t-1}}{p_t} + (1-\sigma)\theta_t\beta_t W_2 \tag{2.19}$$

with the first part being the tax income, the second part being the seigniorage income (or inflation tax) in real terms and the third part being the penalty income it collects. Following Del Monte and Papagni (2001), we assume that the cost of monitoring tax evasion, say $(1-\sigma)vW_2$, exactly offsets the penalty income derived from the evasion described in the third part of (2.19), so that the government budget constraint reduces to:

$$g_t = (1-\beta_t)\tau_t W_2 + \frac{M_t - M_{t-1}}{p_t} \tag{2.20}$$

for simplicity. Also note that money evolves according to the following rule, $M_t = \mu_t M_{t-1}$ with μ_t the gross growth rate of money and $M_t = \gamma_t D_t$.

2.3 EQUILIBRIUM

A competitive equilibrium for this economy is defined as a sequence of prices $\{i_{lt}, i_{dt}, p_t\}_{t=0}^{\infty}$, allocations $\{c_{yt}, c_{ot+1}^1, c_{ot+1}^2, \beta_t, d_t\}_{t=0}^{\infty}$ as well as policy variables $\{\tau_t, \gamma_t, \theta_t, \mu_t, g_t\}_{t=0}^{\infty}$ such that:

- Given τ_t, θ_t, i_{dt} and $W_{i=1}^3$, the depositor optimally chooses β_t and savings, d_t;
- The equilibrium money market condition, $m_t = \gamma_t d_t$ holds for all $t \geq 0$;
- The loanable funds market equilibrium condition, $i_{lt} = \frac{i_{dt}}{(1-\gamma_t)}$ given the total supply of loans $l_t = (1-\gamma_t)d_t$, holds for all $t \geq 0$;
- Banks maximise profits subject to i_{lt}, i_{dt} and γ_t;
- The equilibrium resource constraint, $y_t - \lambda(1-q)cl_t = c_t + i_t + g_t$ holds for all $t \geq 0$, where $c_t = c_{yt} + qc_{ot+1}^1 + (1-q)c_{ot+1}^2 + C_{t+1}^e$ and $y_t = \sum_{i=1}^3 W_i$;
- The government budget constraint in (2.20) is balanced on a period-by-period basis;

- and d_t, m_t, i_{lt}, i_{dt} and p_t are positive for all periods.

2.4 SOLVING THE MODEL FOR THE STEADY STATE DEGREE OF SHADOW ECONOMY

Taking the equilibrium conditions for this economic setting and imposing steady-state on the economy, thus no growth in the economy, we allow the government to follow time-invariant policy rules such that τ_t, γ_t, θ_t and μ_t are all constant over time and realising that in equilibrium $\pi = \mu$, or that the money growth rate equals the inflation rate, we yield a series of equations that allow us to solve the steady state model.

The depositor's optimisation solution essentially yields two equations: one for d^*, the steady state size of deposits in real terms and one for β^*, the steady state tax evasion parameter (or the steady state size of the shadow economy). Formally:

$$d^* = \frac{[(1+\rho)\tau - \theta(1+\rho(1-\sigma))][W_3 + \delta(1+r_d)W_2] + (1+r_d)W_2(\theta\rho\sigma(1-\tau))}{(1+r_d)(1+\rho)(\theta-\tau)} \tag{2.21}$$

and

$$\beta^* = \frac{\rho(\tau - \theta(1-\sigma))[W_3 + (1+r_d)W_2(1-\delta-\tau)]}{(1+r_d)W_2(1+\rho)(\theta-\tau)\tau} \tag{2.22}$$

From (2.5) it is also verified that $\frac{\partial^2 U}{\partial d} < 0$ and $\frac{\partial^2 U}{\partial \beta} < 0$, to ensure that both solutions are in fact, a maximum. It is evident from both (2.21) and (2.22) that the depositor's inter-temporal decision between making real deposits and evading taxes depends somewhat on $1 + r_d$, the gross real rate on deposits held at banks, besides from the real factors like θ, the penalty rate imposed by government when agents are caught evading taxes, τ, the tax rate imposed by government on the young-age endowment and σ, the probability of successfully evading taxes. Therefore, to understand the shadow economy behaviour in this setting it is crucial to understand exactly how $1 + r_d$ impacts the agent's tax evasion and savings decisions.

Firstly, we evaluate how both the real deposits and the fraction of income evaded change with observed changes in $1+r_d$. For β^* we have:

$$(i) \quad \frac{\partial \beta^*}{\partial r_d} : -\frac{W_3\rho(\tau-(1-\sigma)\theta))}{(1+r_d)^2(1+\rho)(\theta-\tau)} < 0$$

since $\tau > (1-\sigma)\theta$ was required to hold in order to obtain an interior solution for β^*, and for d^* we have:

$$(ii) \quad \frac{\partial d^*}{\partial r_d} : \frac{W_3[\theta(1+\rho(1-\sigma))-\tau(1+\rho)]}{(1+r_d)^2(1+\rho)(\theta-\tau)} > 0$$

since $\theta > \tau$. Thus, in line with *a priori* expectation, β^* decreases with an increase in $1+r_d$ and the size of real deposits, d^* increases with an increase in $1+r_d$.

Secondly, from the bank's profit maximisation problem, we have:

$$1+r_d = q\alpha(1-\gamma)+\frac{\gamma}{1+\mu}-\frac{\lambda c(1-q)(1-\gamma)}{1+\mu} \tag{2.23}$$

where inflation has been set equal to the money growth rate, μ and λ is a function of $1+r_d$ itself through the real deposits, d^*. From the optimal financing contract and substituting the loanable funds market equilibrium condition into the expression for λ^*, we have:

$$\lambda^* = \frac{(1-\gamma)d^*}{W_1+(1-\gamma)d^*} \tag{2.24}$$

which together with both (2.21) and (2.23) yields an explicit expression for the gross real rate on deposits to analyse how financial development, which here is captured by both costly state verification c and λ, as well as inflation through μ, impact on the shadow economy in this model. Formally:

$$1+r_d = q\alpha(1-\gamma)+\frac{\gamma}{1+\mu}-\left[\frac{(1-q)c(1-\gamma)}{1+\mu}\right]\left[\frac{(1-\gamma)d^*}{W_1+(1-\gamma)d^*}\right] \tag{2.25}$$

From (2.23) it should be evident that $1+r_d$ is decreasing in c, the bank's monitoring cost parameter. However, to graphically illustrate the impact of the bank's monitoring cost on $1+r_d$, we decompose $1+r_d$ into two parts and then map the decomposed (2.23) in Figure 2.1.

The slope - and hence the shape - of the function is determined by the rate of change in λ. Near the zero bound interest rate, or where $1+r_d$ approaches 0, the slope of the function approaches ∞ and as $1+r_d$ approaches ∞, the slope of the function approaches 0. The function is therefore concave, increasing in $1+r_d$, but at a decreasing rate.

Here $c_2 > c_1$, F is the intercept representation of the function and G_1, G_2 is the slope representation of $1+r_d$ corresponding with the increase from $c_1 \to c_2$, respectively. As the banks' monitoring cost increases, there is a downward movement from G_1 to G_2 as the value of the slope increases. This

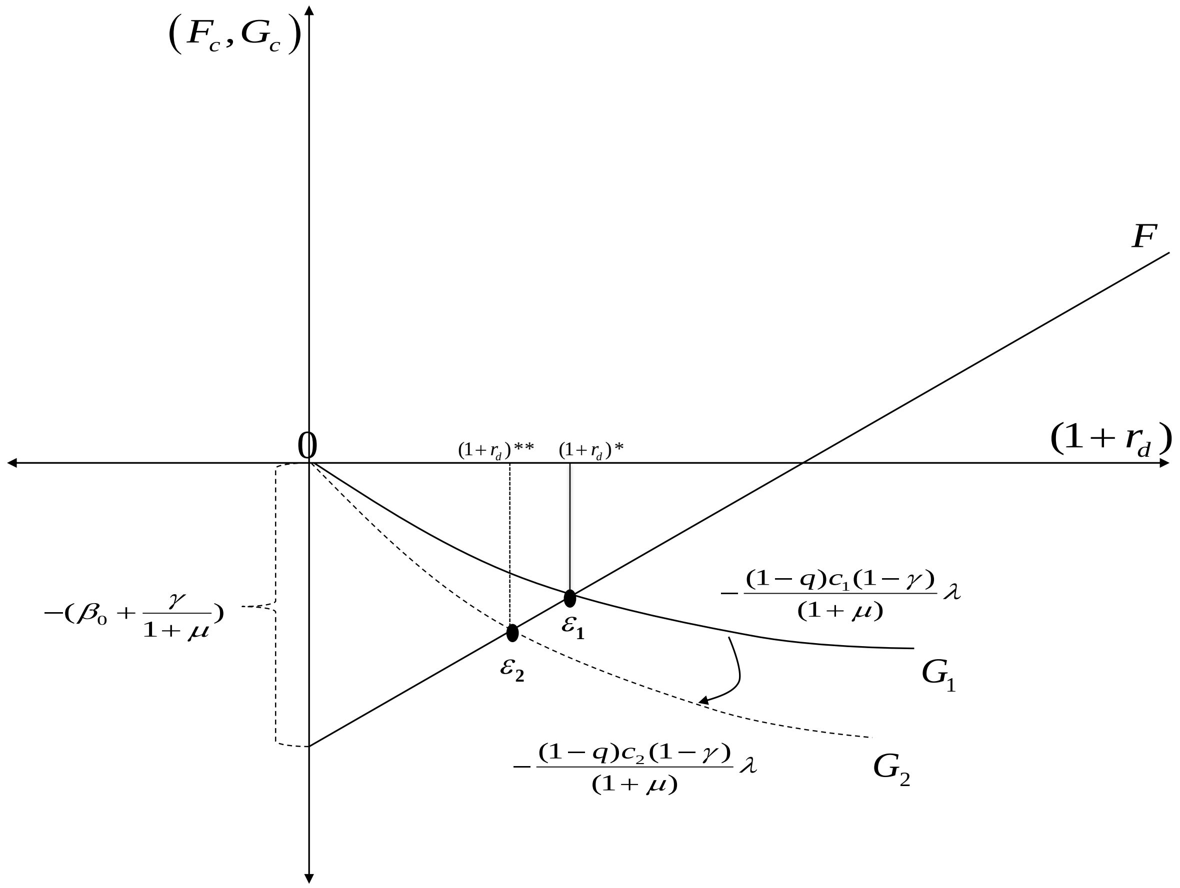

Figure 2.1: The effect of an increase in monitoring costs by the banks on the real deposit rate.

increase in cost results in a new equilibrium level ε_2 which corresponds with the real deposit rate, $(1+r_d)^{**}$ which is clearly lower than the initial equilibrium level ε_1 which corresponds with the real deposit rate, $(1+r_d)^{*}$. The movement in the results presented here flow in the opposite direction for any given decrease in c.

The underlying intuition is straightforward: the higher the cost of monitoring and the higher the incidence of the stochastic monitoring technology employed by the banks, the lower is $1+r_d$. Conversely, higher CSV corresponds with a lower level of financial development, implying a lower level of incentives for the depositor to save and hence, a higher incentive for the depositor to evade in this setting. It is expected that $1+r_d$ is decreasing in λ, as an increase in the probability (or number of times) that misreporting entrepreneurs can be discovered should lead to an increase in costs for the bank and therefore to a higher CSV altogether.

However, what is not immediately clear from (2.25) is the impact of inflation on $1+r_d$. It should be clear, however that there are two competing effects of inflation on $1+r_d$, one an *intercept* effect (from the first two terms in (2.23)) and the other a *slope* effect (from the last term in (2.23)). The amplified graphical representation in Figure 2.2 again separates these two effects to illustrate how the inflation or money growth rate parameter, μ, impacts both the intercept and the slope of the function $1+r_d$ in (2.23) for the case of an increase in μ.

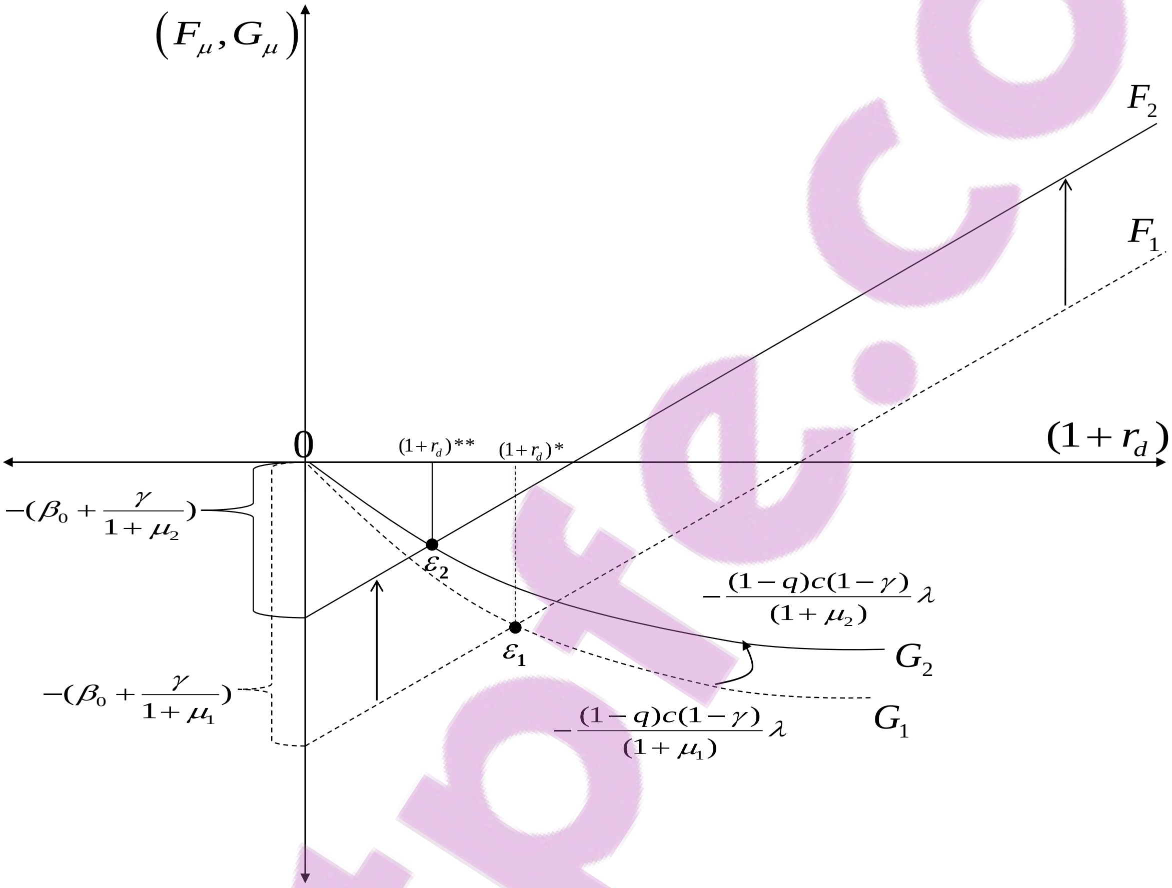

Figure 2.2: The dual effects of an increase in inflation on the real deposit rate.

Here $\mu_2 > \mu_1$, F_1, G_1 is the *intercept* and *slope* of $1+r_d$ corresponding with μ_1, respectively and F_2, G_2 is the *intercept* and *slope* of $1+r_d$ corresponding with μ_2, respectively. As inflation increases from μ_1 to μ_2, there is an upward shift in the intercept as the intercept becomes smaller, from F_1 to F_2. Concurrently, there is an outward swing from G_1 to G_2 as inflation increases. This concurrent increase in inflation results in a new equilibrium level ε_2 which corresponds with the real deposit rate, $(1+r_d)^{**}$ which is clearly lower than the initial equilibrium level ε_1 which corresponds with the real deposit rate, $(1+r_d)^{*}$. These results hold for legitimate parametrisation as outlined in Gupta (2005) and Gupta and Ziramba (2009) for $\gamma > (1-q)c(1-\gamma)\lambda$. Taking the calibrated values for these parameters as found in these studies, we let: $c = 0.10$, $\gamma = 0.10$, $q = 0.64$, and lastly $\lambda = 0.10$, which yields $0.1 > (1-0.64)*0.10*(1-0.10)*(0.10)$ or $0.1 > 0.00324$. Thus, the required condition holds, and the outcome remains qualitatively equivalent for all plausible and legitimate values of the parameters. Chen (2003) provides further empirical support for the plausible values of specifically γ and c.

These results indicate that as inflation increases the real rate on deposits decreases, and from $\frac{\partial \beta^*}{\partial r_d}$ it would imply that β^* increases. So, as the depositor in this economy observes a decrease in the real rate on deposits held at banks, he decides to evade a bigger portion of his income leading to an increase in the size of β^*. In summary, (2.21) to (2.25) and the consequential analysis highlight the most important result that emerges from this analysis: that the fraction of income evaded by a depositor depends not only on real factors such as tax rates, τ; penalty rates, θ; and the probability of getting caught, $(1-\sigma)$; but it also hinges critically on the monetary policy parameters in the model, namely the reserve requirement, γ and inflation, π as well as on the bank's cost parameters, c and λ.

2.5 THE EMPIRICAL SETTING

Recent empirical studies focus mainly on real factors as determinants of the size of the shadow economy. Fishlow and Friedman (1994) find that when current income decreases, tax compliance decreases and hence, the size of the shadow economy increases. Scneider (1994) shows how the imposed penalty rate leads to a higher shadow economy, while Schneider and Enste (2000) argue that the probability of being detected influences the size of the shadow economy. Dabla-Norris and Feltenstein (2005) show that the optimal tax rate may lead to a bigger shadow economy. Dreher, Kotsogiannis and McCorriston (2009) show that improved institutional quality decreases the size of the shadow economy and Elgin (2009) further argues that it is political turnover that determines the size of the shadow economy. Onnis and Tirelli (2011) argue that public expenditures decrease the size of the shadow economy, while Cerqueti and Coppier (2011) show how corruption affects the shadow economy. Most recently, Alm (2012) states that higher tax audit rates may reduce the size of the shadow economy and lastly Bose et al. (2012) provide evidence that it is the level of financial development that determines the size of the shadow economy.

The focal point of a separate strand of the literature is the accuracy of different measures of the shadow economy. There are various different measures for the shadow economy - some more creative than others - but we will only highlight the most widely-used measures. Schneider, Buehn and Montenegro (2010) use a Multiple Indicators Multiple Causes (MIMIC) measure, which essentially is a structural equation model (SEM) with one latent variable. Thiessen (2010) constructs a shadow economy measure based on behavioural theories and Gomis-Porqueras, Peralta-Alva and Waller (2011) models the shadow economy using a currency demand or money demand approach. Onnis and Tirelli (2011) suggest using a Modified Total Electricity (MTE) approach and more recently, Elgin and Öztunali (2012) use a two-sector dynamic general equilibrium (DGE) model to obtain the size of the shadow economy. It should be mentioned that direct approaches, like surveys and structured questionnaires, are also widely used to obtain more "direct" measures of the size of the shadow economy. The essence of our empirical testing however, is based exclusively on our theoretical framework.

2.5.1 Data

The data set used spans the period 1980 – 2009 and includes 150 countries[11], constituting a panel data set where $N = 150$ and $T = 30$. The period was chosen based on data availability for all key variables, and also to include at least one high and erratic inflationary period common in our panel - 1980 to 1990 - in the empirical analysis. The main variables of interest are discussed briefly, but we include a detailed description in Table 6 in the Appendix for ease of reference.

We compare two measures of the size of the shadow economy. *Shadow*1 is taken from the data set on the size of the shadow economy compiled by Schneider et al. (2010) using the MIMIC estimation method. This measurement covers the period 1999-2007. The second measure, *Shadow*2 is from a new data set compiled by Elgin and Öztunali (2012)[12], where the time-varying size of the shadow economy is estimated using a dynamic general equilibrium (DGE) model calibrated to a set of macroeconomic variables. This measure covers the period 1950-2009[13]. The correlation coefficient between *Shadow*1 and *Shadow*2, as stated in Elgin and Öztunali (2012) and also verified in this analysis, is 0.987. The strong correlation between these two different measures of the shadow economy, based on different

[11] A list of all the countries included in this analysis is available from the authors.

[12] We gratefully acknowledge the use of the dataset on the shadow economy compiled by Ceyhun Elgin and Oğuz Öztunali.

[13] The econometric literature, in particular on the monetary model of exchange rate determination and purchasing power parity, suggests that it is the span of the data, and not the frequency that enhances econometric analysis of specifically long-run relationships between macroeconomic variables. This has been shown by Shiller and Perron (1985), Hakkio and Rush (1991), Otero and Simth (2000), Rapach and Wohar (2004) and more recently by de Bruyn, Gupta and Stander (2013).

methodologies over different periods, facilitates balanced results as it excludes the way in which the measurements were calculated as a potential driver of the results.

Bnkcost is a measure of the banking sector's average overhead cost, expressed as a percentage of the banking sector's total assets. Although this measure is not only restricted to the bank's monitoring cost parameter, as denoted by c in (2.23) of the theoretical model, by definition it includes c and is proposed here as a rational proxy for c in the absence of a more direct and widely available measure of c. This cost measure is also an indication of the efficiency with which commercial banks matches surplus units to deficit units in the economy, and is available from the Financial Structure dataset compiled and updated by Beck and Demirgüç-Kunt (2009). Barth, Caprio and Levine (2002) and Bose et al. (2012) have used *Bnkcost* as a measure of the inefficiencies in the banking sector.

$Infl$ captures the effect of inflation and is the annual percentage change in consumer prices. As a proxy for inflation, we consider *Moneygr* which is defined as the annual growth rate of the $M2$ monetary aggregate, since in steady state the money growth rate is set equal to the rate of inflation.

Cba, or central bank assets, is defined as the total claims that the central bank has on the domestic real non-financial sector and is expressed as a percentage of GDP. This variable is included as a relative measure of the size of the central bank in the economy and to account for the level of intervention - and the possible effect of financial repression - that economies experience. Curdia and Woodford (2011) extends a standard New Keynesian model and find central bank assets to be a factor in equilibrium determination. Bernanke and Reinhart (2004) also discuss the importance of central bank balance sheets and the composition thereof, in effectively implementing new and unconventional balance sheet policies. According to Christiano (2011), central bank intervention in asset markets may also prove to be very costly. This may lead to observing a higher overall banking cost in the economy. A 'bank balance sheet' channel for monetary policy through which the central bank can influence the loan decision of banks, was identified by Chami and Cosimano (2010). Through this channel the central bank may influence the bank's cost functions and ultimately, the decisions of the agent to deposit or evade.

The $Control$ variable set includes $Gdppc$, the real gross domestic product (GDP) per capita. Real GDP is a widely accepted measure of economic development in the literature (Boyd, Levine and Smith, 2001; Boyd and Jalal, 2012) and it may plausibly be used as an indicator of financial development since King and Levine (1993) showed that economic and financial development are closely related (Boyd and Jalal, 2012).

The *Control* variable set also includes two other important subsets, where the first set measures the level of financial development in each country, and comprises of: *Dcpb*, the domestic credit provided by the banking sector; *Prvcrt*, the domestic credit provided by the banking sector as well as other financial institutions or intermediaries; *Intsprd*, the interest rate differential between loans and deposits; *M*3, the liquid liabilities as a percentage of real GDP and *Stmk*, a measure of stock market development calculated as the market capitalisation of all listed companies as a percentage of real GDP. These variables are often used in the financial development literature as indicators of the depth and the efficiency of both the banking and the financial sector (King and Levine, 1993; Levine and Zervos, 1998; Levine, Loayza and Beck, 2000; Boyd et al. 2001; Barth et al. 2002 and Boyd and Jalal, 2012). From these variables, we construct two financial development indicators using principal components analysis (PCA) and extract the unobserved common factors of these variables.

We define *Findev* as the first proxy for financial development and it consists of the first principal component of the log-levels of *Dcpb*, *Prvcrt*, *M*3 and *Stmk* which accounts for 80% of the variation in these four variables. We define the second proxy for financial development as *Findev*2, which consists of the first principal component of the log-levels of *Dcpb*, *Prvcrt* and *Intsprd* and it accounts for 68% of the variation in these three variables. *Intsprd* is defined as the lending interest rate minus the deposit interest rate as published by the World Bank, and it indicates the magnitude of the wedge that financial repression induces between the interest rates that banks charge on loans and the interest rate banks offer on deposits[14]. This additional second proxy for financial development, given that *Gdppc* is already a viable alternative to our first proxy, *Findev*, is an attempt to follow the recommendations of Levine (2005) and Boyd and Jalal (2012) that empirical measures of financial development should directly measure financial functions performed by the financial system. The PCA allows us to reduce the dimensionality of the set of variables to be included in our empirical analysis, whilst still retaining most of the informational content offered by these same variables (Bittencourt, 2012). It also aids in ensuring a more stable computational environment (Jolliffe, 1982).

The second subset measures the broad institutional quality of each country, and comprises of:

[14]Gupta (2005) provides a clear theoretical explanation of the characteristics of financial repression through obligatory high reserve requirements set by monetary authorities.

Regquality, regulatory quality captures the perception of the ability of the government to formulate and implement sound policies and regulations that would permit and promote private sector development; *Ruleoflaw* captures the perception of the extent to which agents have confidence in and abide by the rules of their respective society, in particular the quality of contract enforcement, property rights, the police and the courts, as well as the likelihood of crime and violence and *Fiscfreed* measures fiscal freedom, or the extent of a country's total tax burden.

All three these variables are compiled as indices, with higher values of the index corresponding to better governance and a lower tax burden, respectively. These variables are commonly used in the shadow economy literature as important indicators of the policy, institutional and regulatory environment which impact on the size of the shadow economy observed in countries (Schneider, 2007; Bose et al. 2012).

Data on both *Regquality* and *Ruleoflaw* are from the World Governance Indicators (WGI) dataset maintained by the World Bank and covers the period 1996-2009, and *Fiscfreed* is found in the Index of Economic Freedom dataset compiled by The Heritage Foundation and covers the period 1995-2009. All other data is taken from the World Development Indicators and Global Development Finance (WDI) dataset published by the World Bank.

We again employ PCA to construct a proxy for the institutional, regulatory and policy strength of the countries in our sample. *Instit* is the first principal component of the *levels* of *Regquality*, *Ruleoflaw* and *Fiscfreed* and accounts for 66% of the total variation in these three variables. There is strong consensus in the literature on the shadow economy that institutions are very important in depressing the size of the shadow economy[15].

All main variables are expressed in logarithmic form. This is consistent with the depositor's lifetime log-utility function, and as detailed in de Bruyn, Gupta and Stander (2013) this also allows more accurate analysis of the *relative* effect of the change in one variable on the change in another, which here is the relative effect of both financial development and inflation on the size of the shadow economy.

[15] In different economic settings, Koreshkova (2006), Dreher, Kotsogiannis and McCorriston (2009), Elgin (2009) as well as Onnis and Tirelli (2011) all produce results supporting the attenuating effect of good institutions on the size of the shadow economy.

Table 2.1 illustrates the behaviour of the variables of interest, *Moneygr* and *Bnkcost* over the sample period. The mean of *Moneygr* for the sample is 44.3 percent annually, while the mean of *Bnkcost* for the sample is 0.044, or 4.4 percent of the total value of the bank's assets. The values of the variables are aggregated over each year to calculate the mean. The difference between the minimum and maximum value of most of the variables confirms the observed variability in a heterogeneous panel of countries, such as the one presented here.

Table 2.1: Descriptive statistics on variables of interest

Variable	Obs	Mean	Std. Dev.	Min.	Max.	Unit of Measurement
Shadow1	1,314	32.503	12.682	8.1	68.3	% of GDP
Shadow2	3,665	0.334	0.132	0.081	0.791	$\frac{\%ofGDP}{100}$
Moneygr	3,850	44.317	345.174	-81.702	12,513.142	Annual growth rate, %
Bnkcost	2,029	0.044	0.03	0.002	0.27	% of total assets of Bank
Gdppc	3,710	6,384.372	9,497.147	82.672	61,374.754	Constant prices (2000 USD)
Dcpb	3,790	56.729	50.584	-72.994	333.987	% of GDP
Prvcrt	3,773	42.632	41.395	0.683	319.461	% of GDP
Stmk	1,759	48.67	61.076	0.02	617.014	% of GDP
Regquality	2,031	0.079	0.934	-2.676	2.226	Index of −2.5 to 2.5
Ruleoflaw	2,032	-0.018	0.97	-2.086	2.014	Index of −2.5 to 2.5
Fiscfreed	1,847	71.286	14.648	29.8	99.900	Index of 0 to 100

We also provide the correlation matrix of the two main explanatory and other control variables on the size of the shadow economy in Table 2.2.

Firstly, there is a strong positive correlation between the two measures of the shadow economy, confirming the findings in Elgin and Öztunali (2012)[16]. Both our variables of interest, *Bnkcost* and *Moneygr*, are positively correlated with both measures of the shadow economy, *Shadow*1 and *Shadow*2 as expected. Financial development seems to have the expected attenuating effect on the size of the

[16]The two variables are both expressed as a percentage of GDP, and the scale of *shadow1* is 100 times the scale of *shadow2*. Furthermore, a regression of *shadow1* on *shadow2* in its standard form reveals a positive and statistically significant slope of 88.55 and a positive and statistically significant intercept of 4.01, with an R^2–value of 0.984. For the *log* form of both these variables, as used mainly in our model, a regression reveals a positive and statistically significant slope of 0.941 and a positive and statistically significant intercept of 4.54, with an R^2–value of 0.991. Of course, changing the scale of *shadow2* to that of *shadow1* does not change the regression results.

Table 2.2: Correlation Table

Variables	log_shadow1	log_shadow2	moneygr	log_bnkcost	findev	findev2	instit	log_instit	log_gdppc	log_cba
log_shadow1	1.000									
log_shadow2	0.993*	1.000								
moneygr	0.293*	0.279*	1.000							
log_bnkcost	0.493*	0.504*	0.266*	1.000						
findev	-0.680*	-0.666*	-0.427*	-0.585*	1.000					
findev2	-0.618*	-0.610*	-0.340*	-0.548*	0.918*	1.000				
instit	-0.727*	-0.717*	-0.331*	-0.351*	0.690*	0.673*	1.000			
log_instit	-0.628*	-0.557*	-0.213*	-0.147*	0.450*	0.448*	0.837*	1.000		
log_gdppc	-0.704*	-0.685*	-0.254*	-0.380*	0.679*	0.655*	0.802*	0.622*	1.000	
log_cba	0.285*	0.296*	0.100*	0.182*	-0.160*	-0.152*	-0.362*	-0.098*	-0.373*	1.000

1. A * indicates the 5% significance level.

shadow economy, as does the level of and the relative change in the level of institutional quality. $Gdppc$ is negatively correlated to the shadow economy, implying that societies that are more developed both financially and economically seems to be engaging less in underground economic activity. Lastly, Cba is positively correlated to the shadow economy, and negatively correlated to both measures of financial development, institutional quality and $Gdppc$. This suggests that the size of total claims the central bank has over the real domestic non-financial sector, or the stronger the ability of the central bank to intervene in the market, the more adverse conditions these markets face in general.

We also present the simple ordinary least squares (OLS) regression lines between our variables of interest and the size of the shadow economy in Figure 2.3, where we plot country-specific paired observations of the means (aggregated over countries) of both $Moneygr$ and the log-level of $Bnkcost$ against the log-level of the shadow economy.

Note the positive relationship between banking cost and money growth on the shadow economy for country-specific observations[17]. From the observed data, it would seem that higher (lower) values of banking cost and higher (lower) values of the money growth rate, both correspond with higher (lower) values of the size of the shadow economy increases. Therefore - without implying causality at this stage - there seems to be some basis for our *a priori* expectation and predictions of our theoretical

[17] Both these positive relationships hold even when we use the short-span measure of the shadow economy, $Shadow1$ as well as for paired observations over the whole sample period.

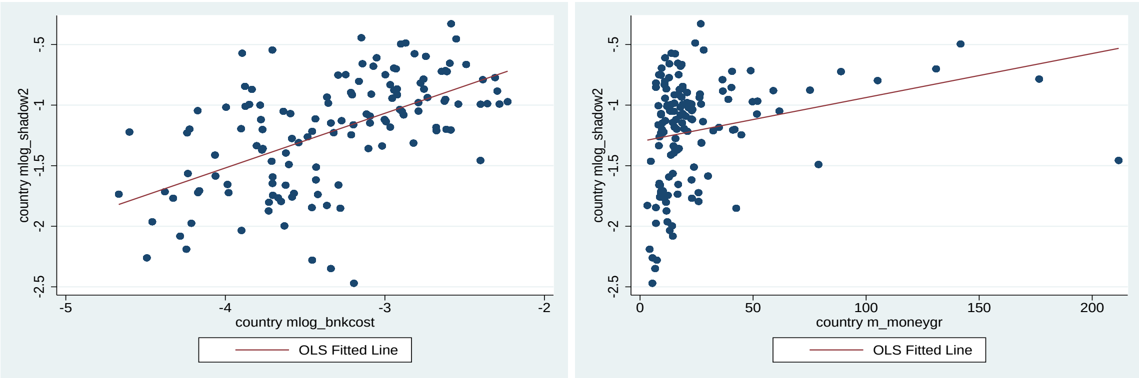

Figure 2.3: OLS regression lines of the log-levels of Banking Cost and Money Growth on the Shadow Economy in each country for 1980-2009, respectively.

model, that both c and μ are positive with respect to the size of the shadow economy.

2.5.2 The empirical methodology employed

Since we have an unbalanced panel of observations from countries ($N = 150$) spanning multiple years ($T = 30$), and it is clear that there is some persistence in some of our variables of interest, we make use of dynamic panel (time-series) data analysis. The dynamic panel methodology allows us to deal more effectively with econometric problems like non-stationarity, joint statistical and economic endogeneity, potential simultaneity bias, unobserved country-specific effects that may lead to omitted variable bias and importantly, measurement error. We are analysing the unobserved economy and as such measurement error is implied. This methodology also explores the added information from the time dimension in order to yield more accurate and informative estimates. Following Aghion, Bacchetta, Rancié and Rogoff (2009), we use the general method of moments (GMM) dynamic panel data estimator developed in Arellano and Bond (1991), Arellano and Bover(1995) and more specifically, the system GMM estimator developed in Blundell and Bond(1998). We compute Windmeijer-corrected two-step standard errors following the methodology proposed by Windmeijer (2005). This system GMM estimator addresses the aforementioned econometric issues in a dynamic formulation, where the lagged variable of the dependent variable is added to account for the persistence observed in the data[18].

[18] Roodman (2009) offers a step-by-step pedagogical account of the use of GMM style estimators.

We also expect our panel to be heterogeneous due to the inclusion of such a large number of countries with different economic, legal and regulatory policies, different political dispensations, different social issues which include different levels of income inequality and different levels of both financial development and economic development. Moreover, the countries in our sample also share certain similar characteristics, like banking institutions, common monetary areas, trade agreements, monetary authorities and in some instances similar rules dictating their participation in the global economy. Our preferred estimator accounts for both scenarios.

Furthermore, within a dynamic panel environment, the stationarity of variables is always a concern. Not only is the stationarity assumption violated due to the persistence in the dependent variable series and - by design - the inclusion of its lagged value, but formal testing also indicates that the log-levels of *Bnkcost* and *Gdppc* are both $I(1)$. Using Fisher-type panel unit root tests that supports the well-known Phillips-Perron (1998) test for a unit root in the variable series, we compute a test based on the p-value of each one of the individual panels to test for stationarity. The value of the test statistic Z, an inverse Normal statistic, for *Bnkcost* and *Gdppc* is -0.481 and 10.00, respectively. Both these tests can not reject the null hypothesis of all panels containing a unit root, although further testing indicates that both variables are in fact, trend-stationary. In our case however, directly addressing the non-stationarity of variables is not required, since an additional advantage of the system GMM estimator is that because it uses differences of all the variables by design, it ensures that all the explanatory variables are stationary in any event (Baltagi, Demetriades and Law, 2009).

The dynamic benchmark empirical model that we will estimate, based on our theoretical framework, is:

$$\begin{aligned} log\_shadow_{it} &= \beta_0 + \beta_1 moneygr_{it} + \beta_2 log\_bnkcost_{it} \\ &+ \beta_4 findev_{it} + \beta_5 log\_gdppc_{it} + \beta_6 instit_{it} \\ &+ \beta_7 log\_shadow_{it-1} + u_{it} \end{aligned} \tag{2.26}$$

where log_shadow represents the measures of the size of the shadow economy, $moneygr$ is the money growth rate as a proxy for inflation, $log\_bnkcost$ is the proxy for the bank's monitoring cost, $findev$ represents the proxies for the level of financial development, log_gdppc is the real GDP per capita (also a proxy for the level of economic development in a country) and $instit$ represents the proxies for the institutional quality in this model. u is the error term that contains both country-specific as well as time-specific fixed effects, and of course a random disturbance term. Throughout the analysis, we will use both proxies for financial development.

2.5.3 Dynamic panel GMM estimation

Including the lagged dependent variable in (2.26), implies implicit correlation between the explanatory variables and the error term. This is because, by inclusion, the lagged shadow economy depends on u_{it-1} which contains the country-specific and time-specific effects. This further supports the choice of our preferred estimator suggested by Blundell and Bond (1998), which basically differences the model to get rid of country specific effects or any time-invariant country specific variable.

The moment conditions utilize the orthogonality conditions between the differenced errors and lagged values of the dependent variable. This assumes that the random disturbances term contained in u_{it}, are serially uncorrelated. We compute two diagnostic tests using the GMM procedure to test for first order and second order serial correlation in the disturbances. For validity, one should reject the null of the absence of first order serial correlation and not reject the null of the absence of second order serial correlation.

The dynamic system GMM estimation treats all the variables - other than the lagged dependent variable - as if they were either strictly exogenous or predetermined but not strictly exogenous, in that it assumes these variables are uncorrelated with the random disturbances in u_{it}. As *cautiously* stated in Baltagi et al. (2009), the differencing performed by the system GMM estimator may also remove any correlation due to the time-invariant common factors. An additional advantage of the system GMM estimator is that it does not "difference away" the fixed effects, but it instruments for the lagged dependent variable and other explanatory variables that may still be correlated with the disturbances by other variables believed to be uncorrelated with these fixed effects.

2.5.4 Empirical results

The two-step system GMM results reported in Table 3 provides encouraging support for the developed theoretical model. The recommendations of Roodman (2009) are followed and a detailed description of the different specification and instrument sets are provided first before the results are discussed. For the results in 2.3, we use the maximum number of instruments that the GMM procedure allows and that are available in the dataset.

Table 2.3: Estimation results of the System GMM Estimators

Variables	1	2	3	4	5	6
moneygr	0.00005**	0.00004*	0.00001	0.00001	0.00001	0.00004*
	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00002)	(0.00003)
log_bnkcost	0.00515*	0.00725**	0.0068*	0.00869**	0.00872**	0.00552*
	(0.00328)	(0.00378)	(0.00436)	(0.00356)	(0.00354)	(0.00299)
findev				-0.00729**	-0.00812***	
				(0.00280)	(0.00287)	
log_gdppc	0.00636	0.00767	-0.00230	-0.00268	-0.00224	-0.00270
	(0.01026)	(0.01095)	(0.02019)	(0.00681)	(0.00765)	(0.00783)
L.log_shadow2	0.93439***	0.91591***	0.899909***	0.92295***	0.91823***	0.91627***
	(0.02652)	(0.04071)	(0.03757)	(0.02495)	(0.02509)	(0.02631)
instit	-0.02740***	-0.02923***	-0.02955**	-0.01105*	-0.01170	-0.01744**
	(0.00932)	(0.01039)	(0.01310)	(0.00735)	(0.00805)	(0.00854)
findev2						-0.00468*
						(0.00302)
Obs	979	1,257	1,517	713	713	963
F	1,778.22	912.18	994.80	1,114.09	1,117.52	1,004.67
Sargan	0.62	0.58	0.61	1.00	1.00	1.00
$AR1$	0.001	0.001	0.001	0.001	0.001	0.002
$AR2$	0.442	0.439	0.531	0.638	0.605	0.310
$\#ofInstruments$	143	142	141	165	164	172

1. A *, **, *** indicates the 10%, 5% and 1% significance level, respectively.
2. Robust, Windmeijer-corrected standard errors in parenthesis. All models reported are two-step GMM.
3. All time dummies are suppressed to save space.

For columns (1) to (3), the endogenous (predetermined) or internal instrument set consists only of *log_bnkcost* and the lagged dependent variable. The external instrument set consists of *log_cba*, *log_intsprd* and the time-dummies for column (1); *log_cba* and the time-dummies for column (2) and only the time-dummies for column (3), respectively. This was done to reduce the instrument count and avoid proliferation of instruments. All instrument sets are valid, as supported by the Sargan statistic, where the hypothesis cannot be rejected that the instruments are exogenous. Moreover, the instrument count is always considerably less than the number of observations. The Arellano-Bond autocorrelation test also indicates that there is no serial correlation in the idiosyncratic disturbance term.

To account for the suspected economic endogeneity between *Moneygr* and *Findev* in a direct way, columns (1) to (3) exclude both principal components measures of financial development. In columns (4) to (6), both the different measures of financial development are included separately. Except for column (1), the forward orthogonal deviations transformation first suggested in Arellano and Bover (1995), are used as an alternative to the standard differencing. This transformation has the advantage of preserving sample size when the selected panel has gaps, or is unbalanced. All specifications reported in Table 3 allow for the idiosyncratic disturbances to be both heteroskedastic as well as correlated within countries, but not across countries. Finite-sample Windmeijer (2005) corrected robust errors are reported in all columns.

The estimation performed in column (4) treats $log\_bnkcost$, $Findev$ and the lagged dependent variable of the shadow economy as endogenous, and therefore uses the second and deeper lagged values of these variables as internal instruments for the differenced equation and the first and deeper lagged differenced values as instruments for the level equation. The size of the central bank, the interest rate spread and the time-dummies are treated as exogenous and therefore used as external instruments for the equation in levels. For column (5), *Findev* is considered to be only predetermined and thus the first and earlier lagged values are used as instruments for the transformed equation and the difference of *Findev* for the equation in levels. The external (or exogenous) instrument set remains the same. In column (6), the second measure of financial development is again treated as an endogenous variable and included in the internal set together with $log\_bnkcost$ and $l.log\_shadow2$. The exogenous instrument set used in column (6) now excludes the interest rate spread, as this forms part of $Findev2$.

Bnkcost estimates reported are positive and significant for all specified system GMM estimations. The size of the coefficients range from 0.00515 to 0.00872 and is in line with estimates obtained using the fixed effects (FE) estimator[19]. These results indicate that an increase of 1% in banking cost, would likely lead to an additional $0.5\% - 0.9\%$ increase in the size of the shadow economy, suggesting that as banks face an increasingly costly state verification problem, the decision of the agents would lean more towards evading a bigger portion of their income and hence we observe an increase in the size of

[19]The GMM results accord well with results obtained from fixed effects (FE) estimations, which serve as a consistency check. The FE results are provided in the Appendix in Table 5.

the shadow economy. In the sample countries examined here, a 1% increase in banking cost would add almost $2 billion to the shadow economy on average as the mean value of *GDP* for these countries is $200 billion.

Moreover, with the exception of columns (3), (4) and (5), *Moneygr* also presents positive and significant estimates against the size of the shadow economy, ranging from 0.00001 to 0.00005. This suggests that a 1% increase in the money growth rate, would likely lead to an increase in the shadow economy of between 0.001% and 0.005% here. The economic significance of these seemingly small estimates, becomes clear once the average money growth rate and the average *GDP* values are considered. Across the whole sample, the average money growth rate is 44% with a standard deviation of 345%, and even for developing countries annual money growth rates exceeding 20% is not uncommon. The sample-wide mean *GDP* is almost $200 billion. It is evident that relatively big swings in money growth occur and hence, an observed 20% increase in the money growth rate, will lead to a 0.0002% to 0.001% increase in the size of the shadow economy, or add between $4 million to $20 million to the shadow economy.

In the case of the exceptions in columns (3), (4) and (5), it is interesting to note that $Findev$ (and the second proxy, $Findev2$), or the measure of financial development, has an attenuating and significant effect on the size of the shadow economy.

These results are consistent with those obtained by Blackburn et al. (2012) as well as Bose et al. (2012). The recent empirical work by Neely and Rapach (2011) on how common shocks, similar central bank functions and policy as well as international trade and capital flows produce commonality in international inflation, offers a more credible explanation for the not significant *Moneygr* results reported in column (3), (4) and (5). The authors find that more than half of inflation variability in countries can be explained by international common influences that is not due to country-specific or time-specific effects in those countries, and since we are not controlling for the degree of openness observed in these countries we are not able to capture the inflationary effect in this specification. Bittencourt (2011) investigated the impact of inflation on financial development and concluded that low and stable inflation is a pre-condition for a more developed financial market. This supports the well-established linkage between financial development and inflation in the economic growth literature and more clearly documented in Boyd, Levine and Smith (2001), among others.

The estimates for *Gdppc* are negative in those equations where a financial development measure is included, and positive in those equations where financial development was not explicitly modelled. Across all columns, *Gdppc* is not significant. It was expected that in more developed societies agents would have less incentive to evade a portion of their income, which is not what is observed here. Bearing in mind that both *Bnkcost* and *Gdppc* are also used as a further indication of the level of financial development in the analysis presented here, economic endogeneity may be driving these unexpected results. A more plausible explanation could be found in the results for the institutional framework. *Instit* estimates are negative and significant throughout the specification (with the exception of column (5)), but highly significant once the measures of financial development were not included. These results coalesce with the findings of Koreshkova (2006), Elgin (2009) and Onnis and Tirelli (2011), among others. In this empirical setting, it is clearly institutions and the level of financial development that impact on the size of the shadow economy, and not the per capita income levels or the level of economic development.

The lagged dependent variable is positive and significant in all specification, as expected from the persistent nature of the shadow economy. The size of the lagged coefficient in most columns is high, again raising concerns about non-stationarity and hence, spurious regression results. In simulation studies, performed by Blundell, Bond and Windmeijer (2001), the efficiency and bias of system GMM estimates are compared to other estimators in the presence of highly persistent series, and found to improve upon both the precision and finite sample bias of other estimates. Moreover, Phillips and Moon (1999) formalised the idea that the cross-sectional information added in a panel framework provides more information, and therefore a clearer signal about the average long-run relation parameter, or the coefficient of the lagged dependant variable. Phillips and Moon (1999) provide panel asymptotic theory which shows that the estimate for the coefficient on the lagged variable is consistent for persistent series, and hence spurious regression results in a non-stationary panel analysis is less problematic.

For robust comparison, we also provide additional GMM results in 2.4 where the maximum number of lags to be used as instruments, were limited to four to further avoid instrument proliferation as suggested by Roodman (2009). The instrument count drops substantially from a range of 141 – 172 to 34 – 39. Again, Windmeijer (2005) finite-sample robust corrected errors are calculated to account for the downward bias in the two-step standard errors. In column (1), we provide a benchmark dynamic model with only the two main variables of interest, *Moneygr* and *Bnkcost*. The estimates are positive and for *Bbnkcost* significant, but the Sargan test of instrument validity expectedly raises concerns about model specification.

In columns (2) and (3), we firstly provide results based on the specification in (2.26) excluding financial development. The external instrument used is log_cba, to capture a bank balance sheet channel effect of monetary policy on the shadow economy. In columns (4) and (5) as well as (6) and (7), respectively, we include the two different principal component proxies of financial development, $Findev$ and $Findev2$ to examine the effect of financial development on the size of the shadow economy. As external instrument/(s) we use both log_cba and $log\_intsprd$, and for $Findev2$ we only use log_cba, to capture both a bank balance sheet channel as well as an interest rate channel effect of monetary policy on informal economic activity observed.

The estimates reported for *Bnkcost* are all positive and almost always significant. The range of the coefficient estimates are 0.0111 to 0.0222. On average, a 1% increase in banking cost would lead to a 1% to 2% increase in the size of the shadow economy, or add between $2 billion to $4 billion to the shadow economy. These estimates, although more pronounced here, are in line with the previous GMM results as well as the FE results in Table 5.

Moneygr estimates reported are mostly positive and either significant or marginally not significant (columns (2) and (3)). The range of coefficient estimates are between 0.0000005 and 0.0001. At the upper end of the range, this would again imply that a 20% increase in the money growth rate would lead to a 0.2% increase in the shadow economy, which translates to an additional $500 million of informal economic activity. These results are also broadly in line with the previous GMM estimates and the FE estimates. It should be noted that the only exception, a negative coefficient estimate reported in column (4), was based on modelling the money growth rate as endogenous to the model, and the result obtained would suggest that the money growth rate does not introduce endogeneity in our specified model in (2.26). Besides, the use of the lagged values of the level variables as instruments for the transformed equation and the lagged values of the first differences as instruments for the equation in levels, already adequately deals with any suspected endogeneity, as further explained in Kose, Prasad and Taylor (2011).

We also report two-stage FE results in Table 5 in the Appendix, firstly for the whole sample following the recommendations of Judson and Owen (1999), and then using sub-samples of OECD and Latin American countries. Owning to the long sample period (T = 30), the Nickell (1981) bias is of order

Table 2.4: Estimation results of the System GMM Estimators with Instrument Limitation

Variables	1	2	3	4	5	6	7
moneygr	0.0000005	0.000114	0.00011	-0.00004	0.00001	0.00010*	0.00010**
	(0.000003)	(0.000085)	(0.00010)	(0.00015)	(0.00008)	(0.00007)	(0.00005)
log_bnkcost	0.0173**	0.0111	0.01436***	0.02225**	0.01128**	0.01326**	0.01377**
	(0.00797)	(0.00857)	(0.00517)	(0.00963)	(0.00537)	(0.00641)	(0.00674)
log_gdppc		-0.00042	0.00092	-0.00411	-0.00382	-0.00047	-0.00288
		(0.0153)	(0.01056)	(0.00946)	(0.00960)	(0.00766)	(0.01033)
L.log_shadow2	0.982***	0.905***	0.93724***	0.93339***	0.94729***	0.96782***	0.96638***
	(0.01423)	(0.0433)	(0.04471)	(0.02611)	(0.01789)	(0.02568)	(0.02710)
instit		-0.0237**	-0.01529	-0.01169	-0.00393	-0.00749	-0.00508
		(0.0098)	(0.01247)	(0.00785)	(0.00942)	(0.00660)	(0.00735)
findev				-0.00205	-0.00574*		
				(0.00533)	(0.00364)		
findev2						-0.00641**	-0.00538*
						(0.00290)	(0.00321)
Obs	1,287	1,257	1,257	723	723	973	973
F	2,111.81	706.39	482.43	754.99	916.56	1,027.22	680.67
Sargan	0.001	0.251	0.70	0.46	0.31	0.24	0.25
DiffSargan	0.129	0.317	0.09	0.20	0.80	0.46	0.47
*AR*1	0.005	0.001	0.004	0.017	0.001	0.004	0.003
*AR*2	0.092	0.493	0.325	0.391	0.695	0.102	0.060
#ofInstruments	35	36	35	34	36	39	39

1. A *, **, *** indicates the 10%, 5% and 1% significance level, respectively.
2. Robust, Windmeijer-corrected standard errors in parenthesis. All models reported are two-step GMM.
3. All time dummies are suppressed to save space.

$O(1/T)$ and hence, presents less of a problem than what is observed in typically shorter time-series panels. Moreover, we supplement the FE estimation by including exogenous regressors through the use of instrumental variables which is not only consistent with our preferred GMM estimator, but also more closely represent the indirect correspondence of our main variables of interest with the shadow economy, evident from (2.21), (2.22) and (2.25). For the full sample, log_cba and $log\_intsprd$ are again used to capture both a bank balance sheet channel effect as well as an interest rate channel effect of monetary policy on the size of the shadow economy. For the respective sub-samples of both OECD and Latin American countries, *Domsave* is used as an instrument to capture the savings decisions of agents in this specification. *Domsave* is gross domestic savings, expressed as a percentage of *GDP*.

The FE results obtained are broadly in line with the GMM results presented herein. *Bnkcost* is almost always positive, yet not significant. The positive *Moneygr* estimates are significant, and apply to the benchmark model as well as to the Latin American sub-sample. For the OECD sub-sample, *Moneygr* estimates are negative and not significant. Interestingly, the estimates for the institutional quality proxy, *Instit* are positive and significant for OECD countries where the *Moneygr* estimates are negative. This confirms earlier findings by Choi and Tum (2005), and recently by Schneider et al. (2010) that an increase in the tax and regulatory burden creates higher incentive for agents to evade a bigger portion of their income, and hence leading to an increase in the size of the shadow economy. Across all models, the estimates for *Ggdppc* are negative and significant. These FE results, especially for the sub-samples with fewer cross-sections, suggest that the money growth rate has a more pronounced impact on the shadow economy in Latin American countries than in OECD countries, and that the level of economic development as captured by *log_gdppc*, has a more attenuating impact on the shadow economy in these countries than the money growth rate[20] .

The reported results demonstrates that for different measures of the size of the shadow economy, controlling for the broad level - and the more "Levine-like" functional level - of financial development, taking the level of economic development into consideration through *Gdppc*, controlling for the level of institutional quality and the ability of the central bank to intervene in the economy, *Bnkcost* and *Moneygr* are important determinants for the size of the shadow economy. Moreover, an increase in any of these variables leads to a contemporaneous increase in the size of the shadow economy. Finally, the results are consistent with the theoretical propositions in Section 2.4: an increase in banking cost and an increase in the inflation rate, leads to an observed increase in the size of the shadow economy or to more underground economic activity.

[20]Despite the best attempts to control for the "spatial effect" through our use of System GMM and Fixed Effects estimation with time– and country–dummies, we are not in a position to explain the differences or interdependency in tax evasion between countries that are spatially compatible.

CHAPTER 3 SOCIAL STATUS, INFLATION AND ENDOGENOUS GROWTH IN A CASH-IN-ADVANCE ECONOMY: A RECONSIDERATION USING THE CREDIT CHANNEL

[1]

3.1 INTRODUCTION

> "In order to hold the esteem of men, it is not sufficient merely to possess wealth or power. The wealth and power must be put in evidence, for esteem is awarded only on evidence." - Thorstein Veblen[2]

The effect of monetary growth - and hence, the efficiency or optimality of monetary policy - on capital accumulation and economic growth remains a central theme in macroeconomic literature. In the aftermath of the 2007–2009 financial crises, renewed theoretical focus has characterised the global monetary policy environment.[3] Complementary to this broader debate, there is also a deepening in

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[2] *The Theory of the Leisure Class: An Economic Study of Institutions* (1899)

[3] See the notable contributions of Blanchard, Romer, Spence and Stiglitz (2012), Sims (2012) and Friedman (2013), among others.

the literature studying the effects of wealth-induced preferences for social status (or ”the spirit of capitalism” of Weber (1905)) on capital accumulation and economic growth using dynamic general equilibrium (DGE) models. Chang, Hsieh and Lai (2000) amend the framework of Stockman (1981) and establish a one-sector monetary growth model where the production function takes the general AK form as the engine of growth and a cash-in-advance (CIA) constraint applies to consumption only. The results from the Chang et al. (2000) model seem to confirm the well-known Mundell (1963) and Tobin (1965) effect,[4] namely that an increase in the money growth rate leads to an increase in the long-run growth rate of the economy, if a capital stock due to a wealth motive is included directly in the production function. This would imply that consumers derive utility not only from consumption, but also from holding capital stock based on a direct wealth motive as some ”evidence of esteem” (Veblen, 1899).[5] Further proof that individuals care about their social status in a market economy and pursue capital accumulation to advertise their wealth to achieve social status and power is provided by Zou (1994), Bakshi and Chen (1996), Corneo and Jeanne (1997) and Futagami and Shibata (1998).

Using Chang et al. (2000) as a benchmark, subsequent studies on Kurz’s (1968) wealth effects, or linking an individual’s preference for capital holding with wealth and social status, produced mixed and ambiguous results. Zou (1998) included money directly in the utility function (MIU) in a one-sector model and found that higher inflation leads to higher capital stock in the long run, thus increasing the endogenous growth rate of the economy. Gong and Zou (2001) find the same result with a similar model, but using a CIA constraint on consumption only, instead of a MIU specification. When the liquidity constraint is applied to both consumption and investment, the results are ambiguous and depend on the weight ascribed to social status in the utility function and investment in the CIA constraint. Chang and Tsai (2003), using the exact framework of Gong and Zou (2001), find the exact opposite result. More recently, Chen and Guo (2009) with a similar framework but with the CIA constraint applying to both consumption and investment, present results that inflation is detrimental to economic growth.[6]

[4]These results, however sharply contradict the super-neutrality of money proposition of Sidrauski (1967).

[5]The holding of capital stock for wealth solely due to its inferred social status, and not for financing future consumption, is a notion that has been well developed by Smith (1776), Veblen (1899), Weber (1905), Keynes (1920) and mathematically by Kurz (1968).

[6]There are also studies that examine the money growth rate effect on the economy within a two-sector framework characterized by social status (see for example Chang et al. (2008), and Chen (2011)). These studies show that when social status is represented by capital, and the CIA constraint applies to both consumption and investment with a generalized human capital formation process (i.e., the process includes physical capital, besides human capital), money growth rate negatively impacts economic growth rate.

To gain an understanding of the Chang et al. (2000) results, consider intuitively the presence of an individual's preferences for social status under a binding CIA constraint: an increase in the money growth rate leads to an increase in inflation, which in turn increases the opportunity cost of consuming as consumption purchases requires the individual to keep cash to effect such purchases. The individual will thus substitute consumption goods for capital goods, and given the social status motive this substitution will lead to higher capital accumulation. In the endogenous growth framework, the mechanism is slightly different: an increase in the money growth rate causes inflation, which in turn leads to a decrease in the holding of real money balances and thus to a decrease in consumption (as consumption require cash in advance). The individual will thus substitute towards physical capital, as the real rate of return on physical capital is constant. As capital accumulation promotes higher social status and the individual's social status matters, he has a further incentive to accumulate capital. As long as there are constant returns to scale (CRS) with respect to capital, the growth rate of the economy will increase due to increasing capital accumulation.

This intuitive explanation and the results presented by Chang et al. (2000), present an impasse in that a positive growth-inflation relationship is inconsistent with the empirical evidence on the growth-inflation phenomenon and is even inconsistent with the literature on threshold inflation as more clearly detailed in Vaona and Schiavo (2007), Jha and Dang (2012) as well as Neanidis and Savva (2013).[7]

We provide a novel and simple explanation of the effects of monetary growth on economic growth that is empirically consistent. Benchmarking the Chang et al. (2000) framework, we reconsider the monetary growth impact by introducing a competitive banking sector subject to mandatory reserve requirements along the lines of Chari et al. (1995). Note that, Chari et al. (1995) attempted to match the size of the effect of inflation on growth as reported in empirical studies, with those obtained from endogenous growth models with and without banking intermediation. However, they are unable to match the size of the impact reported in econometric model, to the extent that the growth rate of the money supply is found to have a quantitatively trivial effect on the growth rate of output. The incorporation of the banking sector into a monetary model of social status with endogenous growth allows the banking system to play a fundamental role in facilitating both production and capital accumulation and hence, long run economic growth.

[7] See Bittencourt (2011), Berentsen, Breu and Shi (2012) and most recently Barro (2013) for more detail on the negative growth-inflation relationship.

To our knowledge, the model presented here is the first attempt at explaining how the money growth rate together with cash reserve requirements - in a similar vein as the reserve requirement coordinating arrangement proposed by Barnett (2005) - affect the outcome of an endogenous monetary model in the presence of the spirit of capitalism or wealth-induced social status. More specifically, the paper brings the importance of the banking literature, especially cash reserve requirements, to bear upon the inflation-growth relationship, which in the presence of social status in an endogenous growth model was found to be positive and hence, inconsistent with the empirical literature. In other words, through the explicit modelling of the banking sector in an otherwise standard endogenous growth model with spirit of capitalism, we are able to obtain the empirically consistent negative relationship between growth and inflation under certain very plausible conditions on the cash reserve requirements.

Cash reserve requirements have long been perceived as a measure of financial repression, since higher cash reserve requirements result in fewer loans available to a bank to lend out for investment/production purposes. For a detailed discussion along these lines, refer to Gupta (2008), Gupta and Ziramba (2009, 2010) and Bittencourt, Gupta and Stander (2014). Essentially, the cash reserve requirement induces a wedge between the deposit rate and the loan rate and hence, creates friction in financial intermediation (Haslag and Young, 1998). Although the mandatory reserve requirement ratios have been reduced consistently across developed and developing countries (Di Giorgio, 1999), it is still considered a monetary policy instrument that broadens the inflation tax base (as it increases real money balances for a given level of deposits in the banking system) and it is still widely used as a liquidity management tool making it easier for central banks to influence the level of market interest rates, as clearly explained in Primus (2017).

Moreover, Chari et al. (1995) report a reserve requirement ratio for the United States (US) over the period 1986-1991 of 4.2 percent. Di Giorgio (1999) summarises data on the reserve requirement for a host of industrial countries over the period 1990-1996 and reports a range of values between 0.5 percent to 22.5 percent, and recently Gupta (2011) reported the average reserve requirement value for a large number of countries to be 22.0 percent. Lastly, Carrera (2013) reports that only 9 of the central banks recently surveyed had a 0 percent reserve ratio; 51 had a reserve ratio between 6 percent to 15 percent, and 15 had a reserve ratio of more than 16 percent. Clearly, reserve requirements are widely prevalent and at times quite significant in size, and hence, cannot be ignored as a monetary policy instrument.

There are two opposing effects on long-run growth in the presence of social status when banks face cash reserve requirements, given an increase in the growth rate of money. One is the well-known Tobin (1965) portfolio substitution effect, where the resultant increase in inflation due to an increase in the money growth rate leads to substituting real balances for capital, as the marginal product of capital is constant and not affected by cash reserve requirements. The resultant increase in capital holdings has a positive effect on long-run growth. This portfolio substitution effect to capital is further reinforced by the preference for social status. The second effect is observed through a deposit rate channel, since the real deposit rate is negatively affected by inflation, even though the real loan rate is still tied to the constant marginal product of capital (given that we consider an endogenous growth framework).

The disconnect between the real deposit rate and the real loan rate arises because of the cash reserve requirements, which, in equilibrium, create a wedge between the deposit and the loan rates. Hence, a lower real rate of deposits results in agents substituting away from capital goods to holding real balances to finance current consumption. The resultant decrease in capital holdings has a negative effect on long-run growth. But these two effects do not simply cancel each other out and lead to money being super-neutral, as in Sidrauski (1967). Our theoretical results show that as long as the cash reserve requirement exceeds a (small) critical value, the effect of inflation or monetary growth on economic growth, is negative. This is in contrast to those findings presented by Chang et al. (2000).

The rest of this paper is organised as follows: Section 3.2-3.4, respectively, defines and solves the specific model, characterises equilibrium along a balanced growth path (BGP) and examines the money growth effects within the characterised economy.

3.2 THE MODEL

The principal economic activities are: (i) consumers receive income from their deposits held by banks, and do not accumulate capital directly. They also receive lump-sum transfers from the government. Consumers must decide on their consumption, which is financed by cash as well as the deposits they accumulate with due regard to their social status preferences; (ii) firms derive income using a simple AK-type production technology, and accumulate capital by financing capital purchases with loans obtained from banks. Firms choose the amount of capital they purchase as well as the amount of loans they take from the bank; (iii) the banks operate in a competitive environment and perform a rudimentary pooling function by collecting the deposits from the consumers and lending it out to the firms after meeting an obligatory cash reserve requirement. Banks collect the interest rate on these loans and meet their obligation to the depositors; and (iv) there is an infinitely-lived government which supplies money and distributes the seigniorage income in the form of lump-sum transfers to the consumers. There is a continuum of each type of economic agent with unit mass.

3.2.1 Consumers

The consumer is an infinitely-lived, representative agent with unit mass who supplies labour inelastically, and hence labour is normalised to unity and there is no labour-leisure decision affecting consumers. The perfect foresight consumer derives utility from both consumption and wealth-induced social status, where social status is represented by his deposits. The idea of direct utility accruing to the consumer from holding capital stock in general, and in this model specifically, deposits, was mathematically formulated by Kurz (1968). The consumer wishes to maximize his intertemporal discounted lifetime utility, where the chosen logarithmic utility function is separable and defined over both consumption and deposits. Formally, the consumer wants to:

$$\max \int_0^\infty U(c,d)e^{-\rho t}\mathrm{d}t \tag{3.1}$$

subject to:

$$\dot{m_1} = r_d d + \tau - c - \pi m_1 - \dot{d} \tag{3.2}$$

$$m_1 \geq c \tag{3.3}$$

where c is real consumption and d is real deposits. m_1 is real money holdings or cash balances held by the consumer to finance consumption; τ is the real lump-sum transfer received from the government; π is the inflation rate, $0 < \rho < 1$ is the constant time discount rate and r_d is the net real rate of return on the consumer's deposits. A dot over the variable denotes the time derivative. Following Chang et al. (2000), we specify: $U(c,d) = [log(c) + \beta log(d)]$ with $\beta \geq 0$ being the degree of the consumer's preference or desire for social status. Both utility functions for consumption and deposits in (3.1) are well-behaved, i.e., are characterized by increasing marginal utilities at a decreasing rate. (3.2) and (3.3) are the consumer's budget constraint and the cash-in-advance (CIA) constraint for consumption goods, respectively. The consumer's current value Hamiltonian is specified as:

$$H_c = log(c) + \beta log(d) + \lambda[r_d d + \tau - c - \pi m_1 - \dot{d}] + q[m_1 - c] \tag{3.4}$$

where λ, the shadow price of real money balances and q, the Lagrange multiplier for the CIA constraint in (3.3), which is assumed to be strictly binding in equilibrium,[8] are the co-state variables (or the multipliers of H_c) and the optimum conditions necessary for the consumer are given by the respective first-order conditions of:[9]

$$c : \frac{1}{c} = \lambda + q \tag{3.5}$$

$$m_1 : -\lambda\pi + q = \rho\lambda - \dot{\lambda} \tag{3.6}$$

$$d : \frac{\beta}{d} + \lambda r_d = \rho\lambda - \dot{\lambda} \tag{3.7}$$

where (3.5) equates the marginal benefit and marginal cost of consumption; (3.6) states that the marginal value of real money holdings is equal to its marginal cost and (3.7) determines the evolution of real deposits over time, where $\frac{\beta}{d}$ is the marginal benefit of accumulating deposits. Note that in the presence of a desire for social status, thus when $\beta > 0$, the marginal benefit of accumulating deposits increases.

3.2.2 Banks

As in Chari et al. (1995), there exist a finite number of banks in this economy, which we assume to behave competitively and who are all subject to an obligatory cash reserve requirement γ, set by the government. Two simplifying assumptions, that no resources are used to operate the banking system and bank deposits are essentially one period contracts, guarantee that all competitive banks levy the same cost on their loans, the nominal loan rate i_l and guarantee the depositor a nominal deposit rate, i_d. Banks accept and pool deposits, choose their allocation portfolio of loans and required cash reserves and then extend loans to firms, subject to γ, with the goal of maximising their profits. Subsequently, banks receive interest income from loans to firms and meet their interest obligations to depositors. The bank's balance sheet is constrained by the reserve requirement, and is represented by $(1-\gamma)d = l$. Hence, all banks attempt to:

$$\max \Pi_B = [i_l l - i_d d] \tag{3.8}$$

subject to:

$$m_2 + l \le d \tag{3.9}$$

$$m_2 \ge \gamma d \tag{3.10}$$

[8] This is a standard assumption in the CIA literature, but more fully explained in Stockman (1981).

[9] Optimisation solutions for the different economic agents are fully set out in the Appendix.

where Π_B is the bank's profit function; m_2 is real money holdings by the banks to meet the reserve requirement, γ is the reserve requirement ratio, and l are loans in real terms. (3.9) is the feasibility constraint (i.e., the bank's balance sheet) and (3.10) is the bank's reserve requirement constraint. A competitive banking sector is characterised by free entry, which drives profits to zero. Thus, given that (3.9) and (3.10) binds, the solution to the bank's problem yields:

$$i_l = \frac{i_d}{1-\gamma} \tag{3.11}$$

(3.11) clearly shows that cash reserve requirements lead to a distortion in financial intermediation. Since fiat money, m_2 has a rate of return dominated by returns on loans, (3.10) will be binding as banks will hold just enough real money balances to satisfy the legal reserve requirements. Note that we could have easily presented the bank's feasibility condition ((3.9)) as an equality, which is what it would be given the bank's profit motive, which would imply that the bank would loan out the entire amount of the deposits after having exactly met the cash-reserve requirement.

The presentation of the constraint as an inequality is to keep the problem structure general, and to indicate that the equality holds only under equilibrium. This helps us avoid imposing the equilibrium condition before solving the optimization problem.

Once we know that the cash reserve requirement is binding, i.e. the banks will only hold reserves up to the point that the requirement is satisfied, it also implies that we could have presented the feasibility condition as equality. The bank's portfolio choice must include both cash reserves and loans, but since reserves do not earn a nominal interest, the real rate of return on deposits is negatively affected by inflation. The size of this effect, or the size of the inflation tax on cash reserves, is $-\gamma\pi$. Hence, in equilibrium, the real rate of return on deposits is given by:

$$r_d = (1-\gamma)r_l - \gamma\pi \tag{3.12}$$

with r_d and r_l the net real deposit and net real loan rates, respectively.

3.2.3 Firms

Firms use only capital k in order to produce the consumption-investment good y with the technology specified by

$$y = Ak, \quad \text{with} \quad A > 0 \tag{3.13}$$

where A is the constant marginal product of capital, and firms face the following profit (Π_F) maximisation problem:

$$\max \Pi_F = \int_0^{\infty} [Py + P\dot{l} - (i_l - \frac{\dot{P}}{P})Pl - P\dot{k}]e^{-rt}\mathrm{d}t \tag{3.14}$$

subject to:

$$P\dot{k} \leq P\dot{l} \tag{3.15}$$

where $\dot{l}$ are new loans that firms take up from banks; l are real bank loans already received; $\dot{k}$ is the purchase of new capital that firms use in the production and r is the firms' discount rate. It should be clear from (3.15) that firms are finance-constrained, in the sense that new capital can only be purchased and accumulated by taking up new loans from the banks.

Moreover, since deposits are one-period contracts, loans are also strictly one-period contracts. Chari et al. (1995) show that with a binding financing constraint as in (3.15), the choice of r becomes irrelevant and hence the firm's problem reduces to a static one. A simplifying assumption that capital does not depreciate, or that $\delta = 0$, does not qualitatively change the results. Since firms rent capital only from the bank,[10] they will rent capital up to that point where the real rental rate of capital (or the real loan rate of the bank) equals the marginal product of capital. So, in equilibrium, the solution to the firm's problem is simply given by the expression for the real rental rate:

$$(i_l - \pi) = A. \tag{3.16}$$

So effectively, unlike in the textbook exposition where firms borrow directly from the household up to the point where the real rate of return on capital is equal to the marginal product of capital, here, with the firms borrowing from the bank, the marginal product of capital equals the real loan rate.

3.2.4 Government

There is an infinitely-lived government which keeps a constant money growth rate μ and redistributes the collected seigniorage, τ to the consumers as lump-sum transfer payments. Hence, the government's budget constraint is given as:

$$g = \tau = \mu m \tag{3.17}$$

[10] A portion of the capital can be rented by the firm directly from the depositor, as in Chari et al. (1995) and Basu (2001).

where

$$m = m_1 + m_2. \tag{3.18}$$

By definition, the law of motion applicable to real cash balances is

$$\frac{\dot{m}}{m} = \mu - \pi. \tag{3.19}$$

The treatment of government in this model is in the vein of Stockman (1981), Wang and Yip (1992), Chang et al. (2000) and more recently, Hosoya (2012)[11].

3.3 EQUILIBRIUM ALONG A BALANCED GROWTH PATH

Similar to Chang et al. (2000) and Chen and Guo (2009), we focus on the economy's balanced growth path (BGP) along which output, consumption, deposits and real money balances all grow at a common positive rate. However, it must be stressed that, there is no transitional dynamics in any case in this *AK* growth model. A BGP competitive equilibrium for the characterised economy is defined as a sequence of prices $\{i_l, i_d\}$, allocations $\{c, \beta, \rho\}$, stock of financial assets $\{d, m_1, m_2, k\}$ as well as policy variables $\{\tau, \gamma, \mu, g\}$ such that:

- Given τ, γ, ρ, i_d and i_l the depositor optimally chooses β, c and d such that (2.2) and (2.3) holds;

- Banks maximise profits subject to i_l, i_d and γ such that (2.12) holds;

- The equilibrium money market conditions, $m_1 = c$ and $m_2 = \gamma d$ hold;

- The loanable funds market equilibrium condition, $i_l = \frac{i_d}{(1-\gamma)}$ given the total supply of loans $l = (1-\gamma)d$, holds;

- The equilibrium goods market resource constraint, $y = c + i$ holds, where $i = (1-\gamma)\dot{d}$ and $y = Ak$;

[11] The introduction of monetary policy through a non-productive government sector setting a constant money growth rate, is a recognised monetary policy treatment – and is regarded as a 'simple' rule instead of an explicit Taylor rule or diffusion process – not only in the social status literature (Chen, 2012; and Hosoya, 2012), but also in the broader monetary model literature (Stockman, 1981 and Chang et al., 2000)

- The government budget constraint in (2.17) is balanced on a period-by-period basis;

- and d, m_1, m_2, i_l, i_d and A are positive.

From (3.5)-(3.7),[12] the endogenous inflation rate in this economy is given by:

$$\pi = \frac{1}{c\lambda} - \frac{\beta}{d\lambda} - (1 + r_d). \tag{3.20}$$

Now, updating (3.6) with the explicit value of π in (3.20), we can write the evolution of the shadow price of real money balances as:

$$-\frac{\dot{\lambda}}{\lambda} = \frac{\beta}{d\lambda} + (r_d - \rho). \tag{3.21}$$

Substituting (3.20) into (3.19), together with the binding CIA constraint from (3.3) expressed as $m_1 = c$, we rewrite the evolution of real money balances as:

$$\frac{\dot{m}}{m} = \mu - \frac{1}{m_1\lambda} + \frac{\beta}{d\lambda} + (1 + r_d). \tag{3.22}$$

Additionally, from the equilibrium condition for the goods market[13] and the binding CIA constraint $m_1 = c$, we have:

$$\frac{\dot{d}}{d} = A - \frac{m_1}{(1-\gamma)d}. \tag{3.23}$$

These expressions in (3.21)-(3.23) represent the set of dynamic equations with respect to λ, m_1 and d in our cash-in-advance economy.

Along a BGP, the growth rates of the shadow price, real money balances and deposits must be equal to the economy-wide steady-state growth rate, g^* and formally,

$$-\frac{\dot{\lambda}}{\lambda} = \frac{\dot{m}}{m} = \frac{\dot{d}}{d} = g^*. \tag{3.24}$$

Hence, from (3.21)-(3.24) we derive an explicit relation for the steady-state growth rate of this CIA, monetary endogenous growth economy characterised by wealth-induced social status preferences of consumers:

$$g^* = A - \frac{\rho + \gamma\mu}{(1-\gamma)[1 + \beta(1 + \mu + \rho)]}. \tag{3.25}$$

The result in (3.25) shows that in this economy, the steady-state growth rate depend on both the monetary policy instruments μ and γ, as well as the desire of consumers for social status, β. This is an extended, but similar result to the one found in Chang et al. (2000).

[12] See Appendix for detail on the BGP solutions.

[13] The standard goods market condition is given by $c + i = y$, but in this economy $i = (1-\gamma)\dot{d}$ results from the fact that $\dot{k} = (1-\gamma)\dot{d}$.

3.4 EQUILIBRIUM ANALYSIS OF MONEY GROWTH EFFECTS

As we are interested in the effects of monetary growth on the characterised economy, we have a set of possible growth outcomes that depend crucially on the parameter specification of the model. To examine the effect of monetary growth on the growth rate of the economy, we take the derivative of g^* with respect to μ, resulting in:

$$\frac{\delta g^*}{\delta \mu} = \frac{\beta(\rho + \gamma\mu) - \gamma[1 + \beta(1 + \mu + \rho)]}{(1-\gamma)[1 + \beta(1 + \mu + \rho)]^2}. \tag{3.26}$$

Next, we examine the complete set of four possible steady-state growth outcomes given monetary growth with respect to the parameters of interest in the model.

Case 1 *:* $\beta = 0$*;* $\gamma = 0$:

When there are no wealth-induced social status preferences or cash reserve requirements in the economy, (3.25) reduces to $g^* = A - \rho$. This is the same result, presented in Barro (1990) and Rebelo (1991), found in standard real economy AK-models and for $g^* > 0$, the assumption that $A > \rho$ or that the marginal product of capital must exceed the constant discount rate of consumers, must hold. More importantly, this result mimics the super-neutrality of money proposed in Sidrauski (1967) and further evidenced in Stockman (1981) and Abel (1985). Case 1 clearly implies that the long-run growth of the economy is completely independent of the money growth rate. Intuitively, this is the case because in the absence of the reserve-requirement, the nominal, and hence real, interest rates on loan and deposits are equal to each other. With the real interest rate on loans and thus, deposits, being equal to the constant marginal product of capital (A), the equilibrium growth rate is independent of inflation. In other words, higher money growth rate, resulting in an increase in inflation, would keep the growth rate unaffected as the real rate of return on deposits (and loans) is independent of inflation.

Case 2 *:* $\beta \neq 0$*;* $\gamma = 0$:

When wealth-induced social status preferences exist and consumers derive direct utility from not only consumption but also holding deposits for the sake of advertising their wealth, but there are no frictions in financial intermediation in the economy, (3.25) reduces to $g^* = A - \frac{\rho}{1+\beta(1+\mu+\rho)}$ and the relevant derivative becomes $\frac{\delta g^*}{\delta \mu} = \frac{\beta\rho}{[1+\beta(1+\mu+\rho)]^2}$, which is the Chang et al. (2000) result. As $\beta \geq 0$, or as long as there are social status preferences present in this economy, $\frac{\delta g^*}{\delta \mu} \geq 0$. This is due to a permanent increase in the growth rate of money, depressing real cash balances and by extension, consumption. A higher rate of money growth also increases the inflation rate, which raises the cost of holding money in advance, while the rate of return on capital is constant. Exaggerated by the spirit of capitalism, this provides incentive for the consumer to hold more deposits. Case 2 then confirms the Chang et al. (2000) findings and even the Mundell-Tobin effect, that any positive monetary growth will induce long-run growth.

Case 3 *:* $\beta = 0; \gamma \neq 0$:

When there are no wealth-induced social status preferences and consumers do not derive any direct utility from holding deposits other than for future consumption, but there are cash reserve requirements constraints in the economy, (3.25) is given by $g^* = A - \frac{\rho + \gamma\mu}{(1-\gamma)}$ and the relevant derivative is $\frac{\delta g^*}{\delta \mu} = -\frac{\gamma}{(1-\gamma)}$. As $\gamma > 0$, it must be that $\frac{\delta g^*}{\delta \mu} < 0$ and thus, any positive monetary growth will negatively effect long-run growth. The effect is observed through a deposit rate channel, since the real deposit rate is negatively affected by inflation, even though the real loan rate is still tied to the constant marginal product of capital. The disconnect between the real deposit rate and the real loan rate arises because of the cash reserve requirements, which, in equilibrium, creates a wedge between the deposit and the loan rates. Hence, due to a lower real rate of deposits following from higher inflation (due to higher money growth rate), agents substitute away from capital goods to holding real balances to finance current consumption. The resultant decrease in capital holdings has a negative effect on long-run growth.

Case 4 *:* $\beta \neq 0; \gamma \neq 0$:

When the economy is characterised by wealth-induced social status preferences and consumers derive direct utility from holding deposits, and simultaneously there is a competitive banking sector subject to a mandatory cash reserve requirement, both (3.25) and (3.26) hold as the equilibrium outcome of the economy. Given an increase in the monetary growth rate μ, the reserve requirement leads to a second, opposing effect in the presence of social status. The first effect results in substituting real money balances for capital goods as the cash-in-advance cost increases, and the desire for social status provides further incentive to hold more deposits that yields higher utility. The opposing effect is through a lower real rate on deposits, where μ negatively effects the real deposit rate. This results in substituting away from holding deposits to holding more real cash balances, besides the need to hold money to finance consumption. However, the main innovation is that the resultant steady-state growth rate being positive or negative, given positive monetary growth, is contingent on the size of γ. Using (3.26), we derive an explicit inequality for γ, which then fully determines the outcome of long-run growth in equilibrium:

$$\frac{\delta g^*}{\delta \mu} \lesseqgtr 0 \quad \text{if} \quad \gamma \gtreqless \frac{\beta\rho}{1+\beta(1+\rho)} = \gamma^*. \tag{3.27}$$

This implies that as long as the reserve requirement, γ exceeds a critical value, $\frac{\beta\rho}{1+\beta(1+\rho)}$ the relationship between the growth rate of the economy and the money growth rate, is negative. Note that, the critical value of γ is positively related to β and ρ, and that $\gamma^* < \rho$, which is of the order of 0.01-0.03, which immediately gives an idea about the order of magnitude of γ^* (numerically suggested below).

To gain some understanding of what this critical value could be, we provide a numerical analysis using a range of parametrisation values observed in Chen and Guo (2011) and Chen (2012) from the social status literature as well as in Karnizova (2010), respectively. The numerical values for β are 1; $0.8-1.2$; 0.83 and for ρ are 0.03; 0.025; 0.016, respectively. The critical values for γ can then be calculated and is given by $\gamma^* = 0.0148$; $0.011-0.0135$; 0.007. Moreover, when compared to current cash reserve ratios as detailed earlier, it is evident that the critical value(s) that γ must exceed are small and within the range when compared to those reserve requirement ratios typically applied by monetary authorities. Hence, the condition required for positive monetary growth to negatively effect the steady-state growth rate, is both plausible and easily met.

CHAPTER 4 OPENNESS AND GROWTH: IS THE RELATIONSHIP NON-LINEAR?

[1]

4.1 INTRODUCTION

> "From the purely economic point of view, nothing speaks against free trade and everything against protectionism." – Ludwig von Mises[2]

Contrary to the assertion by von Mises (1919) in his influential political economy works, almost 100 years on the empirical evidence on the relationship between general openness and economic growth remain mixed, at best. During the "Great Liberalisation", earlier seminal works on the positive link between trade openness (or some form of trade liberalisation) and economic growth include those of Dollar (1992), Edwards (1992, 1998), Sachs and Warner (1995), Frankel and Romer (1999) and Dollar and Kraay (2003).

More recently, using an array of modern econometric techniques and more robust measures of trade openness, the proponents of a positive trade–growth relationship still abound. Adsera and Boix (2002), based on empirical evidence of 65 countries over the period 1950 – 1990 finds that an increase in openness to trade promotes growth through an increase in the size of government, if the government directs increased expenditure towards public goods like infrastructure and human capital. Baltagi, Demetriades and Law (2009) find that both trade openness and financial openness lead to higher banking sector development, which decreases the cost of borrowing and improves the intermediation

[1] This chapter has been submitted to and is under review at: *The Journal of Policy Modelling*

[2] *Nation, State and Economy* (1919)

of capital. It is a readily–accepted fact that financial development is a crucial determinant for long–run growth.[3] The positive effect of trade on growth depends mainly on complementary reforms – such as educational investment, financial depth, inflation stabilization, public infrastructure, governance, labour market flexibility, ease of firm entry and ease of firm exit – as in Chang, Kaltani and Loayza (2009). But there have always been persistent cautionary voices in the earlier trade-growth nexus debate, most notably those of Feenstra (1996), Rodrik (1996), Doppelhofer, Miller and Sala–i–Martin (2000), Rodriquez and Rodrik (2001), Vamvakidis (2002) and Stiglitz (1999, 2003).

Certainly, in the aftermath of the 1990s Washington Consensus[4], the 2007 – 2009 global financial crises and the 2010-2011 *Eurozone* sovereign debt crisis, the nay–sayers found some justifiable momentum for their arguments against wholesale international integration. The negative effects stem from either an increase in cost related to product diversification or the marginal cost of innovating (Baldwin and Robert–Nicoud, 2008), or it depends on country–specific characteristics of some sorts like income profile, inflation or growth characteristics, country size and other geographical features as more clearly detailed in Serranito (2009), Dufrenot, Mignon and Tsangarides (2010) as well as Hur and Park (2012). It is this persistent contrasting evidence on the trade–growth link that necessitates the focal point of this paper – is the relationship between openness and growth actually non–linear?

Against this backdrop, the objectives of this paper are twofold: First, we use a two–sector Lucasian (1988) (human capital) endogenous growth model applied to a small, open economy characterized by *productive* government expenditure and external openness in the human capital accumulation function, to provide a novel and consolidated theoretical explanation of the existence of such a non–linear relationship between openness and growth; and, second, with the theoretical analysis presented yielding an empirically–testable equation relating openness with human capital and economic growth, we test the validity of the theoretical implications using a panel of 176 countries for the period 1980 – 2012 combining semi–parametric methods in the vein of Vaona and Schiavo (2007) with a spline regression function in the vein of Verardi and Dibarsy (2012). We augment this combined

[3] See Levine, Loayza and Beck (2000), Boyd, Levine and Smith (2001), Barth, Caprio and Levine (2004), Aghion, Bacchetta, Ranciere and Rogoff (2009) as well as Boyd and Jalal (2012) for compelling evidence of this.

[4] Probably at the time well–intended, even Williamson (2002) acceded that the terminology – and not necessarily the content – of his much–debated and divisive plan should disappear from modern economic vocabulary. We do not intend to argue the merits of the Washington Consensus here.

analysis with the inclusion of a new index of openness constructed by Dreher (2006).[5]

4.1.1 Theoretical considerations

Following Kang and Sawada (2000), we extend Lucas's (1988) human capital model to a small open economy and incorporate the role of openness directly in the human capital accumulation function of the form:

$$\dot{h} = \phi(E)(1-u_t)h$$

where $\phi(E)$ is the impact of "external openness" on human capital accumulation, $1-u_t$ is the time agents allocate to improving their own education, hence u_t is the labour time agents allocate to production and h is the initial stock of human capital. Openness (E)[6] leads to information spillovers, which may take the form of scientific advances and improvements. These efficient information/knowledge spillovers – positively linked to openness, as in Grossman and Helpman (1991), Edwards (1992) and Sachs and Warner (1995) – require highly–skilled human capital to get acquainted with these new technologies, and the formation of highly–skilled human capital is guaranteed due to higher future incomes. As this process increases the marginal benefit of human capital investment, shifting the marginal benefit curve of human capital accumulation upward, these more open economies experience higher growth rates. This implies that $\phi'(E) > 0$. This positive impact of human capital accumulation on economic growth is empirically confirmed by Benhabib and Spiegel (1994), Weinhold and Rauch (1997), Mingyong, Shuijan and Qun (2006), Chang, Kaltani and Loyaza (2009) and most recently by Benabdennour (2013), among others.

We further depart from the Lucas (1988) and Kang and Sawada (2000) framework by allowing government to play a productive role in the accumulation of human capital. In the spirit of Glomm and Ravikumar (1992), Bose, Haque and Osborn (2007) as well as Glomm and Rioja (2011) we augment the human capital accumulation function to reflect the impact of productive government expenditure on economic growth through the human capital channel. This changes the human capital accumulation

[5]Note that the KOF Index of Globalization constructed by Dreher (2006), was in response to traditional empirical measures of trade openness being highly collinear with other determinants included in growth regressions, and also trade–growth models suffering from omitted variable bias in the quest to deal with potential endogeneity issues.

[6]A first departure from Lucas (1988) is that we do not make any linearity assumption on the functional form of E.

function to the form:

$$\dot{h} = \phi(E)\theta_1(1-u_t)h$$

where θ_1 is the ratio of productive government expenditure to gross domestic product (GDP). Empirical justification for this augmentation is provided by Zeng (2003), Galor and Moav (2006), Ding and Knight (2011) and most recently by Basu and Bhattarai (2012). Government finances this productive expenditure by means of levying a proportional tax on output and collecting seigniorage revenue from printing money.

However, trade protection is normally associated with an increase in government size as eloquently stated in Abizadeh (2005), Spoalore and Wacziarg (2005) and Erauskin (2011). But since trade protectionism depresses income more than it does real money demand (due to the marginal propensity of money holding being < 1), the government's seigniorage revenue earned from printing money, increases as a percentage of gross domestic product (GDP) under a less open economy. Recalling that we allow government expenditure to be productive in the accumulation of human capital, then as an economy becomes more open, seigniorage revenue as percentage of GDP (and hence, total government revenue as percentage of GDP and by extension, productive government expenditure) decreases with a resultant decrease in human capital accumulation leading to a decline in growth.[7] This implies that $\theta_1' < 0$.

Hence, *a priori*, there exists a threshold level of openness beyond which openness negatively affects economic growth. This theoretical result is based on the two competing effects of openness on growth being contingent on the human capital accumulation function – one a direct effect of openness on human capital, the other an indirect effect of openness through a decrease of seigniorage income, which decreases government's productive expenditure on human capital accumulation.

4.1.2 Empirical considerations

Empirically, the trade/openness–growth debate has produced almost as many 'positive' as 'negative' results, with both outcomes robustly represented. Aside from those studies already mentioned herein,

[7] See for instance Bretschger (2010) for more detail on decreasing tax revenues due to openness. Another explanation for the decrease in government expenditure following trade openness, is a change in spending multipliers as detailed in Canzoneri *et al.* (2012).

we highlight only a few more recent studies[8] on both sides of the openness–growth debate.

Stiglitz (2003), albeit in a non–empirical way, listed *eight* channels through which globalisation, or the "New Economy", or broad openness adversely impacts on growth when the process is not well–managed. Vamvakides (2002) echoes his statement, providing supporting results from historical openness and growth figures for more than 60 countries over the period 1870–1990, and only find some significant (and then only some positive) openness on growth impacts from the 1970's onwards. Eriș and Ulașan (2013), employing Bayesian model averaging for 66 countries over the period 1960–2000 to study the trade openness–growth link, report that they find no evidence of a robust relationship between trade openness and economic growth in the long–run, despite using alternative measures of openness and accounting for model uncertainty.

On the 'positive' side, Dowrick and Golley (2004) report that an increase in trade does have "direct and substantial" benefits for growth, based on data over two 20–year periods, 1960–1980 and 1980–2000 using structural equations to measure the direct and the indirect impacts of openness on growth. Chang *et al.* (2009) also report a positive and significant impact of trade on growth, *if* [our emphasis] certain policies – complimentary to trade and openness, like infrastructure, labour markets and firms – are subjected to reforms. Lastly, Estevadeordal and Taylor (2008) found that if tariffs on capital and intermediate goods that are imported were liberalized, trade would have a significant and positive impact on growth.

An interesting and related current debate in the finance–growth literature, further calls for a more in–depth understanding of the impact of both trade and financial openness on the relationship between finance and growth. Rajan and Zingales (2003) are notable as some of the first proponents promoting a more open economy as an enhancer to the positive finance–growth relationship. More importantly, they report a positive correlation between the degree of trade openness and the level of financial development of a country. This is partially confirmed by Baltagi, Demetriadis and Law (2009), who finds that more closed economies will benefit more by opening up their economies, but that only one "type" of openness is required – financial or trade – to generate gains through financial development. Kim, Lin and Suen (2010) somewhat contradict these findings by reporting a dual impact of trade openness on financial development – a negative impact in the short–run and a positive impact only in

[8] See, for instance, Vamvakides (2002), Rodrik and Subramanian (2009) and Nannicini and Billmeier (2011) and the sources cited therein, for a thorough discussion of the relevant literature.

the long–run. Finally, Herwaltz and Walle (2014) conclude that financial openness and trade openness have vastly different impacts on financial development, and specifically state that a high degree of financial openness tends to erode the growth–promoting role of financial development, while a high degree of trade openness strengthens financial development.

However, the aim of this study is not to necessarily join one of the sides. We want to specifically analyse whether there exist any non–linearities in the openness–growth data, and given it's existence, detail the characteristics of such relationship guided by our theoretical finding.

A summary of select literature is provided in Table 4.1, and is not intended as an exhaustive list of studies reporting a non–linear relationship between openness and growth.

Table 4.1: Related studies on Openness–Growth non–linearities

Study	**O–G relationship**	**Method(s)**	**Key features**
Awokuse and Christopoulos (2009)	Positive	LSTAR and ESTAR	Confirms (positive) non–linearity in the export–growth relationship, with the ELG–hypothesis holding for Canada, Italy, Japan, UK and USA.
Kim, Lin and Suen (2010)	Positive for developed countries; negative for developing countries	Threshold regression with instrumental variables	Differential effects of trade on income depending on the level of economic development.
Lim and Ho (2013)	Undetermined	Non–linear cointegration tests and non–linear Granger causality	ASEAN–5 countries, failed to detect significant non–linearity in the causality relationship between export and GDP.
Cuaresma and Doppelhofer (2007)	Depends on model uncertainty and model size	Bayesian Averaging of Thresholds	Robust non–linearity of proportion of years economy is open between 1950 – 1994.
Eriș and Ulașan (2013)	No significant relationship	Bayesian Model Averaging	1960 – 2000 sample period, use vast number of openness measures
Dufrenot, Mignon and Tsangarides (2010)	Effect of openness on growth is higher in countries with low growth rates compared to those with high growth rates	Quantile regressions with Bayesian Model Averaging	Trade–growth nexus is stronger in those countries where the economic policies also drive the economic growth.

The rest of the paper is organised as follows: Section 4.2 describes the economic setting for our analysis; Sections 4.3, 4.4 and 4.5, respectively, defines the competitive equilibrium, solves the model for the steady–state growth rate and the optimal government expenditure ratio, discusses the empirical evidence obtained from our dataset against the current background.

4.2 THE ECONOMIC SETTING

4.2.1 Producer–Consumers

The producer–consumer representative[9] is an infinitely–lived, representative agent with unit mass who supplies labour inelastically. The perfect foresight consumer derives utility from consumption and money holdings in each period. The consumer wishes to maximize his intertemporal discounted lifetime utility, where the chosen constant relative risk aversion (CRRA) utility function is non-separable and defined over both consumption and money holdings. Formally, the consumer wants to maximize life–time utility:

$$U_0 = \int_0^\infty \frac{[c^{(1-\beta)}m^\beta]^{1-\sigma} - 1}{1-\sigma} e^{-\rho t} L dt \tag{4.1}$$

where $L = L_0 e^{nt}$ with L the amount of labour time allocated to production, $L_0 = 1$, ρ is the constant subjective discount rate, β is the weight in consumer preference for holding money implying that $1-\beta$ is the weight in consumer preference for consumption and σ is the (constant) intertemporal elasticity of substitution[10] between consumption bundles in any two periods. Consumer maximization is subject to an inter–temporal budget constraint in per capita form (upper case variables denote the aggregate level of the variable, while its lower case counterpart denotes the per capita level), of:

$$\begin{aligned} \frac{\dot{K}}{L} + \frac{\dot{M}}{PL} + \frac{\dot{B}}{L} &= rb + y - \tau y - c + v - (ex - im) \\ \frac{\dot{B}}{L} &= rb - (ex - im) \end{aligned} \tag{4.2}$$

where household wealth consists of holding three assets namely nominal money balance (M), aggregate capital stock (K) and net foreign debt (B) (a dot over a variable denotes the time derivative) . The balance of payments condition is given by $\frac{\dot{B}}{L} = rb - (ex - im)$, the net interest payments rb minus the trade surplus *ex-im* . *ex* and *im* is the per capita exports and imports, respectively and $\frac{\dot{K}}{L}$, $\frac{\dot{M}}{PL}$, $\frac{\dot{B}}{L}$ is per

[9]This treatment of the consumption and production decisions, being taken by one representative agent, is similar to the private sector set–up found in Minea and Villieu (2010).

[10]This characteristic is sufficient to ensure the existence of a balanced growth equilibrium.

capita capital accumulation, per capita *real* money balances accumulation and per capita net foreign debt accumulation, respectively.

Consistent with our focus on trade openness (recall von Mises's "protectionism"), we allow for perfect capital mobility. There are two simplifying assumptions imposed on the producer–consumer. Firstly, we set $\sigma = 1$, which is consistent with stable savings behaviour and ties the savings rate to the discount rate, as in Chen and Huang (2008). Moreover, as stated in Lucas (1988) the resultant inefficiency between the efficient and equilibrium growth rate of human capital, is small for values of $\gamma \simeq 0$. Secondly, we assume there is no population growth, or that $n = 0$.

4.2.2 Government

There is an infinitely–lived government which sets a constant money growth rate μ and a constant proportional tax rate of τ, and redistributes the collected seigniorage to the consumers as lump–sum transfer payments and spends productively on the human capital in the economy. Hence, assuming a government balanced budget holds for all periods, the budget constraint in per capita form is:

$$g + v = \tau y + \mu m \tag{4.3}$$

which states that the sum of per capita *productive* government expenditure (g) and lump–sum transfers (v) to consumers is equal to the sum of proportional tax revenues and seigniorage revenues.

The treatment of government here and the extension of the role it plays in human capital accumulation, is equivalent to that of Roubini and Sala–i–Martin (1992), Glomm and Ravikumar (1992), Kang and Sawada (2000), Holman and Neanidis (2006) and recently, Bittencourt, Gupta and Stander (2014).

Letting $g + v = R$, we define $g = \delta R$ and $v = (1 - \delta)R$ as the productive government expenditure share and the non–productive government expenditure share, respectively. We define the ratio of *productive* government expenditure to income as $\theta_1 = \frac{g}{y} = \delta \frac{R}{y} = \delta(\tau + \frac{\mu m}{y}) = \delta\theta$, where θ is the ratio of *total* government expenditure to income.

As the focus here is specifically on the seigniorage revenue of government in the presence of openness, we set $\tau = 0$ in solving the model.

4.2.3 Production Technology

Both physical and human capital are used in the production sector with the per capita production function assumed to be:

$$y = Ak^{\alpha}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma} \tag{4.4}$$

with A the typical technology parameter, u is the time allocated to the production of final output by the agent, endogenously determined by the optimisation behaviour of producer-consumers since they can only accumulate human capital by choosing to spend time in the accumulation effort[11]. h_a is the per–capita level of human capital available in the economy, and captures an external effect of human capital on productivity which does not depend on individual human capital accumulation decisions (see Lucas (1988) for a more detailed discussion on this).

In the analysis presented here, the social and private optimum coincide. Hence, we assume $\gamma = 0$ or that the external effect of the average level of human capital falls away, since a sustained growth rate is achieved whether the externality exists or not. Moreover, in equilibrium it must hold that $h = h_a$.

4.2.4 Human capital

As anticipated in the Introduction, we have the following human capital accumulation form:

$$\dot{h} = \phi(E)\theta_1(1-u_t)h \tag{4.5}$$

with $\phi(E)$, θ_1 and $(1-u_t)$ as already defined.

4.3 EQUILIBRIUM ALONG A BALANCED GROWTH PATH (BGP)

A BGP equilibrium for the characterised economy is defined as allocations $\{c, \beta, \rho, u, h, \delta\}$, stock of financial assets $\{m, k, b\}$ as well as policy variables $\{\tau, \mu, g\}$ such that:

- Given τ, μ, δ the producer–consumer optimally chooses c and u as well as asset holdings, m;

[11] This follows from Lucas (1988), based on the Uzawa-Rosen formulation. If no effort is devoted to the accumulation of human capital, then no human capital accumulates.

- The government budget constraint in (2.3) is balanced on a period–by–period basis;
- Market clearing requires that $h = h_a$;
- and k, m, δ, τ and u are positive for all periods.

Recall that $\sigma = 1$, $n = 0$, $\tau = 0$ and $\gamma = 0$. Then, rearranging the government budget constraint in the following way:

$$\begin{aligned} g + v &= \mu m \\ v &= -g + \mu m \end{aligned} \tag{4.6}$$

and considering that

$$g = \delta(\mu m) \tag{4.7}$$

one has

$$\begin{aligned} v &= -\delta(\mu m) + \mu m \\ v &= (1-\delta)\,\mu m \end{aligned}$$

Hence, we can rewrite (4.2) and (4.3) as:

$$\dot{k} + \dot{m} = y - c - \left[\pi - (1-\delta)\mu\right] m \tag{4.8}$$

and then set up the current value Hamiltonian to solve the producer–consumer's problem. In the vein of Itaya (1998), Kang and Sawada (2000), Walsh (2003) and Kam and Moshin (2006), we let $a = k + m$ represent household real wealth – which comprises both capital and money[12].

$$\begin{aligned} H_c &= ln(c^{1-\beta} m^{\beta}) \\ &\quad + q_1[Ak^{\alpha} u^{1-\alpha} h^{1-\alpha} - c - m\big(\pi - (1-\delta)\mu\big)] \\ &\quad + q_2[\phi(E)\theta_1(1-u)h] \end{aligned} \tag{4.9}$$

[12]This would imply that when we consider the first order conditions of the optimisation problems, specifically the FOC with respect to m, we will include the derivative of k (or the MPK). See both Walsh (2003) as well as Kam and Moshin (2006) for a thorough discussion of the treatment of this FOC when $a = k + m$.

with q_1 and q_2 the respective co–state variables. The control variables are c, m and u (the time spent in production), with k and h being the state variables, respectively.

The optimum conditions for the consumer's problem are given by the respective first–order conditions (FOC's) of:[13]

$$c : (1-\beta)c^{-1} = q_1 \tag{4.10}$$

$$m : \beta m^{-1} = q_1[\pi - (1-\delta)\mu - \alpha A k^{\alpha-1} u^{1-\alpha} h^{1-\alpha}] \tag{4.11}$$

$$u : q_1[(1-\alpha)A k^{\alpha} u^{-\alpha} h^{1-\alpha}] = q_2[\phi(E)\theta_1 h] \tag{4.12}$$

$$k : \rho q_1 - \dot{q}_1 = q_1[\alpha A k^{\alpha-1} u^{1-\alpha} h^{1-\alpha}] \tag{4.13}$$

$$h : \rho q_2 - \dot{q}_2 = q_1[(1-\alpha)A k^{\alpha} u^{1-\alpha} h^{-\alpha}] + q_2[\phi(E)\theta_1(1-u)] \tag{4.14}$$

Note that we define a steady state solution such that it must hold that $\frac{\dot{c}}{c} = \frac{\dot{m}}{m}$ and hence from (4.10), taking logs and time–derivatives we get:

$$\frac{\dot{q}_1}{q_1} = -z \tag{4.15}$$

where we define $z = \frac{\dot{c}}{c}$.

From (4.13), we also have:

$$\frac{\dot{q}_1}{q_1} = (\rho) - [\alpha A k^{\alpha-1} u^{1-\alpha} h^{1-\alpha}] \tag{4.16}$$

where the last term on the right–hand side is the marginal product of capital (MPK).
Focusing on the steady–state, namely when $\frac{\dot{q}_1}{q_1}$ and u are constants with respect to time[14], we take (4.13) and (4.14), and again taking logs and the time–derivative, we obtain an expression relating the growth rate of physical capital accumulation to human capital accumulation:

$$\frac{\dot{k}}{k} = \frac{1-\alpha}{1-\alpha} v \tag{4.17}$$

with $v = \frac{\dot{h}}{h}$ or the growth rate of human capital formation.

On a balanced growth path, $h = h_a$ is required to hold. Using (4.12), we derive the following expression:

$$\frac{q_1}{q_2} = \frac{\phi(E)\theta_1}{(1-\alpha)A k^{\alpha} u^{-\alpha} h^{-\alpha}} \tag{4.18}$$

[13]Optimisation solutions for the different economic agents are fully set out in the Appendix.

[14]Following the argument in Lucas (1988), the balanced growth path *by definition* is characterized by the fact that $\frac{\dot{q}_1}{q_1}$ is constant.

and from (4.14) together with (4.18), we get:

$$\frac{\dot{q}_2}{q_2} = (\rho) - \phi(E)\theta_1 \quad (4.19)$$

From (4.18), taking logs and derivatives and combining with (4.19), we have:

$$\frac{\dot{q}_1}{q_1} = (\rho) - \phi(E)\theta_1. \quad (4.20)$$

4.4 SOLVING THE MODEL FOR THE STEADY–STATE GROWTH RATE

The steady–state growth rate follows immediately from the agents optimisation problem, under the simplifying assumptions mentioned above.

Now, substituting (4.15) into (4.20) we derive the steady–state growth rate (where $\lambda = \frac{\dot{k}}{k} = \frac{\dot{c}}{c}$) as:

$$\lambda = \phi(E)\theta_1 - \rho \quad (4.21)$$

4.4.1 Solving the Government revenue ratio

From the government's budget constraint stated in (4.3), we have:

$$\theta = \frac{\mu m}{y} \quad (4.22)$$

The government expenditure component of this, θ, is then solved from:

$$(1+\delta)\theta = \frac{\mu\beta}{(1-\beta)(\mu+\rho)}\left[(1-\alpha) + \frac{\alpha\rho}{\phi(E)\delta\theta}\right] \quad (4.23)$$

with $\theta_1 = \delta\theta$, the *productive* government expenditure component following directly from the solution in (4.23).

From (4.23) it becomes clear that $\theta = f(\phi(E))$. Hence, there is a direct effect of openness on growth, as shown in (4.21), and there is an indirect effect of openness through productive government expenditure, since it is financed in our analysis exclusively through seigniorage revenue.

To gain some intuition regarding the effect of external openness on the ratio of total government expenditure, we decompose the relationship and then plot the left–hand side of (4.23) against the right–hand side of (4.23) in Figure 4.1 to analyse changes in θ, the government expenditure given changes in E, or external openness.

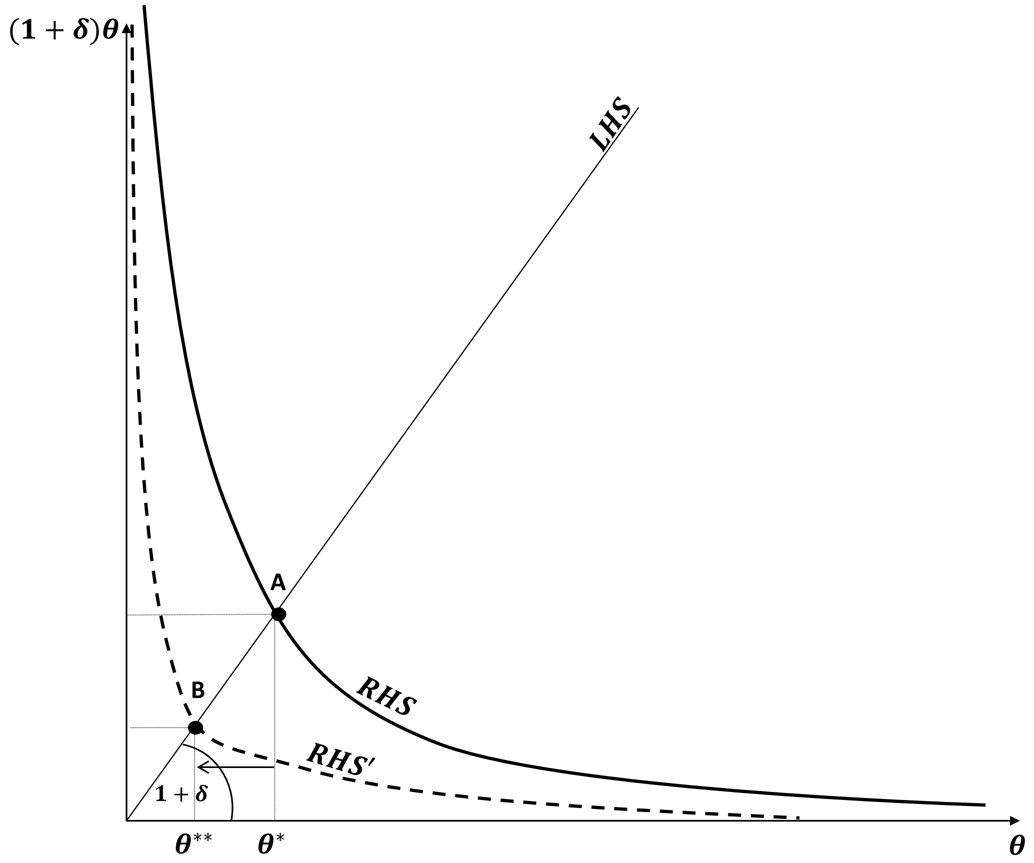


Figure 4.1: A plot of the decomposition of (4.23) to analyse movements in θ related to changes in E

The line *LHS* is the left–hand side of (4.23), with a slope of $(1+\delta)$ and the curve *RHS* is the right–hand side of (4.23), asymptotic to both axes since the *RHS* tends to infinity on the *y*–axis as $\theta \to 0$ and a fixed value on the *x*–axis as $\theta \to 1$. The shape of *RHS* is determined by the first and second derivative of the right–hand side of (4.23) with respect to ϕ, which is given by $-\frac{\mu\beta\alpha\rho}{(1-\beta)(\mu+\rho)\delta\theta\phi^2(E)} < 0$ and $\frac{2\mu\beta\alpha\rho}{(1-\beta)(\mu+\rho)\delta\theta\phi^3(E)} > 0$, respectively. Hence, the slope of curve *RHS* is negative, non–linear and becomes flatter ("smaller" in negative terms) moving from left to right. Using a basic calibration exercise – where all other variable values are held constant and only the value of openness is varied – we see that as openness increases, hence $\phi(E)$ increases as $\phi(E) > 0$, the curve *RHS* shifts to the left or closer to the origin. This effect is graphically depicted in Figure 4.1 as curve RHS', and the intersection point shifting from A to B. An increase in openness would therefore result in a lower ratio of government expenditure to income, as seen from the move of θ^* to θ^{**} in Figure 4.1.

Hence, as openness E increases, the human capital accumulation due to openness $\phi(E)$ increases causing the growth rate λ to increase, but simultaneously $-\frac{\mu\beta\alpha\rho}{(1-\beta)(\mu+\rho)\delta\theta^2\phi(E)}$ becomes steeper for a given E. So as the ratio of government expenditure to income θ decreases, the portion of *productive* government expenditure to income $\delta\theta = \theta_1$ decreases as well, and it follows that λ should decrease as well. Thus, there are two competing effects of an increase in external openness, E on the growth rate, λ.

4.4.2 Conditions for concavity or convexity

In the presence of these two opposing effects of external openness on growth, we gain a better understanding of the possible nature of the Openness–Growth relationship by examining the first, and then the second order derivatives of λ with respect to E:

$$\frac{d\lambda}{dE} = \phi'(E)\theta_1(E) + \phi(E)\theta_1'(E) = 0 \tag{4.24}$$

$$\phi'(E)\theta_1(E) = -\phi(E)\theta_1'(E) \tag{4.25}$$

$$\frac{\phi'(E)E}{\phi(E)} = -\frac{\theta_1'(E)E}{\theta_1(E)} \tag{4.26}$$

Hence, from the FOCs there exists an extreme point (minimum or maximum) of the growth function expressed in (4.21), characterized by the equality of the two elasticities above.

For concavity (convexity) of the function in (4.21) defined on an interval X, it must hold that for any $x \; \varepsilon \; X$, given that the derivative $f''(x)$ exists, $f''(x) \le 0$ ($f''(x) \ge 0$). The second order derivative of (4.21) is:

$$\frac{d^2\lambda}{dE^2} = \phi''(E)\theta_1(E) + \phi'(E)\theta_1'(E) + \phi'(E)\theta_1'(E) + \phi(E)\theta_1''(E) \tag{4.27}$$

From (4.27), for concavity (convexity) it must then hold that $\frac{d^2\lambda}{dE^2} < 0$ ($\frac{d^2\lambda}{dE^2} > 0$).

From the discussion herein, and based on the assumptions of the model we have $\theta_1'(E) < 0$ and $\phi'(E) > 0$, and hence, $\phi'(E)\theta_1'(E) < 0$. The uncertainty in determining concavity (convexity) therefore emanates from the characteristics of both $\phi''(E)$ and $\theta_1''(E)$. It is intuitive to assume that $\phi''(E) < 0$, namely that the marginal effect of openness on human capital accumulation is positive but decreasing. From an empirical point of view, it would be hard to think of openness as an explosive function, or $I(2)$ variable. But, to theorise this assumption would require choosing or obtaining a functional form for $\phi(E)$, which we do not endeavour to achieve here. We could also assume that $\phi''(E)$ is a constant, and more specifically that $\phi''(E) = 0$.

Both of these assumption would imply that concavity (convexity) depends solely on the characteristics of $\theta_1''(E)$, the speed at which productive government expenditure as a ratio to income changes as openness increases. From the government's budget constraint, it would therefore imply assuming specific values for the unknown parameter of income elasticity of money demand, since the government implements a constant money growth rate. It should be noted that for concavity (convexity), $\theta_1''(E) < 0$ ($\theta_1''(E) > 0$) **and** $|\phi(E)\theta_1''(E)|$ must be $> |\phi''(E)\theta_1(E) + 2\phi'(E)\theta_1'(E)|$.

However, since we do not wish to obtain and present theoretical results definitively with conjectural functional forms and specifying values to unknown parameters (like the elasticity of money demand and the share of capital in production) in the model, we instead rely on a semi–parametric, data–driven empirical approach following Vaona and Schiavo (2007) and Verardi and Debarsy (2012), augmented with a restricted cubic spline regression function to determine and test the exact nature of the Openness–Growth relationship.

4.5 THE EMPIRICAL SETTING

4.5.1 Data description and model matching strategy

Our sample period covers 1980 – 2011, and we initially collect data for 176 countries. Table 4.2 provides concise summary statistics of the main variables analysed in (4.33).

In analysing the proposed growth regression in (4.28), we use 4–year averages to account for business cycle fluctuations mainly because we are interested in the characteristics of the openness–growth relationship over the long–run. It is almost standard treatment in the growth literature to use 5–year averages to account for business cycle fluctuations when analysing long–run relationships. The selected 4–year average period used here, which deviates from the standard treatment, results in two more data

Table 4.2: Summary statistics of Main Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Growth	5064	0.018	0.06	-0.502	0.917
Openness	4903	47.669	18.031	12.257	92.836
Popgrow	5628	0.017	0.016	-0.073	0.191
Inflation	5196	0.109	0.181	-0.488	1
$\text{Investment}_{\text{GDP}}$	5162	23.323	11.203	0.692	93.637
$\text{Govex}_{\text{GDP}}$	5162	12.378	9.335	0.898	67.189
$\text{Education}_{\text{yrs}}$	5805	6.351	0.893	4	9
Capital Openness	5132	0.1	1.562	-1.875	2.422
$\text{Open}_{\text{X+Z}}$	5162	76.816	46.93	6.69	433.045
Terms_{gr}	3714	0.007	0.12	-0.623	1.181
Terms_{sd}	5808	20.901	18.864	0.9	82.989

points across our sample period, as compared to taking 5–year averages. Annual data, although with the advantage of more variation, may not capture the true underlying non–linear relationship between openness and growth due to volatility not related to the openness–growth relationship. Moreover, as shown recently by de Bruyn, Gupta and Stander (2013) it is the span of the data and not the frequency of the data that enhances econometric analysis.[15] As part of the robustness analysis, 4–year medians, 8–year averages and 8–year medians are also used.

However, our exact model–match sample selection strategy requires some detailed explanation. In setting up our theoretical model, we made two essential assumptions that have to be accounted for in our empirical analysis. The first, found in the section on the "Producer-Consumer", is that we allow for perfect capital mobility. This assumption dictates that we have to ensure that we select a sample of countries where the capital mobility is near–perfect or perfect. The Chinn–Ito (2008) capital account openness index, *kaopen* is the benchmark for our criteria. The data, updated to 2011, contains a capital account index for 182 countries over the period 1970–2011. The index value for any country in any year has been normalized to between $[-1.86; 2.44]$, with the lower bound representing those

[15] See Shiller and Perron (1985), Hakkio and Rush (1991), Otero and Simth (2000) and Rapach and Wohar (2004) for further discussion on this.

countries that are ‘least financially open’ and the upper bound representative of countries that are ‘most financially open’.[16]

Our inclusion-criteria, based on the Chinn–Ito index, is countries that have a *kaopen* index–value higher than the 75^{th} percentile[17] of the entire 4–year averaged dataset.

The second assumption, found in the section on the “Government”, is that we focus solely on seigniorage as the source of funding government expenditure – both productive expenditures and lump–sum transfers – and hence, set $\tau = 0$. This assumption narrows our selection of exact–model match countries to only those countries which are ‘open’, and which rely heavily on seigniorage to fund budget deficit (surplus). Again, we employ inclusion–criteria based on calculated values of 4–year averaged seigniorage for each country across the entire sample period. Both the 75^{th}– as well as the 66^{th}–percentile of the entire 4–year averaged dataset is used.

Using *budget* as an indication of government running a deficit or a surplus, where *budget*[18] is the cash surplus or deficit maintained by the government as a percentage of Gross Domestic Product (GDP) recorded in the World Development Indicators data base hosted by the World Bank, we first calculate seigniorage (defined as $seign_1$) and then the seigniorage/deficit ratio. We calculate $seign_1 = \frac{nmoney2_n - nmoney2_{n-1}}{ngdp_n}$ as the ratio of the level of seigniorage to GDP following Cukierman, Edwards and Tabellini (1992), where $nmoney2 = \frac{m_2}{exchangerate}$ as a measure of the stock of nominal money in comparable dollar–terms, and $ngdp$ being nominal GDP in dollar–terms. As a robustness check we also calculate and use $seign_3 = \frac{nmoney2_n - nmoney2_{n-1}}{gdpdefin_n}$ following Obstfeld (1989), where $gdpdefin$ is the GDP deflator index from the World Bank as a measure of the seigniorage extracted from the public through money creation, in real terms. Again, this measure is in comparable dollar–terms.

This exact model–match sample selection strategy allows us to test 16 different scenarios – implying that we have 16 different subsets of countries, not necessarily overlapping – encompassing a wide range of different possible model and country characteristics in our search for a non–linear relationship

[16] The Chinn–Ito index dataset is available from http://web.pdx.edu/~ito/Chinn-Ito_website.htmhttp://web.pdx.edu/~ito/Chinn-Ito_website.htm

[17] As a consistency check, the inclusion–criteria was extended to include countries with values higher than the 66^{th} percentile of the entire 4–year averaged dataset as well.

[18] When government revenue is more than expenditure, this measure is + to reflect a surplus and − to reflect a deficit when government expenditure is more than its income.

between openness and growth, although we report only some of the findings here that we believe elucidate our theoretical findings the best.[19]

Openness is our measure of the degree of openness (or globalization) of a country, and is based on the Dreher (2006) Globalization index, updated to 2009 by KOF Swiss Economic Institute. It is a weighted composite index of 23 different variables, grouped into 3 different categories: (i) an index of data on economic integration, with a weight of 36%; (ii) an index of data on political engagement, with a weight of 26%; and (iii) an index of data on social globalization, with a weight of 37%. These weights are allocated to the different categories and sub–indices following principal components analysis, with the weights determined to maximize the variation of the resultant principal component so that the indices capture the underlying variation of all variables as fully as possible. The Dreher (2006) index was constructed in response to the need for a more robust measure of openness, that simultaneously accounted for international economic, political, social and information flows along different dimensions whilst addressing the endogeneity problems that more traditional trade measures (exports, imports, exports + imports) suffered from in typical cross–country growth regressions at the turn of the millennium.[20] The final index is scaled from 1 to 100, with higher values indicative of more open countries.

Growth is the dependent variable, and calculated as the growth rate of GDP per capita in real terms.

We include a set of control variables that are standard in the growth literature[21], and data is collected from the World Bank's *World Development Indicators* (WDI). $GDP_{initial}$, the initial level of real GDP per capita at the start of each 4–year or 8–year period is included in the semi-parametric estimation as a measure of conditional convergence to the steady–state growth rate. *Popgrow* and $Education_{yrs}$ are included as proxies for human capital, the identified theoretical channel through which the one effect of the impact of openness on economic growth is non–linear. $Education_{yrs}$ is the number of years of secondary schooling. $Inflation$ is the difference in the GDP deflator index, as a measure

[19] However, the results across all 16 scenarios are consistent and match our theoretical findings. All additional results are available from the authors on request.

[20] See Dollar and Kraay (2001) and Bhagwati and Srinivasan (2002), among others.

[21] There are many text books and studies discussing the various determinants of economic growth. We refer the reader to any of Barro and Sala–i–Martin (2004), Aghion and Durlauf (2005) or Acemoglu (2008) for invaluable reading on the determinants of growth.

of macroeconomic stability. $Investment_{GDP}$ and $Govex_{GDP}$ is the share of private investment in real GDP per capita, PPP adjusted as a proxy for *per capita* capital stock, and the share of government consumption in real GDP per capita, PPP adjusted respectively. Government consumption also includes public expenditure on education, as the representation of the *productive* portion of government expenditure in Section 4.2.2. The latter is directly related to our theoretical model, as it represents the other competing effect of the impact of openness on economic growth. We also include an alternative and more traditional measure of openness, $Open_{(X+Z)}$ being the ratio of exports and imports to real GDP. Data for the last three variables are obtained from the *Penn World Tables* (PWT 7.1). Lastly, the growth in the terms of trade, $Terms_{gr}$ and the volatility in the terms of trade, $Terms_{sd}$ attempt to control for the possible impact that the relative price of exports in terms of imports may have.

4.5.2 The empirical methodology

We follow Verardi and Debarsy's (2012) semi–parametric framework for cross–country analysis, based on Robinson's (1988) double–residual estimator, to detect the non–linear impact of openness on growth. Let the general regression form be:

$$y_i = c_i + \beta_i X_i + f(z_i) + \varepsilon_i \tag{4.28}$$

where y_i is economic growth in country i, c_i is a constant term, X_i is a vector of control variables for each country discussed in Section 5.1 and $f(z_i)$ is the non–linear function with which the $Openness$ variable enters the relationship. ε_i is the disturbance term assumed to have a mean of zero and constant variance. A critical difference in our analysis compared to other semi–parametric or non–linear studies, is that our choice of non–linear variable is not based on an assumption or is not a "suspected" non–linear variable, but is informed by our theoretical model and more specifically, by (4.21) and (4.23). The semi–parametric part of the analysis entails that the conditional expectation, *given* that $Openness$ is non–linear, of each of the independent and dependent variables is subtracted on both sides and subsequently the β_i's, the coefficients of the control variables are then estimated from:

$$[y_i - E(y_i|z_i)] = [X_i - E(X_i|z_i)]\beta_i + \varepsilon_i \tag{4.29}$$

Since the known non–linearity in $Openness$ has been accounted for, Robinson (1988) shows that the estimates for β_i, $i = 1,2,3...N$ is $\sqrt{n}$–consistent, and akin to a feasible generalized least squares (FGLS) estimator. One could also interpret the Robinson (1988) double–residual estimator as an OLS estimation of the model:

$$y_i - \hat{m_y}(z_i) = [X_i - \hat{m_X}(z_i)]\beta_i + \varepsilon_i \tag{4.30}$$

with $[X_i - \hat{m_X}(z_i)]$ a vector of differences between each explanatory variable and the fitted conditional expectation of that variable, given that z_i (*Openness*) is non–linear. The main advantage of this estimation procedure for our purpose in this section, is it provides a fit of the non–linear relation between y_i and $f(z_i)$, as a non–parametric estimation of:

$$y_i - X_i\hat{\beta}_i = c + f(z_i) + \varepsilon_i \tag{4.31}$$

Of course, if ε_i is not $i.i.d.$, then standard sandwich and cluster variance adjustments can be implemented. This ensures that standard errors for the estimated parameters are reported that are resistant to both heteroskedasticity as well as clustered errors.

However, this semi–parametric procedure does not provide informative point estimates of the non–linear z_i.[22] We find point estimates of z_i by augmenting the semi–parametric estimation described here with a restricted cubic spline. Specifically, we estimate $f(z_i)$, the non–linear *Openness* variable with a restricted cubic spline of the form:

$$\begin{aligned} f(z) = {} & \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3 + \beta_4 (X - a_1)^3_+ \\ & + \beta_5 (X - a_2)^3_+ + \beta_6 (X - a_3)^3_+ \end{aligned} \tag{4.32}$$

where the plus functions $(X - a_i)^3_+$ have the value of $(X - a_i)$ if positive, and 0 otherwise. We restrict the cubic spline around three knots[23], $\{a_1, a_2, a_3\}$ such that we impose linearity on the function when $X < a_1$ and when $X > a_3$, and hence the X^2, X^3 terms should be eliminated. Plainly, we restrict the Growth–Openness relationship to be linear before the first knot, a_1 and after the last knot, a_3. This restriction ensures that the regression spline is stable and that our analysis does not suffer from Runge's phenomenon in that it excludes problematic (or trivial) non–linearities near the edges of the *Openness* data interval. Between the adjacent knots $\{a_1, a_2, a_3\}$, we fit piecewise cubic polynomial functions

[22] We use the **semipar** command package written by Verardi and Debarsy (2012) to execute this analysis in Stata. The package can be found at: http://fmwww.bc.edu/repec/bocode/shttp://fmwww.bc.edu/repec/bocode/s.

[23] Since cubic splines are sensitive to the number of knots and its placement, we follow the recommendation of Harrell (2001) and restrict the cubic spline strictly to only the interior of the *Openness* data interval, by selecting 3 knots corresponding with the 10^{th}, 50^{th} and 90^{th} quantiles of the data, respectively. For robustness, we implement this estimator using combinations of different number of knots with different placement. Our main results are not affected significantly, irrespective of the choice of number of knots and its placement. These are not reported but are available from the authors on request.

that are smooth and continuous at each knot, and have continuous first and second derivatives.[24] This ensures a smooth and continuous function with continuous slopes and curvatures.

Since we analyse the non–linear $Openness$ with a spline function of order three, we report two coefficient estimates, one for the slope of the Growth–Openness function before knot a_2, and one for the slope of this function after knot a_2. Based on our theoretical result, we would expect the slope prior to a_2 – or the first of the cubic spline coefficients – to be positive and the slope beyond a_2 – or the second of the cubic spline coefficients – to be negative. This implies that a_2, a value on the $Openness$–axis is a threshold–value partitioning the dual regime of the Growth–Openness relation as detailed in Section 4.

Our benchmark growth regression for both the semi–parametric and cubic spline estimations, is of the form:

$$\begin{aligned} Growth_i &= f(Openness) + \beta_2 GDP_{initial} + \beta_3 Popgrow \\ &+ \beta_4 Inflation + \beta_5 Investment_{GDP} + \beta_6 Govex_{GDP} \\ &+ \beta_7 Education_{yrs} + \beta_8 Terms_{gr} + \beta_9 Terms_{sd} + \varepsilon_i \end{aligned} \tag{4.33}$$

with $f(Openness)$ the non–linear function through which $Openness$ impacts $Growth$.

Lastly, to localize our analysis of this non–linearity in the Growth–Openness literature, we also compare the outcomes of our semi–parametric non–linear analysis with a parametric Fixed Effects (FE) non–linear panel data estimator, and employ a novel procedure to test the proposed non–linearity in the parametric Growth–Openness relationship. The U–test, developed by Lind and Mehlum (2010) and based on the largely unnoticed work done by Sasabuchi (1980), tests for the presence of U–shaped or inverted U–shaped non–linearity between two variables. For this FE estimator, we estimate the following:

$$\begin{aligned} Growth_i &= \beta_1 Openness + \beta_2 Openness^2 + \beta_3 Popgrow \\ &+ \beta_4 Inflation + \beta_5 Investment_{GDP} + \beta_6 Govex_{GDP} \\ &+ \beta_7 Education_{yrs} + \beta_8 TOT + \varepsilon_i \end{aligned} \tag{4.34}$$

[24] We implement this procedure in Stata using the **mkspline2** command available as an ado–file and contributed by Maarten L. Buis (2009). This command forms part of the **postrcspline** package and can be found at: http://fmwww.bc.edu/RePEc/bocode/phttp://fmwww.bc.edu/RePEc/bocode/p.

and then test the validity of the non–linearity captured by the *Openness* and $Openness^2$ terms. Specifically, we test if β_1 is + and β_2 is − over the interval of $[x_l, x_h]$, with x_l the lowest value of the data interval of *Openness* and x_h the highest value, respectively. We also test if the extreme value, say x_x is part of this chosen interval and present Fieller (1954) exact confidence intervals for this extreme point, and then finally test if there is indeed an inverse U–shaped relationship in the data represented by this quadratic regression form.[25]

The U–test differs from the more traditional – but less formal –"testing" for non–linearity that is commonly used in the growth literature, in that it does not rely on individually statistically significant positive and negative coefficients of β_1 and β_2, respectively but uses a joint hypothesis testing with a likelihood ratio approach developed by Sasabuchi (1980) to test if the slope of the function is positive and upward–sloping for β_1 at the start and negative and downward–sloping for β_2 at the end of a reasonable chosen interval of the data, $[x_l, x_h]$. To ensure that there is only one extreme point, the first derivative of the function is required to be monotone over the chosen interval.[26] We already know from our theoretical findings that there is one extreme point, depicted by (2.21). Based on the quadratic form we fit to the data in the parametric part of the analysis, this extreme point is $x_x = -\frac{\hat{\beta}_1}{2\hat{\beta}_2}$.

Essentially, this extreme value is the parametric counterpart of the threshold value in the semi–parametric and spline analysis, given by the second knot a_2. We include a discussion of the threshold knot of our restricted cubic spline and the extreme value of the parametric U–test in the result section.

The implementation process of the estimation procedure is detailed as follows: we start our analysis with the semi–parametric estimation on the sub–sample of countries that fits our sample–selection criteria (a complete list of countries included in each sub–sample is provided in Appendix B). In the first estimation, we include both country– and time–dummies to account for country–specific or time–specific effects that are significantly different than the average effect across the entire sub–sample and sample–period. Then, we re–run the semi–parametric estimation with only those countries and time–periods identified in the first estimation included, and those results are reported in Column *a*, for

[25] We implement this procedure in Stata with the **utest** package written by Lind and Mehlum (2010). The package can be found at: http://fmwww.bc.edu/repec/bocode/uhttp://fmwww.bc.edu/repec/bocode/u.

[26] We refer readers to the paper by Lind and Mehlum (2010) for all the technical details of the joint hypothesis and test statistics, as well as comparison of their test with some applied work. Further application of their test can be found in Arcand, Berkes and Panizza (2015).

each sub–sample of countries. This generates the semi–parametric (or non–linear) fit of the *Openness* variable on *Growth*, which are depicted graphically for each estimation.

Using the same sub–sample of countries, we estimate a restricted cubic spline function with *Openness* specified as the non–linear variable and again include country– and time–dummies in the first estimation. Consistent with our semi–parametric treatment, we estimate a restricted cubic spline regression with only those countries and time–periods, identified in the first estimation to be significantly different from the average effect, included. Additionally, using a leverage–versus–squared–residual plot, we graphically identify outliers for both country– and time–dimensions, and remove those specific outliers from the sub–sample to ensure that the results are not contaminated by these outliers or influential observations[27]. Since we restrict the cubic spline function around three knots, this generates two coefficients for the non–linear *Openness* variable, one before the threshold knot and one after. These results are then reported in Column *b*, for each sub–sample of countries. The cubic spline fit is again depicted graphically for each estimation.

Lastly, an additional procedure is added for our empirical estimation of the full sample of countries, where we report the fixed effects results with a non–linear treatment of *Openness*, modelled through adding a squared term of *Openness*. These results are reported in Column *c* for the full sample of countries. For all Columns *a–c*, robust standard errors are reported to account for possible heteroscedasticity.

4.5.3 Empirical results

4.5.3.1 4–year Results

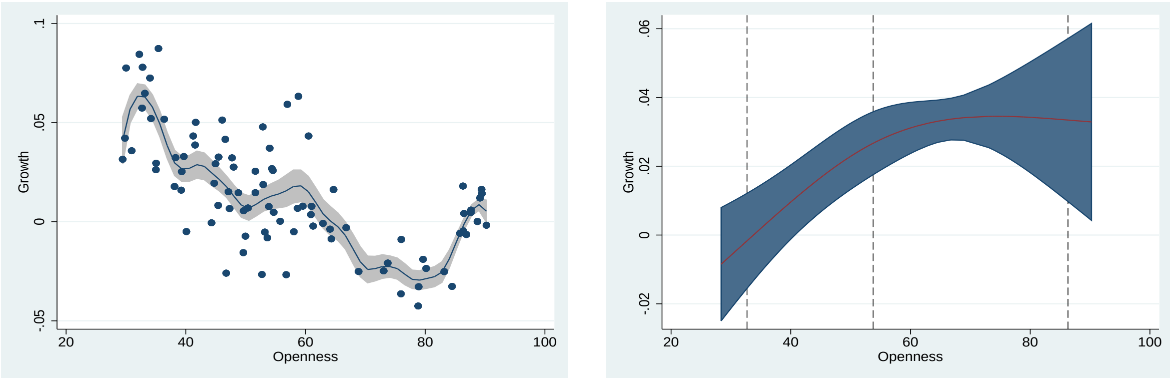
Table 4.3 contains the results from the exact model–match sample selection strategy, using the 4–year averaged data as described earlier[28].

The results should not be interpreted in a "line–by–line" fashion, as the context to each sub–sample of countries is critical in understanding the estimated coefficients, especially for column *a* throughout

[27] For each Column *b*, the dropped observations are stated and discussed in the results section.

[28] The detailed qualifying criteria and variables used in each sub–sample is explained in the footnote of Table 2.3.

the different sub–samples.[29] In general, the prevailing economy within which these estimates are generated, is one characterised by highly mobile capital and one where the government has a very high seigniorage–deficit ratio (or seigniorage–GDP ratio or seigniorage dependency, i.e. higher incentives to create more money). Moreover, these estimates are generated within a framework where it is *given* that *Openness* is non–linear and an inverted U–shape relationship is expected, but there is no clear *a priori* expectation of where in the distribution of the *Openness* scale a specific sub–sample of countries are located.



(a) Semi–parametric openness on growth with 18 qualifying countries

(b) Adjusted cubic spline function after removing outliers

Figure 4.2: Non–linear Openness and Growth: 4–year means

Panel *a* in Figure 4.2 clearly depicts the non–linear fit of *Openness* with *Growth* for our first sub–sample of 18 countries. As described earlier, there are no available point–estimates for *Openness*. The associated Hardle and Mammen (1993) test of the semi–parametric estimation suggests that the parametric and non–parametric fits are not significantly different. For the restricted cubic spline estimation – depicted in panel *b*[30] – the three knots corresponding to the 10th, 50th and 90th percentile are [32.69034; 53.75542; 86.3131], respectively and indicated by the dashed lines. The coefficient on the first spline, before the threshold knot a_2, is positive and statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is negative and statistically significant. The coefficients are roughly of similar magnitude, suggesting that the rate of *Growth* before and after the threshold value for *Openness* is broadly the same, and graphically the inverted–U holds.

[29]Furthermore, taking 4–year means (or medians) implies that there are 8 periods, being 1980 – 1983, 1984 – 1987, 1988 – 1991, 1992 – 1995, 1996 – 1999, 2000 – 2003, 2004 – 2007 and 2008 – 2011.

[30]Based on the leverage–versus–squared–residual plot, the outlying or influential observations for Chile during 1980 – 1983 and Qatar during 2000 – 2003, are dropped.

Table 4.3: 4–year Semi-parametric and Restricted Cubic Spline Regression Estimates

Variables	1a	1b	2a	2b	3a	3b	4a	4b
$GDP_{initial}$	-0.00000***	-0.00000***	-0.00000**	-0.00000***	-0.00001***	-0.00000***	-0.00000***	-0.00000***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Popgrow	0.11219	0.92068***	-0.47617***	-0.72705***	0.19922	0.06113	-0.21779	0.97167***
	(0.21909)	(0.21544)	(0.14764)	(0.10628)	(0.27375)	(0.28231)	(0.17006)	(0.20809)
Inflation	-0.09730***	-0.07717***	-0.07699***	-0.05153***	-0.07899*	-0.05631***	-0.09680***	-0.09445***
	(0.02252)	(0.01273)	(0.02414)	(0.01986)	(0.03789)	(0.01768)	(0.01281)	(0.01112)
$Investment_{GDP}$	-0.00020	-0.00162***	0.00106***	0.00148***	-0.00002	-0.00084***	-0.00085**	-0.00119***
	(0.00045)	(0.00025)	(0.00035)	(0.00021)	(0.00037)	(0.00029)	(0.00035)	(0.00025)
$Govex_{GDP}$	-0.00016	-0.00232***	0.00004	-0.00044	-0.00209**	-0.00260***	-0.00024	-0.00033
	(0.00049)	(0.00064)	(0.00059)	(0.00038)	(0.00083)	(0.00065)	(0.00024)	(0.00022)
$Education_{yrs}$	0.02379***	-0.02133***	-0.00330	-0.00382***	-0.01256	-0.01373***	0.01334***	0.02839***
	(0.00332)	(0.00626)	(0.00303)	(0.00136)	(0.00873)	(0.00488)	(0.00341)	(0.00236)
$Terms_{gr}$	-0.01795	0.13208***	-0.00679	-0.01633	0.03734	0.08401***	-0.03445	-0.03672*
	(0.03665)	(0.01970)	(0.03829)	(0.01915)	(0.04691)	(0.02125)	(0.04907)	(0.02095)
$Terms_{sd}$	0.00043	0.00054***	0.00007	-0.00013	0.00060	0.00024	0.00062**	0.00015
	(0.00034)	(0.00017)	(0.00023)	(0.00010)	(0.00037)	(0.00016)	(0.00029)	(0.00013)
Openness(Open) $Spline_1$		0.00157***		0.00072***		0.00039		0.00028*
		(0.00044)		(0.00021)		(0.00043)		(0.00015)
Openness(Open) $Spline_2$		-0.00145*		-0.00084***		0.00191**		-0.00067***
		(0.00081)		(0.00018)		(0.00079)		(0.00018)
N	364	356	416	396	396	388	336	320
R^2	0.690	0.646	0.522	0.569	0.629	0.516	0.685	0.776
Adjusted R^2	0.667	0.619	0.505	0.551	0.601	0.485	0.661	0.757
Hardle and Mammen T Test	1.762413		1.6294571		1.3459184		2.1018138	
	(0.11)		(0.12)		(0.24)		(0.02)	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Country- and Time dummies are suppressed to save space. Hardle and Mammen Standardized T-Test with associated p-values reported.

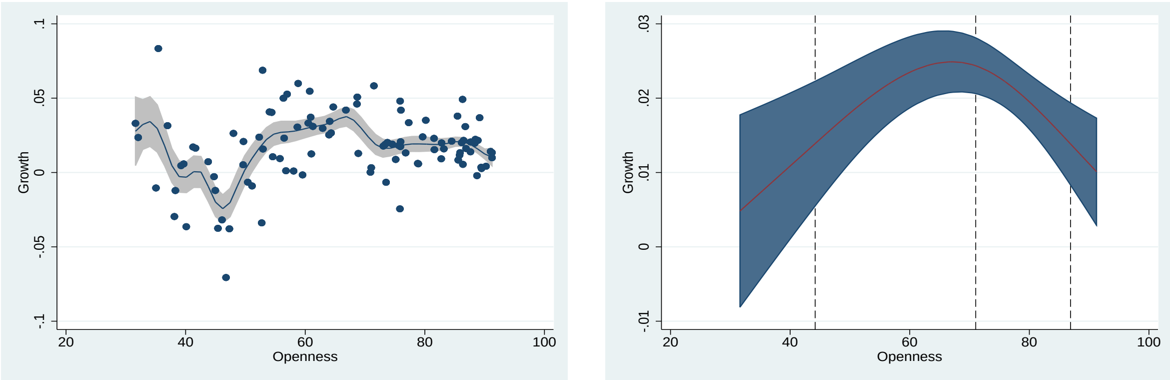
Column 1: 18 countries; 75*th* percentile *kaopen*; 75*th* percentile seigniorage/deficit ratio (Cukierman-type); *Openness*; 4–year means.

Column 2: 23 countries; 75*th* percentile *kaopen*; 75*th* percentile seigniorage/deficit ratio (Obstfeld-type); *Openness*; 4–year means.

Column 3: 19 countries; 75*th* percentile *kaopen*; 75*th* percentile seigniorage/deficit ratio (Cukierman-type); *Openness*; 4–year medians.

Column 4: 18 countries; 75*th* percentile *kaopen*; 75*th* percentile seigniorage/deficit ratio (Cukierman-type); $Open_{(X+Z)}$; 4–year means.

Panel a in Figure 4.3 again clearly depicts the non–linear fit of *Openness* with *Growth* for the sub–sample of 23 countries, using the Obstfeld–type seigniorage as the qualifying criteria. The associated Hardle and Mammen (1993) test suggest that the parametric and non–parametric fits are not significantly different. For the restricted cubic spline estimation (panel b), the three knots corresponding to the 10th, 50th and 90th percentile are $[44.18743; 71.03677; 86.89211]$, respectively. The threshold knot a_2 for

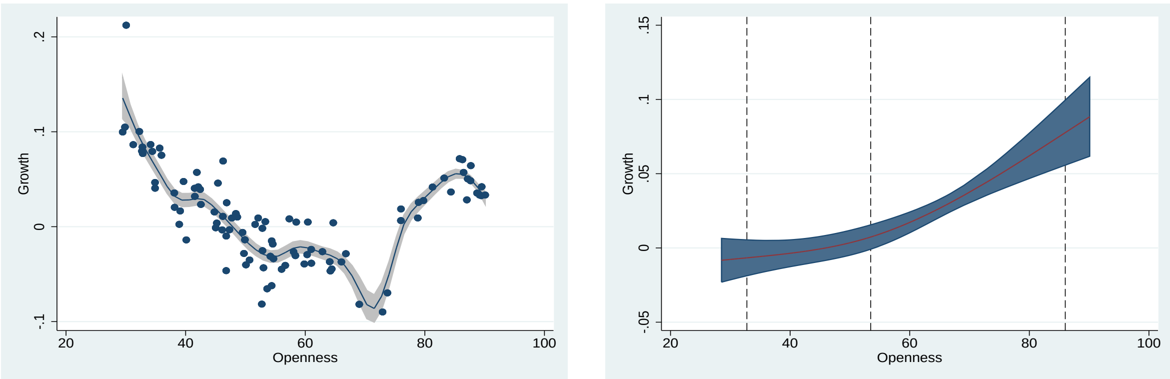


(a) Semi–parametric openness on growth with 23 qualifying countries

(b) Adjusted cubic spline function after removing outliers

Figure 4.3: Non–linear Openness and Growth: 4–year means

this sub–sample of countries is significantly higher than in sub–sample 1.[31] The coefficient on the first spline, before the threshold knot a_2, is positive and statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is negative and also statistically significant. Again, both coefficients are roughly of similar magnitude, and graphically the inverted–U holds.



(a) Semi–parametric openness on growth with 19 qualifying countries

(b) Adjusted cubic spline function after removing outliers

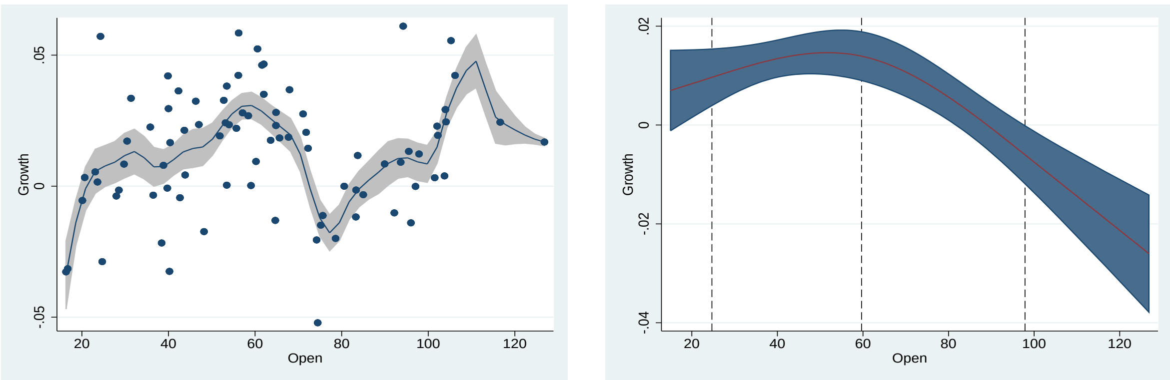
Figure 4.4: Non–linear Openness and Growth: 4–year medians

From Figure 4.4, the non–linear fit of *Openness* with *Growth* for this sub–sample of 19 countries based on the 75th percentile of the *median values*, is suggestive of the opposite relationship. Compared

[31] The leverage–versus–squared–residual plot identifies the outlying or influential observations as Peru during 1984 – 1987 and 1988 – 1991, Qatar during 2000 – 2003 (again), Trinidad and Tobago during 1984 – 1987 and United Arab Emirates during 2004 – 2007, and those are dropped.

to the first sub–sample reported in Column 1 of Table 4.3, it is not only the addition of Mauritius[32] that adds to the information set, but also the measure of the central tendency of the data. The element of ordering in computing the median values may well skew the distribution of our *Openness* and *Growth* variables, especially since there are high–growth economies (Hong Kong, Mauritius and Qatar) as well as extremely open economies (Canada, Denmark and Japan) included in this sub–sample.

Again, the associated Hardle and Mammen (1993) test suggest that the parametric and non–parametric fits are not significantly different. For the restricted cubic spline estimation (panel *b*), the three knots corresponding to the 10th, 50th and 90th percentile are [32.76994; 53.47794; 86.00994], respectively. The threshold knot a_2 for this sub–sample of countries is very close to the one obtained in sub–sample 1.[33] The coefficient on the first spline, before the threshold knot a_2, is positive but not statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is positive and statistically significant. In this sub–sample, graphically a U–shaped relationship holds.



(a) Semi–parametric *trade openness* on growth with 18 qualifying countries

(b) Adjusted cubic spline function after removing outliers

Figure 4.5: Non–linear Trade Openness and Growth: 4–year means

Although a clear non–linear fit of *Openness* with *Growth* is depicted for the first sub–sample of 18 countries, using the more direct trade measure $Open_{X+Z}$ in Figure 4.5, the form of the non–linearity is not initially apparent. This time, however the associated Hardle and Mammen (1993) test suggests there is a significant difference between the parametric and non–parametric fits. The restricted cubic

[32]The “Mauritius Growth Miracle” is well–documented, especially over our sample period, with average real growth exceeding 5% per annum over this period. See Svirydzenka and Petri (2014) for more detail.

[33]The leverage–versus–squared–residual plot identified the following outliers or influential observations, namely Liberia during 2000 – 2003 and Qatar during the same period, 2000 – 2003.

spline estimation is constructed around the respective three knots, [24.69711;59.66927;97.86832]. The threshold knot a_2 for this sub–sample of countries is completely different since it refers to a different measure of openness.[34] The coefficient on the first spline, before the threshold knot a_2, is positive and statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is negative and statistically significant. The expected negative effect is markedly stronger than the positive effect before the threshold knot. In this sub–sample, based on the more traditional measure of trade openness, graphically the inverted–U again holds.

4.5.3.2 8–year Results

Table (4.4) contains the results from the exact model–match sample selection strategy, using the 8–year averaged data as described earlier[35].

Again, the same cautionary explained earlier applies to the interpretation of the results listed in Table (4.4) in that these should not be interpreted in a "line–by–line" fashion.[36]

Panel *a* in Figure 4.6 clearly depicts the non–linear fit of *Openness* with *Growth* for our first sub–sample of 17 countries. The associated Hardle and Mammen (1993) test of the semi–parametric estimation again suggests that the parametric and non–parametric fits are significantly different. For the restricted cubic spline estimation – depicted in panel *b* – the three knots corresponding to the 10th, 50th and 90th percentile are [32.46357;53.78305;86.18161], respectively and indicated by the dashed lines.[37] The coefficient on the first spline, before the threshold knot a_2, is positive and statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is also positive and statistically significant. This would suggest that in this sub–sample there is strong support for the U–shaped relationship. Moreover, based on the coefficients reported in panel *b*, the positive effect before the threshold is dominated by the even stronger positive effect after the threshold, implying that

[34] In this instance, the leverage–versus–squared–residual plot identifies the outlying or influential observations to be dropped as Chile during 1980 – 1983, Qatar during 2000 – 2003 (yet again) and Trinidad and Tobago during both 2000 – 2003 as well as 2004 – 2007 (also, again).

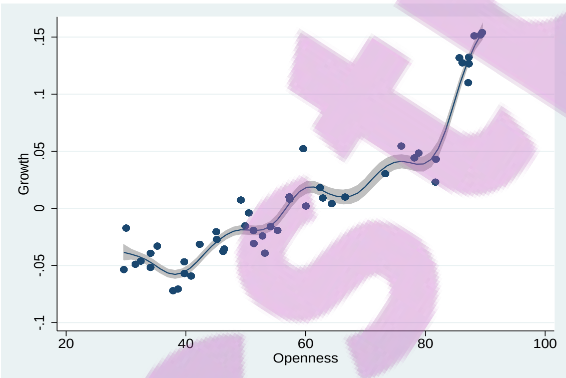
[35] The detailed qualifying criteria and variables used in each sub–sample is explained in the footnote of Table (4.4).

[36] Furthermore, taking 8–year means (or medians) implies that there are 4 periods, being 1980 – 1987, 1988 – 1995, 1996 – 2003 and 2004 – 2011.

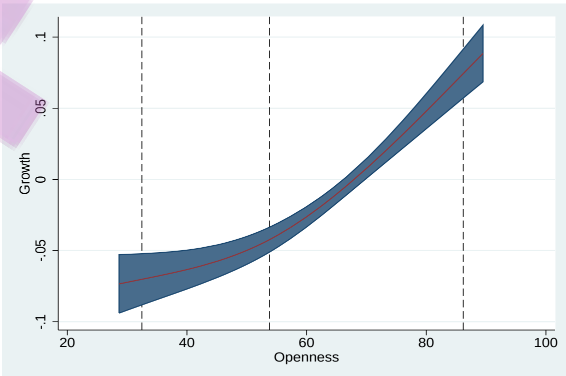
[37] Based on the leverage–versus–squared–residual plot, the outlying or influential observations for Guatemala during 1980 – 1987 and for Liberia during 2004 – 2011, are dropped.

for this sub–sample of countries further trade liberalisation reinforced its initial positive impact on these economies.

Since this sub–sample of countries is the only sub–sample that offers clear evidence of a *Trade–Growth* relationship contrary to the rest of our findings, it warrants a discussion. This sub–sample, after removing the outliers based on the leverage–versus–squared–residual plot, contains countries such as Canada, Denmark, Hong Kong, New Zealand, Singapore and Switzerland where the services sector are the largest contributor to output (although New Zealand has an established agricultural processing and trade industry and Denmark has a well–developed manufacturing industry, both countries also have a thriving tourism sector). It also includes strictly small, completely open island economies like Cyprus, Trinidad and Tobago and Vanuatu (aside from the other islands being Hong Kong, New Zealand and Singapore) – islands that are heavily dependent on a tourism sector. This group also includes Chile, Liberia, Nicaragua and Peru – countries that are heavily dependent on the export of their natural resources, like copper, iron ore, coffee and gold (although Chile boasts a sizeable services sector as well). This group of countries, save for the small island economies and one or two exceptions, are also big economies with some of the highest GDP per capita in the world, higher than average Human Development Index rankings as well as educational attainment. A plausible reason for observing the U–shape contra–effect here, given the theoretical framework provided in Section (4.4.2), is that the marginal benefit of human capital investment in these economies is high enough to sustain continued increases in productive government expenditure.



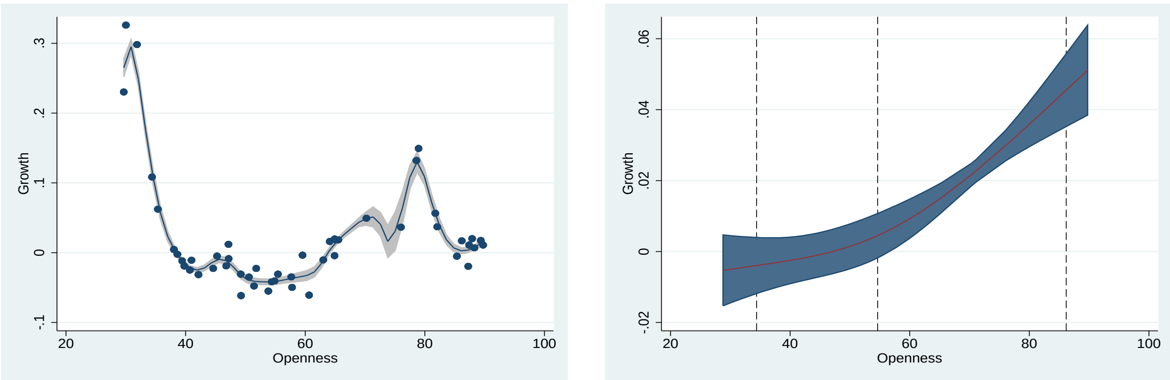
(a) Semi–parametric openness on growth with 17 qualifying countries



(b) Adjusted cubic spline function after removing outliers

Figure 4.6: Non–linear Openness and Growth: 8–year means

From Figure 4.7, the non–linear fit of *Openness* with *Growth* for this sub–sample of 18 countries based on the 75th percentile of the *median values*, is apparent. The associated Hardle and Mammen (1993) test again suggests that the parametric and non–parametric fits are significantly different. For the restricted cubic spline estimation (panel b), the three knots corresponding to the 10th, 50th and 90th percentile are [34.38634;54.63613;86.17198], respectively. Unlike the comparison when using 4–year means and medians, the threshold knot a_2 for this sub–sample of countries using 8–year means and medians is only slightly higher than in sub–sample 1.[38] The coefficient on the first spline, before the threshold knot a_2, is positive but not statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is positive and statistically significant. In this sub–sample, again there seems to be an acceleration after the threshold, and graphically the U–shape holds.



(a) Semi–parametric openness on growth with 18 qualifying countries

(b) Adjusted cubic spline function after removing outliers

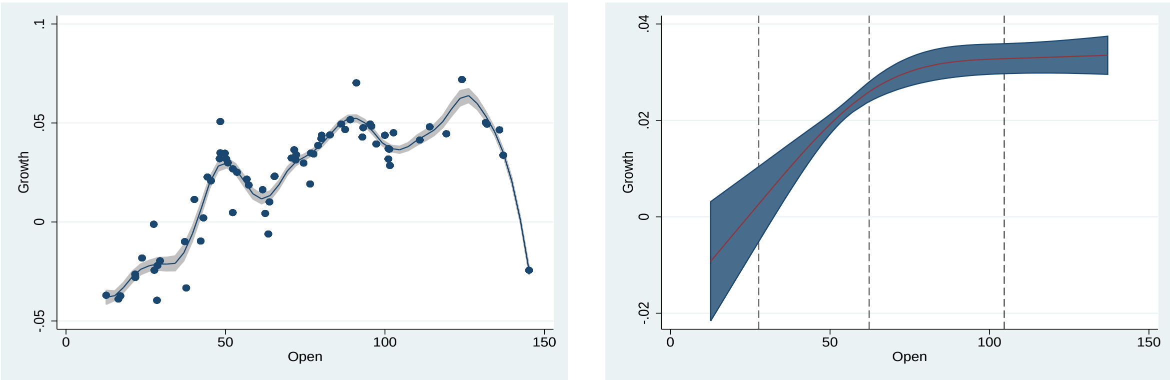
Figure 4.7: Non–linear Openness and Growth: 8–year medians

For sub–sample 3 in Table (4.4), Figure (4.8) clearly depicts the non–linear fit between *trade openness* and growth, using the more conventional trade measure, $Open_{X+Z}$. This sub–sample of 29 countries is based on the Obstfeld–type seigniorage measure, and the inclusion criteria is extended to include the 66th percentile of the *median values*. In this sub–sample, the associated Hardle and Mammen (1993) test suggests that the parametric and non–parametric fits are significantly different. For the restricted cubic spline estimation (panel b), the three knots corresponding to the 10th, 50th and 90th percentile are [27.69407;62.24104;104.5931], respectively.[39] The coefficient on the first spline is

[38]The leverage–versus–squared–residual plot identifies the outlying or influential observations as Liberia during 1980 – 1987 and 1996 – 2003, Nicaragua during 1980 – 1987 and Qatar during 2004 – 2011, and those are dropped.

[39]The leverage–versus–squared–residual plot identifies the outlying or influential observations as Trinidad and Tobago during 1980 – 1987 as well as 1996 – 2003 and United Arab Emirates during 2004 – 2011, and those are dropped.

positive and statistically significant, and the coefficient on the second spline is negative and statistically significant, suggesting that the inverted–U holds for this broader sub–sample. Graphically, however the relationship suggests rather a drastic slowdown of the positive effect after the threshold than an outright reversal, or opposing effect kicking in.



(a) Semi–parametric *trade openness* on growth with 29 qualifying countries

(b) Adjusted cubic spline function after removing outliers

Figure 4.8: Non–linear Trade Openness and Growth: 8–year medians

Across all sub–samples, the negative and statistically significant coefficient of $GDP_{initial}$ confirms some form of convergence implied by neoclassical growth models and some form of "club–convergence" or conditional convergence, as proposed in Sala–i–Martin (1996), although the speed of convergence among the countries in these sub–samples is nowhere near the 2% reported in Sala–i–Martin (1996). Interestingly, the two–sector endogenous growth model presented here with perfect capital mobility does seem to predict at least some conditional convergence, albeit agonizingly slow, in contrast with the findings in Barro, Mankiw and Sala–i–Martin (1995) that a one–sector model of endogenous growth can not predict convergence irrespective of the level of capital mobility.

Inflation is negative and statistically significant across all sub–samples of countries. These results accord with the well–established notion that price stability (or macroeconomic stability) as measured by lower levels of inflation or, at the least, predictable levels of prices, are conducive to economic growth.[40] However, more related to these findings are the results documented in Boyd, Levine and Smith (2001) on the negative impact inflation has on financial sector activity (since the countries in the sub–samples reported here are all highly open in terms of capital mobility, which requires

[40] See Brito and Bystedt (2010), López-Villavicencio and Mignon (2011) as well as Bittencourt, Gupta and Stander (2014) for empirical evidence on this in a non–linear or threshold setting.

conducive financial institutions), the results presented in Barro (2013) on the depressing effect of inflation on investment activities as well as the results documented in Chu and Lai (2013) reporting the negative impact of inflation on the *R&D* sector, since the identified channel for the negative part of the non–linear *Openness–Growth* relationship is through human capital. The interpretation of the negative coefficient of inflation on economic growth (in *per capita* terms) is therefore not necessarily a direct decrease in growth, but rather a slowing down of growth rates of the countries in the sub–sample due to the sub–optimal allocation of resources taking place through the financial sector, as well as the detrimental effect of inflation on the accumulation of human capital through the *R&D* sector.

The next set of results cannot be discussed without pausing first, to understand where in the distribution of the openness measurements these countries are. The countries included in Table 4.3 and Table 4.4 are highly open in terms of capital mobility, and are located – relative to the mean and median values of openness for all countries (see Table 4.1) – to the right in the distribution of both the openness measures. This would imply that, based on the theoretical indication for the existence of some threshold value that partitions the effect of openness on growth into two regimes, the countries analysed here have already transitioned beyond that threshold, on average. The subsequent results presented will further highlight why the consideration of the non–linear effects of openness on growth, is crucial in thinking about the possible policy implications related to "opening up" economies even more.

$Terms_{gr}$ and $Terms_{sd}$ as part of the control set, seem to be economically significant explanatory variables in the specification reported here, although these variables are not always statistically significant. The growth in the terms of trade and its standard deviation was included as a way of accounting for the relative price effects of export and imports during trade. The statistically significant and in most cases positive estimates of the growth in the terms of trade, accord with the empirical literature. These results reinforce that if there is any improvement in the average terms of trade for these countries, in the long-run, the impact on the average growth rate is likely to be positive. For the volatility in the terms of trade, the results are less clear. Over the 4–year averaged sub–samples, it would seem as if the uncertainty in relative prices actually supports economic growth, given that *Openness* is non–linear. However, for the 8–year averaged sub–samples the situation is reversed, implying that the increased uncertainty around the ratio of export and import prices, depresses growth.

$Investment_{GDP}$, as the proxy for per capita capital stock is negative and statistically significant for growth for three of the four sub–samples over a 4–year horizon in the context of this non–linear setting.

Moreover, over the longer 8–year horizon there is a clear, non–trivial and statistically significant negative impact across all sub–samples of $Investment_{GDP}$ on growth. This may be due to existing high levels of per capita capital stock in these countries, or (more likely) due to these countries having high levels of capital mobility, any increase in capital formation creates future obligations that may adversely impact these highly open economies more. However, we propose a three–fold interpretation that stems directly from our theoretical model: a) to increase per capita capital stock, workers allocate more labour time to production which implies they spend less time accumulating human capital, which leads to less than the required increase in future ability to adopt new technologies and since both physical and human capital accumulation is required to ensure growth, the net impact of "working harder" and "studying less" is negative; b) the decision to "work harder" takes place within a declining (and even negative) savings rate environment which implies that even more per capita capital stock should be accumulated just to maintain the existing capital stock net of depreciation and the labour growth – leaving even less time available to allocate towards the accumulation of human capital; and c) an artefact of these highly open economies is migratory patterns incentivised by an observed higher h_a, or Lucas's external effect of human capital, in other countries where workers rationalise that they are more productive in economies where the existing per capita level of human capital is highest, irrespective of their own initial stock of human capital. This erodes both the physical and the human capital stock in those economies with observed or perceived lower per capita levels of human capital.

$Govex_{GDP}$, per capita government expenditure – both productive and unproductive – has a consistently negative and statistically significant impact on growth. The well–known "bigger governments are bad for growth" does not really apply here. The interpretation here is twofold: a) the composition of government expenditure is biased more towards consumption and infrastructure investment expenditure than to human capital or productivity enhancing expenditure. This is quite evident when you regard the structurally declining government expenditure on education to GDP ratio that is observed globally, specifically in the tertiary education sector; and b) in these highly open economies, the composition of government revenue includes a seemingly ever–increasing public debt component coupled with a seemingly ever–decreasing tax revenues component. In short, highly open economies are collecting less tax revenues which necessitate raising more debt. With the exception of a few economies, all governments finance an increasing portion of their expenditure by raising more debt in highly open and well–developed capital markets.

$Education_{yrs}$ and $Popgrow$, representing the accumulation of human capital from our theoretical model – providing both a quantity and quality measure of human capital – should be interpreted simultaneously. $Education$ yields mixed results over both the 4–year and 8–year horizons. In this non–linear setting, further human capital accumulation (or the quality of human capital) seems to be depressing growth as much as it stimulates growth. This could most likely be attributed to a delayed effect of more education or higher quality human capital, since the immediate or contemporaneous effect of more time allocated to the accumulation of human capital is a contraction in output due to less time being allocated in production. However, this trade–off is largely offset by the impact of $Popgrow$ (or the quantity of human capital) that is positive and statistically significant for growth in this non–linear environment. Contingent on the migratory incentives already discussed, an increase in the quantity of human capital positively contributes to an increase in output in highly open economies.

4.5.3.3 Full Sample Results

Table (4.5) contains the semi–parametric and restricted cubic spline results for the full sample of countries over the period 1980 – 2011, as well as the parametric fixed effects results for the full sample as described earlier.

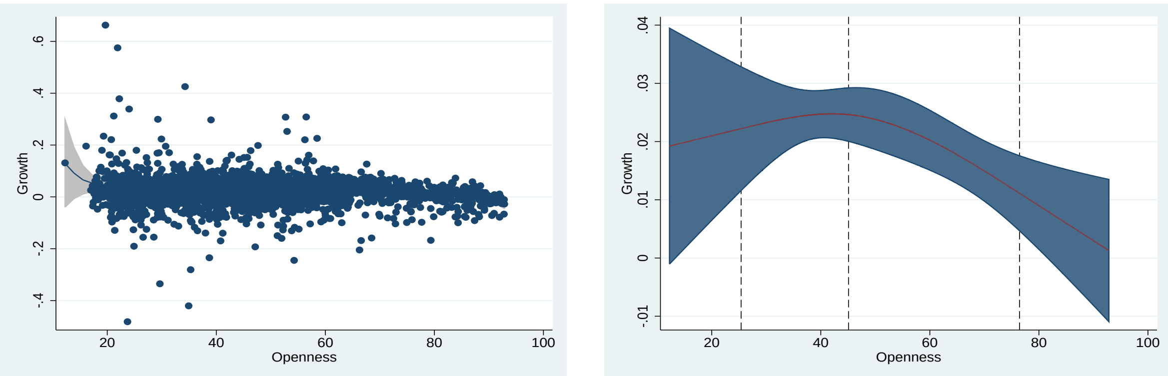
From Figure 4.9, the non–linear fit of $Openness$ with $Growth$ for the entire sample of 176 countries is clear. The associated Hardle and Mammen (1993) test for Column $1a$ in Table (4.1) with a standardised T–statistic of 2.2752962 and associated p–value of 0.01, again suggests that the parametric and non–parametric fits are significantly different. For the restricted cubic spline estimation (Column $1b$), the three knots corresponding to the 10th, 50th and 90th percentile are [25.384352; 45.08202; 76.446973], respectively. For all countries, on average, the threshold knot a_2 of the broad $Openness$ variable is well below the midpoint value of the Dreher (2006) Globalization index. This is interesting in itself, since it implies that for all countries included in the index the positive effect of $Openness$ on $Growth$ is only maintained the "less" open they are, or conversely the more closed they become.[41]

The coefficient in $1b$ on the first spline, before the threshold knot a_2, is positive but not statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is negative but not

[41]The leverage–versus–squared–residual plot identifies the outlying or influential observations as Armenia during 2003 and 2006, Equatorial Guinea during 1997 and 2001, Rwanda during 1994 as well as United Arab Emirates during 2001 and 2002, and those are dropped.

statistically significant. Graphically, the inverted–U shape holds as depicted in panel *b* of Figure (4.9). In Column 1*c*, the parametric fixed effects (FE) coefficients for the *Openness* variable is positive, statistically significant and of magnitude 0.00232. For a given 10% increase in the Globalisation index value, there is a 0.02% increase in the per capita growth rate. The FE coefficient on the non–linear term of the *Openness* variable is negative, statistically significant and of magnitude 0.00002. This would suggest that there is a threshold, beyond which the positive impact of having a more open or globalised economy dissipates.

The Lind–Mehlum (2010) U–test provides further insight into and reinforces previous results. The U–test is statistically significant with an associated p–value of 0.0285 and a t–statistic of 1.92, suggesting that the relationship between *Openness* and *Growth* is indeed inverted–U shaped. Moreover, the slope of the continuous *Openness* function at the lowest bound of the entire data interval is positive and statistically significant at 1% and hence, the function is increasing while the slope of the same continuous function at the highest bound of the entire data interval is negative and statistically significant at 5% and hence, the function is decreasing. Lastly, the extreme point or the threshold for the *Openness* variable is contained within the constructed 95% Fieller confidence interval, and is given as 61.37. In short, the *Openness* function is upward sloping at the start of the data interval up to the threshold value, but is downward sloping at the end of the data interval. The extreme value beyond which the sign of the slope in the function switches, is also contained within the data interval. Hence, the *Openness–Growth* relationship is a non–linear, inverted–U relationship.



(a) Semi–parametric and Parametric Openness and Growth: Full sample

(b) Adjusted cubic spline: Full sample

Figure 4.9: Non–linear relationship between Openness and Growth, 1980–2009

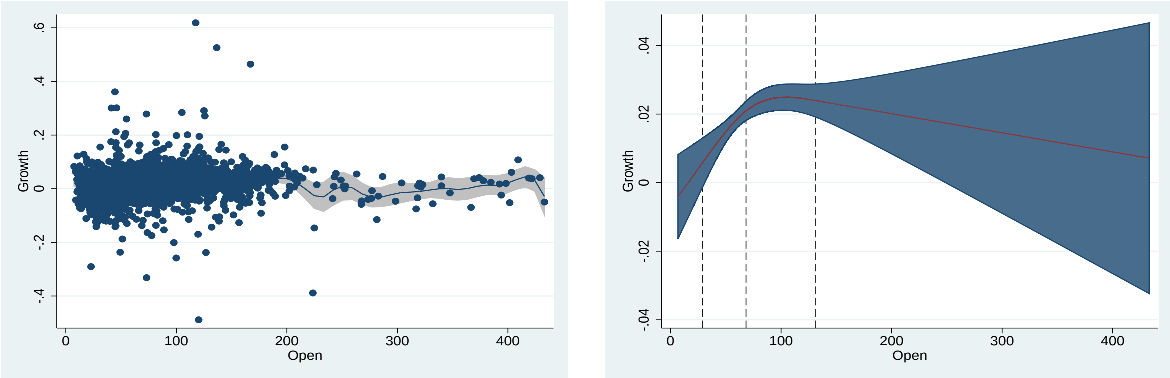
Even more robust evidence in support of the non–linear inverted–U relationship between openness and growth emerge when the more traditional trade openness measure is used. From Figure 4.10, the non–linear fit of $Openness$ with $Growth$ for the entire sample of 176 countries is clear. The associated Hardle and Mammen (1993) test for Column 2a in Table (4.5) with a standardised T–statistic of 1.544477 and associated p–value of 0.15 is suggestive of a parametric and non–parametric fit that are not significantly different. For the restricted cubic spline estimation (Column 2b), the three knots corresponding to the 10th, 50th and 90th percentile are [29.09108;68.2863;131.3601], respectively. The threshold knot a_2 of the traditional $Open_{(X+Z)}$ variable is well below the mean value of trade openness for the entire sample of countries. This is again interesting in itself, since it implies that for all countries the positive effect of trade openness on $Growth$ is only maintained as long as the exports and imports ratio to GDP is less than 68.3%. To appreciate the importance of this, we note that in 2010 there were 115 of the total 176 countries with trade measures higher than the threshold value. 61 of those countries had trade measures comfortably exceeding 100% of GDP. [42]

The coefficient in 2b on the first spline, before the threshold knot a_2, is positive and statistically significant, while the coefficient on the second spline, after the threshold knot a_2, is negative and statistically significant. Graphically, the inverted–U shape strictly holds as depicted in panel b of Figure (4.10). In Column 2c, the parametric fixed effects (FE) coefficients for the $Open_{(X+Z)}$ variable is positive, statistically significant and of magnitude 0.00027. For a given 10% increase in the Globalisation index value, there is a 0.003% increase in the per capita growth rate. The FE coefficient on the non–linear term of the $Open_{(X+Z)}$ variable is negative, statistically significant but economically insignificant. Again, this would suggest that there is a threshold, beyond which the positive impact of having a more open or globalised economy dissipates.

The Lind–Mehlum (2010) U–test again reinforces previous results. The U–test is statistically significant with an associated p–value of 0.0313 and a t–statistic of 1.87, suggesting that the relationship between $Open_{(X+Z)}$ and $Growth$ is indeed inverted–U shaped. Moreover, the slope of the continuous $Openness$ function at the lowest bound of the entire data interval is positive and statistically significant at 5% and hence, the function is increasing while the slope of the same continuous function at the highest bound of the entire data interval is negative and statistically significant at 1% and hence, the function is decreasing. Lastly, the extreme point or the threshold for the $Open_{(X+Z)}$ variable is contained within the

[42] The leverage–versus–squared–residual plot identifies the outlying or influential observations as Equatorial Guinea during 1997 and 2001, Iraq during 2003 and 2004 as well as Rwanda during 1994, and those are dropped.

constructed 95% Fieller confidence interval, and is given as 207.39. In short, the $Open_{(X+Z)}$ function is upward sloping at the start of the data interval up to the threshold value, but is downward sloping at the end of the data interval. The extreme value beyond which the sign of the slope in the function switches, is also contained within the data interval. Hence, the $Open_{(X+Z)}$–$Growth$ relationship is a non–linear, inverted–U relationship.



(a) Semi–parametric and Parametric Trade and Growth: Full sample

(b) Adjusted cubic spline: Full sample

Figure 4.10: Non–linear relationship between Trade Openness and Growth, 1980-2009

In this large panel of 176 countries, the expected empirical relationship detailed in much of the literature on economic growth, holds. $Inflation$ is negative and statistically significant for growth, as is $Popgrow$ as well as $Govex_{GDP}$ which is in line with recent findings by Barro (2013), among others. $Education$ and the volatility in relative export prices $Terms_{sd}$, both have an indeterminate impact on per capita growth. The very large disparities in the quality of human capital across the 176 countries here is largely responsible for the insignificant results, albeit most of the coefficients on $Education$ are positive. An improvement in the terms of trade, $Terms_{gr}$ has a positive and statistically significant impact on per capita growth. This result is not surprising, but as pointed out by Barro (2013) can be mostly attributed to increases in either productivity or factor utilisation stemming from higher relative export prices. As a panel, these countries are not subject to a Zero Lower Bound rate environment on average, which implies that the accumulation of per capita capital stock has the desired positive impact on growth. Significantly, $Seigniorage$ is positive and statistically significant in panel 2c, which somewhat supports the contention that since it is a source of government revenue and therefore funds expenditure, an increase in this type of revenue is likely to have a mild positive effect on growth.

Table 4.4: 8–year Semi-parametric and Restricted Cubic Spline Regression Estimates

Variables	1a	1b	2a	2b	3a	3b
$GDP_{initial}$	-0.00000***	-0.00000***	-0.00000**	-0.00000***	-0.00000***	-0.00000***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Popgrow	5.44277***	4.85663***	1.83259*	0.35142	0.25486	0.48841***
	(1.08651)	(0.33397)	(0.95318)	(0.24623)	(0.15251)	(0.05056)
Inflation	-0.08033***	-0.08187***	-0.13884***	-0.06193***	-0.03991**	-0.06830***
	(0.02350)	(0.01128)	(0.03476)	(0.00766)	(0.01829)	(0.01294)
$Investment_{GDP}$	-0.00228***	-0.00204***	-0.00203**	-0.00132***	-0.00166**	-0.00027
	(0.00052)	(0.00019)	(0.00095)	(0.00022)	(0.00063)	(0.00018)
$Govex_{GDP}$	-0.00318**	-0.00386***	-0.00739***	-0.00382***	-0.00214***	-0.00195***
	(0.00112)	(0.00042)	(0.00190)	(0.00048)	(0.00062)	(0.00028)
$Education_{yrs}$	0.03367***	0.01037***	-0.04449**	-0.01658***	-0.01557***	-0.00583***
	(0.00952)	(0.00224)	(0.01699)	(0.00284)	(0.00413)	(0.00175)
$Terms_{gr}$	0.22351**	0.17512***	0.36908***	0.14684***	0.00250	0.00317
	(0.10216)	(0.01881)	(0.11385)	(0.02226)	(0.02621)	(0.01001)
$Terms_{sd}$	-0.00033	-0.00040***	-0.00187***	-0.00026	-0.00027	0.00006
	(0.00035)	(0.00012)	(0.00057)	(0.00018)	(0.00029)	(0.00007)
Openness(Open) $Spline_1$		0.00085**		0.00024		0.00079***
		(0.00041)		(0.00028)		(0.00016)
Openness(Open) $Spline_2$		0.00289***		0.00113**		-0.00057***
		(0.00053)		(0.00049)		(0.00013)
N	384	368	400	368	568	544
R^2	0.853	0.819	0.735	0.732	0.781	0.790
Adjusted R^2	0.845	0.807	0.720	0.714	0.769	0.777
Hardle and Mammen T Test	2.2539158		2.2352021		1.9410027	
	(0.03)		(0.04)		(0.05)	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Country- and Time dummies are suppressed to save space. Hardle and Mammen Standardized T-Test with associated p-values reported.

Column 1: 17 countries; 75th percentile $kaopen$; 75th percentile seigniorage/deficit ratio (Cukierman-type); $Openness$; 8–year means.

Column 2: 18 countries; 75th percentile $kaopen$; 75th percentile seigniorage/deficit ratio (Cukierman-type); $Openness$; 8–year medians.

Column 3: 29 countries; 66th percentile $kaopen$; 66th percentile seigniorage/deficit ratio (Obstfeld-type); $Open_{(X+Z)}$; 8–year medians.

Table 4.5: Semi–Parametric and Spline Regression Estimates for full sample and Parametric Fixed Effects with U–test

Variables	1a	1b	1c	2a	2b	2c
Popgrow	-0.55187***	-0.70796***	0.05118	-0.35564**	-0.48169***	0.01720
	(0.15651)	(0.16275)	(0.51765)	(0.15281)	(0.09575)	(0.49108)
Inflation	-0.04310***	-0.04530***	-0.07929***	-0.05156***	-0.04372***	-0.07745***
	(0.01026)	(0.01018)	(0.01337)	(0.01153)	(0.01119)	(0.01284)
Investment_{GDP}	0.00114***	0.00100***	0.00070***	0.00099***	0.00082***	0.00057***
	(0.00025)	(0.00020)	(0.00025)	(0.00021)	(0.00019)	(0.00022)
Govex_{GDP}	-0.00070*	-0.00039	-0.00158***	-0.00113***	-0.00102***	-0.00162***
	(0.00035)	(0.00028)	(0.00053)	(0.00030)	(0.00026)	(0.00048)
Education_{yrs}	0.00092	0.00082	-0.00134	0.00195	0.00136	-0.00133
	(0.00231)	(0.00223)	(0.00373)	(0.00261)	(0.00261)	(0.00359)
Terms_{gr}	0.05791***	0.06235***		0.05431***	0.05603***	
	(0.00970)	(0.01154)		(0.00819)	(0.00937)	
Terms_{sd}	-0.00022	-0.00016		0.00037	0.00032*	
	(0.00017)	(0.00015)		(0.00023)	(0.00018)	
Openness(Open) Spline_1		0.00023			0.00045***	
		(0.00039)			(0.00012)	
Openness(Open) Spline_2		-0.00072			-0.00044***	
		(0.00048)			(0.00014)	
Openness(Open)			0.00232***			0.00027*
			(0.00068)			(0.00014)
Openness(Open)^2			-0.00002***			-0.00000**
			(0.00001)			(0.00000)
Seigniorage			0.00004			0.00005*
			(0.00003)			(0.00003)
N	3,014	3,007	4,134	3,256	3,251	4,393
R^2	0.143	0.165	0.116	0.203	0.234	0.103
Adjusted R^2	0.120	0.142	0.108	0.171	0.203	0.100
U-test			1.92**			1.87**
Slope X_l			.0018572***			.0002579**
Slope X_h			-.0011901**			-.00029***
Extreme Point			61.36642			207.394
Fieller 95% CI			[41.851; 94.739]			[-47.096; 290.519]

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Country- and Time dummies are suppressed to save space.

CHAPTER 5 ENDOGENOUS FLUCTUATIONS IN AN ENDOGENOUS GROWTH MODEL: AN ANALYSIS OF INFLATION TARGETING AS A POLICY

[1]

5.1 INTRODUCTION

"Economic progress, in capitalist society, means turmoil." – Joseph A. Schumpeter[2]

In this paper, we develop a monetary endogenous growth overlapping generations model with inflation targeting, characterised by production lags, to analyse growth dynamics. The growth process is endogenized by allowing for productive government expenditure on infrastructure[3] in the vein of Barro (1990). Money is introduced through an obligatory reserve requirement, set by government and

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[2]*Capitalism, Socialism and Democracy* (1942)

[3]The infrastructure referred to here, comprises typical government activities that stimulate firm activities, such as highways, railways, water systems, power systems, police and fire services, and courts. For simplicity, we will assume that there is no congestion as in Barro and Sala-i-Martin (1992) and the infrastructure provided is a non-rival public good for firms.

imposed on the banking system, which otherwise operate in a perfectly competitive environment[4]. Moreover, instead of the standard money growth rule set by the monetary authority, we assume that the monetary authority implements an inflation-targeting (IT) regime across both generations. This assumption introduces growth dynamics into the model that yield results much richer than those presented by related works of Michel (1993), Chetty and Ratha (1996), and Gupta (2011), which we discuss below in detail.

The motivation for this paper stems largely from the initial findings in Michel (1993), the subsequent analysis detailed in Chetty and Ratha (1996) and finally, Gupta (2011) who studies growth dynamics in a similar OLG model with no money or productive government expenditure, but rather using firm-specific and per capita economy-wide capital input. In this setting, endogenous convergent fluctuations emerge due to the lagged production input, where the speed of the convergence is determined by the marginal product of labour given the initial value of the gross growth rate. The Chetty and Ratha (1996) findings, that growth is feasible in an OLG model with production lags if the productivity of capital is sufficiently high and borrowing is for capital services only, and not to finance wages in advance as well, is not only contradictory to the well-known Jones and Manuelli (1990) result – that growth rates in an OLG model with convex production is bounded above by zero, and hence, sustained growth is not feasible – but it also highlights the crucial impact of the time-structure of production on the economic growth rate.

Due to the technology used in Chetty and Ratha (1996) being of the Solow (1956)-type, and hence, the results pertaining only to exogenous growth processes determined by the population growth, there was no implication for endogenous growth processes in a setting where the time-structure of the production process is altered. In this sense, the Chetty and Ratha (1996) findings suffer from the same drawback as any Solow (1956)-type model, in that it lacks the ability to explain the non-zero growth in the per-capita standard of living in steady-state observed in the data. The Gupta (2011) findings do extend the impact

[4]This is a standard treatment of money in the literature. See Bittencourt, Gupta and Stander (2014) as well as Gupta and Stander (2017) and the references cited therein, for a detailed account of the related literature and the motivation for this treatment of money. Alternatively, we could have introduced money through a cash-in-advance constraint as in Kudoh (2007). However, our results would remain unchanged, as long as we either assume the parameterization of the utility function is such that either savings is positively related to the interest rate or is inelastic with respect to the interest rate. However, in the former case, where the savings function is positively related to the interest rate, no closed-form solutions are obtained and we need to linearize equations. Introducing money through the cash-reserve requirement allows us to avoid these complications without any loss of generality.

of lagged production inputs to endogenous growth processes, however the economic environment presented therein included a Romer (1986)-type production technology and did not include a role for money, and hence, a role for monetary policy.

Complimentary to the theoretical motivation, Day (1983) provides a more philosophical reminder:

> ...concerned with the emergence of erratic fluctuations in economic growth processes, fluctuations of a highly irregular or unstable nature termed "chaotic" in the mathematical literature, that emerge *endogenously* [own emphasis] through the interplay of technology, preferences, and behavioural rules alone, with *no exogenous interference* [own emphasis] from stochastic shocks.

The model developed by us, albeit in an OLG framework, could be compared to the "time-to-build" model of Kydland and Prescott (1982), and the "vintage capital" infinitely-lived, representative agent model of Benhabib and Rustichini (1991). The first comprehensive survey on indeterminacy of equilibriums in OLG models, was provided by Woodford (1984). Quite clearly, the endeavour to understand the impact of production lags and growth dynamics across two different strands of the literature is not new.[5] Though, the use of lagged inputs is not as prevalent in analysing growth processes as perhaps it should be, especially in the theoretical[6] growth literature where the use of contemporaneous capital and labour inputs are almost the standard treatment. This could perhaps largely be attributed to a concern first shared in Fabbri and Gozzi (2008), that "...the introduction of vintage capital allows to explain some growth facts, but strongly increases the mathematical difficulties". Fabbri and Gozzi (2008) then proceed to analyse fluctuations using the Maximum Principle as well as Dynamic Programming.

[5] Since the seminal work of Kalecki (1935) on production lags and business cycles, the study of the impact of different types of lags (including production lags) has been the intense focus of a vast literature. Note that, although Jevons (1835-1882) has been credited with opening the discussion on production lags and cycles in output whilst it was more likely Hearn (1826-1888) who first broached the concept, it was in fact Kalecki who formally analysed this first in his 1935 paper, "A Macrodynamic Theory of Business Cycles" published in *Econometrica*. Noteworthy contributions analysing the impact of various forms of lags on theoretical issues relating to prices, markets, investments, and cycles, among others include those of Goodwin (1947), Mayer (1960), May (1976), Kydland and Prescott (1982), Day (1983), Grandmont (1985) and again, Goodwin (1990).

[6] In the empirical literature, however, the standard inclusion of lags of the growth process in the modelling of growth dynamics could be seen as a *de facto* attempt to account for the impact of lagged inputs on the growth process.

In contrast, we follow a simpler tract in analysing growth fluctuations that are generated endogenously. The theoretical OLG model presented here is developed along the lines of Gupta (2011). However, we extend this analysis by allowing for the role of money and hence, monetary policy as well as productive government expenditure and we include a role for the banking sector. Furthermore, introducing an inflation targeting regime ties the optimal growth rate to the inflation target, which allows for a deeper understanding of the role of monetary policy on the equilibrium growth path and endogenous fluctuations in the characterised economy.

More closely related to the discussion in this paper are the studies of El-Hodiri, Loehman and Whinston (1972) who are the first to introduce lags into a model of optimal growth; Benhabib and Day (1982) who characterize wide classes of utility functions which generate erratic dynamics in an overlapping generations OLG model; Reichlin (1986) who uses the Hopf bifurcation theorem to detect stable or unstable equilibrium trajectories where the determining parameter of the bifurcation is the technological externality to the production process; Galor and Ryder (1991) who study the dynamic efficiency of equilibria in an OLG model; Michel (1993) who shows that the growth rate of the economy oscillates on a transitional path if capital used in production is *not* contemporaneous; Matsuyama (1999) who finds that economic fluctuations are driven by periods of high investment or periods of high innovation; Kitagawa and Shibata (2001) who show that investment gestation lags cause permanent cyclical movements in the *level* of national income without a production technology; and lastly Kitagawa and Shibata (2005) who develop a simple OLG model with investment gestation lags and find that if the production technology is of the AK-type, the existence of investment lags causes permanent cyclical fluctuations in the growth rate. But, as indicated above, we deviate primarily in highlighting the importance of monetary policy, and in particular, the role played by the size of the inflation target in causing growth fluctuations.

The rest of this paper is organised as follows: Section 5.2 defines the economic environment that comprises of representative consumers, banks, producers and a productive government. In these sections, we also solve the optimization problem of each of the agents. Once the optimization is solved, in Section 5.3, we characterise the equilibrium of the economy along a balanced growth path (BGP), along which all real variables grow at the same rate. In Section 5.4, we then examine the growth dynamics of the characterised economy, highlighting the possibility of multiple equilibria, indeterminancy and growth fluctuations to the extent that chaos might emerge under certain conditions. Section 5.5 presents associated policy implications of our results, whereby we also indicate the ways to avoid chaotic growth dynamics by the appropriate choice of the size of the inflation target.

5.2 THE ECONOMIC SETTING

Time is divided into discrete segments and indexed by $t = 1, 2, \ldots$. The principal economic activities are: (i) every possible two-period lived overlapping generation consumer/labourer, receives a positive young-age labour endowment of unit one, but retires and consumes only when old[7]. Thus, at time point t, there are two coexisting generations of young-age and old-age consumers. N people are born at each time point $t \geq 1$. At time point $t = 1$, there exist N people in the economy called the initial old, who live for only one period. The young-age consumers supply their one unit of labour inelastically to earn a wage income. The entire wage income is deposited into banks for future consumption; (ii) each infinitely-lived producer uses the same production technology to produce a single final good, using the inelastically supplied labour, physical capital which is borrowed from the banks and public capital supplied by the government; (iii) the banks operate in a competitive environment and perform a simple pooling function[8] by collecting the deposits from the consumers and lending it out to the firms after meeting an obligatory cash reserve requirements. We assume that banks do not spend any resources in performing this intermediary function[9]; and (iv) there is an infinitely-lived government which meets its productive expenditure on infrastructure by generating seigniorage income. The government follows an inflation targeting (IT) regime and also controls the reserve requirement. The government balances its budget on a period-by-period basis. There is a continuum of each type of economic agent with unit mass.

[7]This assumption ensures tractability and makes the analysis independent of the consumers utility function, as it abstracts from the consumption-savings decision. See Woodford (1984) for initial discussion on this, although this assumption is frequently used in the OLG literature. See among others, Cazzavillan (1996) and Sodini (2011) for more details. In fact, Bhattacharya and Qiao (2007), Gupta and Vermeulen (2010) and Gupta (2011) stress that the interest-inelastic nature of the savings function is a realistic representation of the true world.

[8]This is an implicit assumption that individual consumers cannot finance the firm's demand for investment, as the firm requires a minimum level of supply of capital that the consumer can not meet.

[9]This is a simplifying assumption, but the profit function of the bank could easily be adapted to account for a fraction of the deposits spent as resource cost. See footnote 13 for more details.

5.2.1 Consumers

All consumers have the same preferences, so there is a representative agent in each period. When young, consumers inelastically supply their unit of time endowment, n_t to earn a real wage of w_t that is saved as a real bank deposit, d_t. The consumer retires when old and consumes c_{t+1} from the investment of young-age savings[10]. Formally, the young-age consumer wants to maximize[11]:

$$\max_{c_{t+1}} \quad U = u(c_{t+1}) \tag{5.1}$$

subject to:

$$p_t d_t = p_t w_t \tag{5.2}$$

$$p_{t+1} c_{t+1} = (1 + i_{dt+1}) p_t d_t \tag{5.3}$$

where U is assumed to be twice-differentiable, such that $U'(c) > 0$ and $U''(c) < 0$. i_{dt+1} is the nominal interest rate received on deposits at $t+1$, p_t is the price level in t and p_{t+1} is the price level in $t+1$. Note that, $d_t = \frac{D_t}{p_t}$ where D_t is the amount of nominal deposits held by consumers. Equation (5.2) is the feasibility (first-period budget) constraint for the young-age consumer and (5.3) is the budget constraint of the old-age consumer.

5.2.2 Financial intermediaries

There exist a finite number of banks in this economy, which we assume to behave competitively and who are all subject to an obligatory cash reserve requirement γ_t, set by the government. Two simplifying assumptions – that no resources are used to operate the banking system and bank deposits are essentially one period contracts – guarantee that all competitive banks levy the same cost on their loans, the nominal loan rate i_{lt} and guarantee the depositor a nominal deposit rate, i_{dt}. Banks accept and pool deposits[12], choose their allocation portfolio of loans and required cash reserves and then extend loans to firms, subject to γ_t, with the goal of maximising their profits. Subsequently, banks receive interest income from loans to firms and meet their interest obligations to depositors. The bank's balance sheet is constrained by the reserve requirement, and is represented by $(1-\gamma)D_t = L_t$. Hence,

[10] We omit tax transfers from the consumer's budget constraint for simplicity. See Gupta and Vermeulen (2010) and the references cited therein, for further details.

[11] Optimisation solutions for the different economic agents are fully set out in the Appendix.

[12] Pooling occurs along the lines described in Bryant and Wallace (1980), since we assume that capital is illiquid and is only created in large minimum denominations.

all banks attempt to:

$$\max \Pi_{Bt} = i_{lt} L_t - i_{dt} D_t \tag{5.4}$$

subject to:

$$M_t + L_t \leq D_t \tag{5.5}$$

$$M_t \geq \gamma_t D_t \tag{5.6}$$

where Π_{Bt} is the bank's net profit function[13]; M_t is the cash reserves held by the banks to meet the reserve requirement, γ_t is the reserve requirement ratio, and L_t are the amount of nominal loans extended to the firms. Equation (5.5) is the feasibility constraint resulting from optimal financing contracts[14] and (5.6) is the bank's reserve requirement constraint. A competitive banking sector is characterised by free entry, which drives profits to zero. Thus, given that (5.5) and (5.6) bind, the solution to the bank's problem yields:

$$i_{lt} = \frac{i_{dt}}{1 - \gamma_t} \tag{5.7}$$

Equation (5.7) clearly shows that cash reserve requirements lead to a distortion in financial intermediation, in the sense that it induces a wedge between the interest rate on deposits and the lending rates[15]. Since the cash reserves held by banks, M_t is rate-of-return dominated by loans, (5.6) will be binding as banks will hold just enough real money balances to satisfy the legal reserve requirements.

5.2.3 Firms

Firms have access to the same Barro (1990)-type production technology to produce a single final good, using lagged physical capital k_{t-1}, labour, n_t and public capital, g_t with the technology specified

[13]Note that although the reserve requirement M_t is part of the bank's resources, it only forms part of the bank's gross profit function as in Chari et al. (1995), Haslag and Young (1998) and Basu (2001).

[14]See Myerson (1979) for more detail.

[15]The simplifying assumption that banks operate without spending resources, could easily be dropped in favour of the following environment: if we assume that banks spend a portion of the deposits as resource cost in operating the bank system, the bank's optimisation problem is based on the net profit function represented by $\max \Pi_{Bt} = i_{lt} L_t - i_{dt} D_t - c D_t$, with c being the fraction of deposits banks spend on their operations. This would lead to the optimisation solution (with the same constraints) where $i_{lt} = \frac{i_{dt}}{1-\gamma_t - c}$. Redefining $\gamma_t^c = (\gamma_t + c)$ will not affect our results.

by:[16,17]

$$y_t = Ak_{t-1}^{\alpha}(n_t g_t)^{1-\alpha} \tag{5.8}$$

where $A > 0$, $0 < \alpha < 1$ and $0 < (1-\alpha) < 1$ are the elasticities of output with respect to capital and labour/publicly-provided infrastructure, respectively. Investment in physical capital, i_{kt} is limited by the availability of funding to the firms since we assume that firms are able to convert loans, L_{t-1} into fixed capital such that $p_{t-1}i_{kt-1} = L_{t-1}$. Following Diamond and Yellin (1990) and Chen, Chiang and Wang (2008), we assume that the goods producer uses up the unsold consumption good in a way which is consistent with lifetime value maximization of the firms. The representative firm therefore maximises its discounted stream of net profit flows subject to the capital evolution constraint and the loan constraint. Formally:

$$\max_{k_t, n_t} \quad \sum_{i=0}^{\infty} \rho^i [p_t y_t - p_t w_t n_t - (1+i_{Lt})L_{t-1}] \tag{5.9}$$

subject to:

$$k_t \leq (1-\delta_k)k_{t-1} + i_{kt-1} \tag{5.10}$$

$$p_{t-1}i_{kt-1} \leq L_{t-1} \tag{5.11}$$

$$L_{t-1} \leq (1-\gamma_t)D_{t-1} \tag{5.12}$$

where ρ is the firm's (constant) discount rate and δ_k is the (constant) rate of capital depreciation. The firm solves the following recursive problem to solve for the demand of labour and investment:

$$V(k_{t-1}) = \max_{k_t, n_t} \quad \left[p_t A k_{t-1}^{\alpha}(n_t g_t)^{1-\alpha} - p_t w_t n_t - p_t(1+i_{Lt})(k_t - (1-\delta_k)k_{t-1})\right] + \rho V(k_t) \tag{5.13}$$

The corollary of this dynamic formulation is the following optimality conditions for the choice variables:

$$n_t: \quad w_t = (1-\alpha)A\left(\frac{k_{t-1}}{n_t}\right)^{\alpha} g_t^{1-\alpha} \tag{5.14}$$

$$k_t: \quad (1+i_{Lt}) = \rho\left(\frac{p_{t+1}}{p_t}\right)\left[\alpha A\left(\frac{n_{t+1}g_{t+1}}{k_t}\right)^{1-\alpha} + (1+i_{Lt+1})(1-\delta_k)\right] \tag{5.15}$$

[16] Note also that the form of the production function implies that the public services are complementary with the private inputs in the sense that an increase in g_t raises the marginal products of n_t and k_t. This setting parallels the production function for the learning-by-doing/spillovers model of Romer (1986), except that the per-capita aggregate capital stock, $\overline{k_t}$, has been replaced by the quantity of public goods, g_t.

[17] One could also allow the public capital input in the production function to be lagged by one period, which would yield a technology of the form: $y_t = Ak_{t-1}^{\alpha}(n_t g_{t-1})^{1-\alpha}$. This specification, however, does not affect our results in any way, as can be seen from the brief discussion in the Appendix.

Equation (5.15) represents the condition for the optimal investment decision of the firm. Intuitively, the firm weighs the cost of increasing investment in the current period with the future stream of benefits generated from the additional capital invested in the current period. Furthermore, assuming that capital depreciates fully between periods, or $\delta_k = 1$ without any loss of generality[18], simplifies (5.15) to $(1 + i_{Lt}) = \rho\left(\frac{p_{t+1}}{p_t}\right)\left[\alpha A\left(\frac{n_{t+1}g_{t+1}}{k_t}\right)^{1-\alpha}\right]$. Equation (5.14) represents the optimal hiring decision for a firm, whereby labour is hired up to the point where the marginal product of labour is equal to the real wage.

5.2.4 Government

An infinitely-lived consolidated government – comprising a monetary as well as a treasury (or fiscal) wing – purchases g_t units of goods, and government expenditure is assumed to be a productive factor in the firm's production function. The government finances its productive expenditure solely through the collection of seigniorage income (to ensure a balanced budget at each point in time), given that we have omitted taxation for the sake of simplicity, without affecting our main results. Formally, the government's budget constraint is:

$$g_t = \frac{M_t - M_{t-1}}{p_t} \tag{5.16}$$

and furthermore the monetary authority implements an inflation targeting regime to bring about macroeconomic stability. These interventions could be directed at either price stability or output stability, or a combination of both, given that government also provides productivity-enhancing infrastructure that is used as a factor in the production of the consumption good. Hence, we have that $\Pi_t = \hat{\Pi}$ for all t. Note, now with $(1 + i_{Lt}) = \rho\hat{\Pi}\left[\alpha A\left(\frac{n_{t+1}g_{t+1}}{k_t}\right)^{1-\alpha}\right]$ from (5.15), $n_{t+1} = 1$ and from the government budget constraint $\frac{g_{t+1}}{k_t} = \left(\gamma_t(1-\alpha)A\left[1 - \frac{1}{\Omega_{t+1}\hat{\Pi}}\right]\right)^{\frac{1}{\alpha}}$, this leads to an interest rate rule where the monetary authority not only responds to inflation, but also the growth rate of the economy. Given this policy rule for the rate of inflation, the nominal quantity of money adjusts endogenously to satisfy the demand for money. Therefore, using $M_t = \gamma_t D_t$ from (5.6), the government budget constraint in real terms can be rewritten as:

$$g_t = \gamma_t d_t\left(1 - \frac{1}{\Omega_t\hat{\Pi}}\right) \tag{5.17}$$

[18]This assumption provides analytical tractability in the same vein as Barnett, Bhattacharya and Bunzel (2013), and should be viewed against the generational structure of the OLG model, where a typical generation might span 20 or 30 years. Also see Cazzavillan (1996), Chen (2006) and Dávila (2012).

where Ω_t is the gross growth rate at time t and $\hat{\Pi}$ is the gross inflation rate across all t.[19] Note that the actual monetary policy rule is stated by (5.17), which as mentioned earlier, implies that the government responds to both inflation and growth under an inflation targeting regime.[20]

5.3 EQUILIBRIUM

A valid, perfect-foresight equilibrium for the characterised economy is defined as a sequence of prices $\{p_t, i_{Lt}, i_{Dt}\}_{t=0}^{\infty}$, allocations $\{c_{t+1}, n_t, i_{kt}\}_{t=0}^{\infty}$, stock of financial assets $\{m_t, d_t\}_{t=0}^{\infty}$ as well as policy variables $\{g_t, \gamma_t\}_{t=0}^{\infty}$ such that:

- Taking g_t, γ_t, p_t, p_{t+1}, i_{Dt} and w_t, the consumer maximises utility in (5.1) such that both (5.2) and (5.3) hold;

- Banks maximise profits subject to i_{Lt}, i_{Dt} and γ_t such that (5.7) holds;

- The real allocations solve the firm's date t profit maximization problem, given prices and policy variables, such that (5.14) and (5.15) hold;

- The equilibrium money market condition, $m_t = \gamma_t d_t$ holds for all $t \geq 0$;

- The loanable funds market equilibrium condition, $p_{t-1} i_{kt-1} = L_{t-1}$ given the total supply of loans $L_{t-1} = (1-\gamma_t) D_{t-1}$, holds for all $t \geq 0$;

- The equilibrium goods market resource constraint, $c_t + i_{kt-1} + g_t = A k_{t-1}^{\alpha} (n_t g_t)^{1-\alpha}$ holds, where $i_{kt-1} = (1-\gamma_t) d_{t-1}$;

[19] It should be noted that because of this IT-regime, it implies that inflation is constant across both periods. Hence, to contrast a low versus high inflation environment entails simply changing the value of $\hat{\Pi}$. However, most countries that have implemented IT, have actually implemented an inflation targeting band. In the case of South Africa, for example, the inflation targeting band is $3-6\%$. Therefore, any discussion around a high versus low inflation target is intended to also include the sensitivity, or accuracy, of these IT bands.

[20] Although not a traditional Taylor rule, we are of the opinion that it does resemble a "Taylor–type" rule, in the sense that it incorporates information from both the growth rate (as an approximation of deviations from the output gap) as well as from the inflation target itself (under IT, expected future inflation is just inflation in the current period, and hence there are no deviations). See Taylor (2012), Taylor (2013) and Hatcher and Minford (2014) for a detailed discussion on this point.

- The government budget constraint in (5.17) is balanced on a period-by-period basis; and

- d_t, p_t, i_{lt}, i_{dt} and A are positive for all $t \geq 0$.

5.4 GROWTH DYNAMICS

In this section, we analyse the growth dynamics derived from the model. Using (5.2), (5.10), (5.11), (5.12), (5.14) and (5.17) we obtain the following relation between the gross growth rate in $t+1$, Ω_{t+1} and the gross growth rate in t, Ω_t. More clearly, we have $\Omega_{t+1} = f(\Omega_t)$ [21] which is given by:

$$\Omega_{t+1} = (1-\gamma_t)(1-\alpha)A\left[\gamma_t(1-\alpha)A\left(1-\frac{1}{\Omega_t\hat{\Pi}}\right)\right]^{\frac{1-\alpha}{\alpha}}\frac{1}{\Omega_t} \tag{5.18}$$

The function $f(\Omega_t)$ satisfies the following conditions: (a) $f'(\Omega_t) > 0$ for $\Omega < \Omega^*$ $[= \frac{1}{\hat{\Pi}\alpha}]$[22]; (b) $f'(\Omega_t) = 0$ for $\Omega = \Omega^*$; (c) $f'(\Omega_t) < 0$ for $\Omega > \Omega^*$; (d) $lim_{\Omega\to 0} f'(\Omega_t) = \infty$; (e) $lim_{\Omega\to\infty} f'(\Omega_t) = -\infty$; and (f) $lim_{\Omega\to\infty} f(\Omega_t) = 0$.

Depending upon the values of A, α, γ_t [23] and $\hat{\Pi}$ and based on the given properties of $f(\Omega)$ described above, there are different types of equilibrium growth paths, yielding two discrete versions of multiple equilibria – one low-growth and one high-growth – as clearly shown in Figure 5.1 and Figure 5.2.

The inverted U-shape nature of the function, $f(\Omega)$ should be intuitively understood given there exists both a positive and negative effect of an increase in Ω_t, the gross growth rate at t. An increase in Ω_t results in higher seigniorage revenue for government, raising the ratio of real government expenditure to real wage. This implies a higher growth rate via the higher available resources for productive

[21] Note, if we relaxed the assumption that $\delta_k = 1$ and we allow for any non-negative range of depreciation, say $0 < \delta_k < 1$, the growth equation in (5.18) would just be amended with an additional term on the RHS, equal to $+(1-\delta_k)$.

[22] When g_{t-1}, along with k_{t-1}, is included in the production structure instead of g_t, the optimal value for $\Omega^* = \frac{2-\alpha}{\hat{\Pi}}$, which shifts the turning point of the unimodal $f(\Omega)$ to the left, relative to the current case. This does not, however, change our results in terms of analysing indeterminacy, stability, endogenous fluctuations or chaos in any possible way.

[23] It is easily verified that in the case of $\gamma_t = 0$, or when the cash reserve requirement is zero, the equilibrium growth rate falls to 0, or in the case of non-negative depreciation ($0 < \delta_k < 1$) it collapses to $(1-\delta_k)$, the undepreciated portion of the capital stock carried over from the previous period. This equilibrium is not economically interesting, as it turns out that for the growth process to initiate, a strictly non-negative (small) γ_t is required. Absent the cash reserve requirement, the uni-modal $f(\Omega)$ becomes a horizontal line, regardless of the parameter values of A, α or $\hat{\Pi}$. We will offer a brief discussion on the different alternative rules we could have used to introduce money in this economy, in the concluding remarks beside those contained in footnote (4).

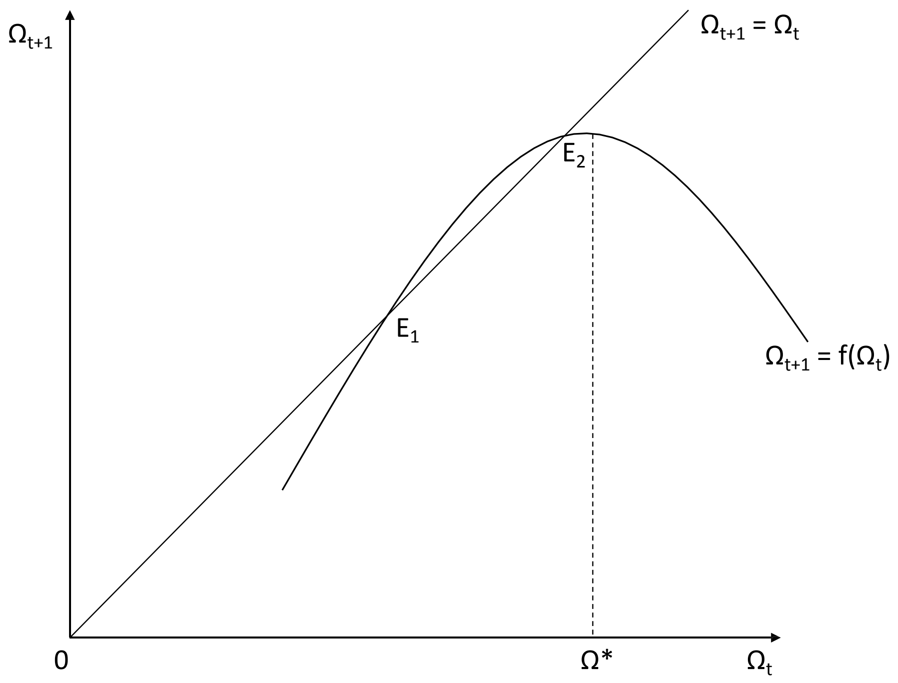

Figure 5.1: Multiple Equilibria *without* endogenous fluctuations

expenditure on publicly-provided infrastructure relative to real wage. Due to the complementarity between private and public capital investment in output, private capital investment in output now also increases. The negative effect stems purely from the time-structure of the production function, where $f(\Omega)$ decreases as k_{t-1} decreases.

The positive effect is prevalent for values of Ω_t less than the optimal $\Omega^* = \frac{1}{\hat{\Pi}\alpha}$, hence $f(\Omega)$ is positively-sloped until Ω^*. Beyond the optimal Ω^*, the negative effect is prevalent, hence a negatively-sloped $f(\Omega)$ is observed in this region. It should be clear that the different positional f loci in Figure 5.1 and Figure 5.2, is determined by different values of the parameter set consisting of $\{A, \alpha, \gamma_t, \hat{\Pi}\}$. It obtains then, that the position and existence of the different equilibria hinges critically on the values of these parameters, and these values have to be such that the function $f(\Omega)$ intersects the 45 degree line, which is representative of the loci of steady states of this OLG economy. Based on this, the particular inference is:

- The low-growth (high-growth) equilibrium depicted in E_1 (E_2) is unstable (stable) and locally determinate (locally indeterminate)[24]. The low-growth (high-growth) equilibrium is unstable (stable) under perfect foresight because the f loci intersects the 45 degree line from below (above). Furthermore, although k_{t-1} is a state variable and cannot jump, $\Omega_t = \frac{k_t}{k_{t-1}}$ is not a state variable and, hence, can jump[25]. This resultant jump then implies that there is infinitely many rational expectations (RE) paths to the high-growth and stable equilibrium from any initial given value for k_1. Hence, the stable equilibrium in this economy at E_2 suffers from local indeterminacy, as there is still asymptotic convergence to the BGP;

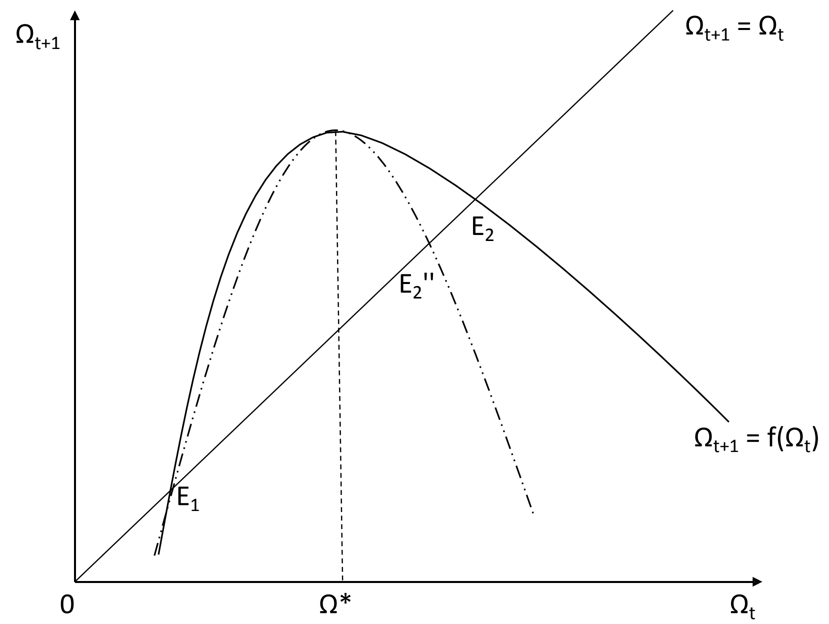

Figure 5.2: Multiple equilibria *with* endogenous fluctuations

- As depicted in Figure 5.2, on a different growth path the high-growth and stable equilibrium can also be characterized by endogenous fluctuations, given that the slope of the f locus is negative at point E_2. At point E_2, however, the growth path might still display convergent fluctuations,

[24]See Eggoh and Villieu (2014) for a detailed discussion and technical graphical analysis of indeterminacy. Also, Mitra and Nishimura (2001) provide an extensive survey on stability and indeterminacy.

[25]Vind (1967) first formulated the idea that if time as a variable can be controlled, and it should be clear that $\Omega_t = \frac{k_t}{k_{t-1}}$ is a mechanism for controlling, or eliminating time, then jumps with respect to time are possible.

if the slope of the function f is not "too steep", or formally, if the slope of $f < 1$ in absolute terms. Recall, the position of the f locus depends on the values of the structural parameters of the model, A, α, γ_t and $\hat{\Pi}$;

- As in Gupta and Vermeulen (2010), our framework too can yield chaotic behaviour of the growth rate around the high-growth equilibrium, given that the slope of the function f is "steep enough", or if the slope of $f > 1$ in absolute terms. This "steepness requirement" holds if and only if the following conditions are satisfied[26]: Mitra (2001) describes the conditions required for chaos to emerge from growth cycles, namely the map f is required to be a continuous function from X to X, where the state space X is an interval on the non-negative part of the real line, with (X, f) defining the dynamical system. Further, the map f must have a unimodal distribution with a maximum at Ω^* with $f(\Omega^*) > \Omega^*$ and the high-growth equilibrium at point $E_2^{''}$ must ensure that the steady-state level of growth rate corresponding to point $E_2^{''}$, exceeds Ω^*. Plainly, for a non-linear function with a single maximum, the value of Ω^* must be less than the value (say, Ω_H) corresponding to point $E_2^{''}$ – or the intersection point of $f(\Omega)$ with the steady state locus (the 45 degree line). Furthermore, the value of Ω^* must be smaller than the value of its first iterate and bigger than the value of its second iterate. Evidently, the high-growth equilibrium point $E_2^{''}$ on the equilibrium path depicted in Figure 5.2 is exactly such point, and therefore exhibits topological chaos at that equilibrium. Economically, a change in the IT regime could lead to such chaotic behaviour.

- The economic intuition for the scenario's described above, flows from the parameter set of (5.18). For the dynamics in the growth process to initiate, a "small" strictly non-negative γ_t is required, without which the dynamics in the growth process never takes off. It is evident that without γ_t, there is also no productive government expenditure, and hence output is produced by $y = Ak_{t-1}^{\alpha}$. Recall $0 < \alpha(1-\alpha) < 1$, implies decreasing returns to scale in capital which would result in no feasible sustained growth. The initial dynamics is then kick-start by say $\gamma_t = 0.01$. In fact, in this setting $\gamma_t > 0$ is a sufficient and necessary condition for growth dynamics, and hence fluctuations to occur. The shape of the map (or curve) is determined solely by $\hat{\Pi}$, which controls the position of the optimal Ω^*, given a fixed value of α, and α, which controls the curvature (or "steepness") of the map, especially for values of $\Omega_t > \Omega^*$. The technology parameter A shifts the map up (down) for bigger (smaller) values of A, along the vertical. So, for observed growth rates to the

[26]See Bhattacharya and Qiao (2007) as well as Boldrin, Nishimura, Shigoka and Yano (2001) for full details.

left of the optimum, higher growth results in higher seigniorage revenue and hence increased production.

5.5 POLICY IMPLICATIONS

From the perspective of inflation targeting monetary policy, our theoretical results have very important implications. While gestation lags are part of any production process, irrespective of whether we consider either developed or developing economies, they are of greater importance and more likely to occur in the latter set of countries. Hence, our model is perhaps more evident of developing nations pursuing inflation targeting monetary policy, contingent on production lags in the investment process.

Consequently, we show that central banks in developing countries should be exceptionally careful in deciding on their inflation targets. Inflation targets should be chosen based on the structural parameters of the model, and independent of any pressure from groups, such as the labour unions. Under external pressures, it is more likely that the inflation target will be relatively less stringent, and likely to be higher. As we show, in such a scenario, uncertain growth dynamics like fluctuations and even chaos are likely to emerge. What is of even greater concern is that these uncertain fluctuations will occur around the high-growth path; which, though indeterminate, is the stable equilibrium.

In this regard, it is also important to emphasize that in most countries, especially in the developed world, a complete separation between monetary and fiscal policies must exist. In our economic environment, to close the model, i.e., to ensure a balanced-budget in the steady-state, as is standard practice in the growth literature (see for example, Gupta and Vermeulen (2010) for a detailed discussion), fiscal and monetary policy decisions are intertwined. In other words, it is the consolidated government (i.e., its central bank wing) that establishes an inflation target and also finances its expenditures (associated with the treasury) solely through the collection of seigniorage revenues, which in turn depends on the inflation target. So in some sense, we are also confining the analysis to developing nations where monetary and fiscal competencies may be blurred, given the architecture of the state. To elaborate this, let us consider an increase in government expenditure, which in turn, must be funded through higher seigniorage to ensure a balanced-budget. An increase in seigniorage would involve an increase in the inflation target, which as we show and discuss in detail above, is likely to lead to growth fluctuations, to the extent that even chaotic dynamics might emerge.[27]

In other words, setting a high inflation target as a result of extraneous pressure, either from the labour unions or an expansionary government, instead of being theoretically motivated is likely to lead to tremendous uncertainty in the economy, at the extreme even making it chaotic, and nullifying the possible positive growth–effects of inflation targeting. Recall that the whole idea of inflation targeting was to ensure low stable rates of inflation to allow stability in the growth process, which in turn, is likely to ensure the achievement of other goals like addressing unemployment, eradicating poverty and reducing income inequality.

Therefore the message is quite clear, in the presence of production lags, monetary authorities should be pursuing low inflation targets to avoid uncertainty in the behaviour of the growth process.

[27]Even if alternative instruments to fund government expenditures are present, as long as seigniorage is increased, even partially, to accommodate for higher productive expenditures, our line of reasoning continues to hold. Of course, this is not an issue if the seigniorage is kept unchanged to meet additional government expenditures through higher taxation (or even issuance of more government debt).

CHAPTER 6 CONCLUDING REMARKS

> "The produce of the soil maintains at all times nearly that number of inhabitants which it is capable of maintaining. The rich only select from the heap what is most precious and agreeable. They consume little more than the poor, and in spite of their natural selfishness and rapacity, though they mean only their own conveniency, though the sole end which they propose from the labours of all the thousands whom they employ, be the gratification of their own vain and insatiable desires, they divide with the poor the produce of all their improvements. They are led by an invisible hand to make nearly the same distribution of the necessaries of life, which would have been made, had the earth been divided into equal portions among all its inhabitants, and thus without intending it, without knowing it, advance the interest of the society, and afford means to the multiplication of the species. When Providence divided the earth among a few lordly masters, it neither forgot nor abandoned those who seemed to have been left out in the partition. These last too enjoy their share of all that it produces. In what constitutes the real happiness of human life, they are in no respect inferior to those who would seem so much above them. In ease of body and peace of mind, all the different ranks of life are nearly upon a level, and the beggar, who suns himself by the side of the highway, possesses that security which kings are fighting for." - Adam Smith[1]

6.1 INTRODUCTION

The work presented in this thesis started during May 2012.

[1] *The Theory of Moral Sentiments* (1759)

The **second chapter** has been published as: Bittencourt, M., Gupta, R., and Stander, L. (2014). Tax evasion, financial development and inflation: Theory and empirical evidence. *Journal of Banking and Finance*, 41, 194-208.

The **third chapter** has been published as: Gupta, R. and Stander, L. (2017), Social Status, Inflation and Endogenous Growth in A Cash-in-Advance Economy: A Reconsideration using the Credit Channel. *The Manchester School*. doi:10.1111/manc.12207.

The **fourth chapter** is currently Under Review at *Journal of Policy Modelling*.

The **fifth chapter** has been published as: Gupta, R., and Stander, L. (2018). Endogenous Fluctuations in an Endogenous Growth Model: An analysis of Inflation Targeting as a Policy. *The Quarterly Review of Economics and Finance*. https://doi.org/10.1016/j.qref.2018.03.008.

Any remaining errors in the work, as there invariably will be, are solely mine.

The work presented in Chapter 4, which was completed last, was submitted to *Journal of Policy Modelling* in October 2018.

6.2 RESEARCH OBJECTIVE ONE

We develop a theoretical model using an OLG framework consisting of depositors, entrepreneurs, banks and the government, to analyse the relationship between endogenously determined tax evasion as an indication of the size of the shadow economy, and both financial development and inflation. Financial development is defined through the introduction of a CSV problem faced by banks as the lender to entrepreneurs in the economy. This CSV problem forces banks to employ monitoring technology and incur monitoring cost in order to observe the same outcome as the entrepreneur, which increases the banks' cost function and leads to a decrease in the real interest rate on deposits held by banks. Following the broad literature, societies with a higher (lower) level of financial development will have a lower (higher) cost of state verification. Entrepreneurs endogenously determine the portion of their income to misreport or under-declare to the bank, but face the price of doing so in the form of higher costs for access to and conditions of obtaining credit. These higher costs, or lower real rate on deposits and hence a lower level of financial development, provide an incentive to depositors to participate in tax-evasion activities as the marginal benefit of tax evasion is at least equal to the marginal cost thereof.

The empirical results provide consistent support for the theoretical findings. Once the level of both economic development and institutional quality is accounted for, concurrent with the size of the central bank and hence its ability to intervene in the economy, the reported estimates are evident of the fact that lower (higher) levels of financial development and higher (lower) inflation causes a bigger (smaller) shadow economy. Thus from a policy perspective, the role of financial development and lower rates of inflation in curbing the size of shadow economy is of paramount importance.

6.3 RESEARCH OBJECTIVE TWO

Traditionally, monetary models that include the desire for social status and that face a CIA constraint on consumption, have uphold the empirically–inconsistent Mundell–Tobin finding that a positive monetary growth rate leads to positive long-run growth. These findings are demonstrated through stimulated capital accumulation that is observed due to higher inflation that depresses real money holdings and raises the cash-in-advance cost, and also further enhanced through the individual's preference for social status that provides incentive towards accumulating more capital.

However, we develop a monetary endogenous growth model with a CIA constraint on consumption, characterised by consumer preference for wealth-inducing social status and financial repression through a mandatory reserve requirement that is empirically consistent with the international evidence on the negative growth–inflation relationship. Besides the usual substitution effect of real money balances for capital goods (here consisting of deposits) arising from an increase in the inflation rate and an increase in the cost of holding money, there is a second, opposing effect necessitated by a decrease in the real deposit rate caused by the disconnect between the loan rate and the deposit rate due to the cash reserve requirement.

The cash reserve requirement distorts the optimal working of the financial market in that deposits can not be fully converted into loans, and hence drives a wedge between the nominal loan rate and the nominal deposit rate in equilibrium. While the real loan rate is tied to the constant marginal product of capital, the real deposit rate is now negatively related to the rate of inflation. So higher inflation resulting from a higher money growth rate lowers real rate on deposits, and since the consumer derives direct utility from holding deposits due to wealth-induced social status, there is an opposite substitution effect away from holding deposits to holding real money balances.

Importantly, following a simpler approach than what is used in the current literature, the model is able to concomitantly account for the Sidrauski effect, the Mundell–Tobin effect and the empirically observed negative growth-inflation relationship, contingent on the consumer deriving direct utility from social status and a mandatory reserve requirement imposed on banks. The popular empirical literature result of a negative growth–inflation relationship hinges on the cash reserve requirement exceeding a (small) critical value, the size of which is determined by the weight of the consumer's desire for social status and the constant time discount rate.

6.4 RESEARCH OBJECTIVE THREE

Globalisation is often thought of as a "modern" phenomenon when in fact, it is only the *term* that gained popularity from the late 1970s. The process itself, or more specifically, the First Globalisation had already started as long ago as the 1840s. Today, popular media opinion on the benefits and pitfalls of globalisation is divided. This division is even more apparent in the literature, with as many proponents as detractors in the debate on "Is openness good for growth?"

As participants to this debate, and either beneficiaries of or victims to globalisation, we develop an open economy human capital–based endogenous growth model, where the role of government expenditure and openness is embedded in the human capital accumulation function. First, we detail the existence of a theoretical non–linear relationship between openness and growth where the steady–state growth rate is a result of the interaction between openness directly and productive government expenditure, which in turn also depends on openness. We further show how productive government expenditure depends not only on openness, but also on seigniorage income as the only source of funding this expenditure. In this, we abstract away from the complex tax structures and different sources of funding government expenditure that often characterises analyses of international trade, to allow us to focus only on two channels of transmission of the impact of openness on economic growth.

To gain insight into the nature of the non–linearity between openness and growth we take a data–driven, semi–parametric approach that enables the data "to speak for itself" on the exact nature and characteristics of the non–linear relationship. The empirical analysis, crafted in such a way as to carefully account for the peculiarities of the theoretical model, explores the non–linearity using the variation in cross–country differences, first for a variety of sub–samples of countries and then for the entire set of 176 countries over the period 1980 – 2011. The results presented here not only support the theoretical non–linearity, but it further points to a specific inverted–U relationship between openness and growth, irrespective of the measure of openness used and robust to the selection of different sub–samples of countries. It is clear that there is a specific threshold for the degree of openness beyond which the positive impact of international trade on growth, dissipates at differing speeds. The identified threshold is around a value of 45.1 for the broad measure of Openness, the Dreher Globalisation Index and around a trade–GDP ratio of 68.3 (the more traditional measure of openness). These thresholds are important, since both are significantly lower than the world average for these respective measures which implies than on average, world trade has passed the threshold below which trade acts exclusively as a stimulus for growth.

The findings and results presented here have two critical implications: firstly, for trade and growth economists alike it cautions against the modelling of trade or openness impacts on economic growth in a linear framework. The impact of openness or trade on economic growth is indeed, non–linear and this underlying relationship should be respected and subsequently, treated as such. The failure or neglect to study this relationship in a non–linear way, will continue to lead to mixed results that are not attributable to country differences, different measures or different modelling techniques; and secondly, policy makers should take note of this non–linearity in their setting of trade policy or liberalisation programmes. It should be evident that the goal of any economy should not be an increase in its trade–GDP ratio or in its position on the Globalisation Index without understanding where in the distribution of the *Openness–Growth* nexus it is.

In fairness to von Mises, in 1919 he could not have seen past the then–prevailing distance to the horizon on the impact of free trade. New econometric techniques and ever–improving modelling methodologies endow our generation with the ability to understand the Openness phenomenon finitely better.

6.5 RESEARCH OBJECTIVE FOUR

In this paper, we develop a monetary endogenous growth overlapping generations models with inflation targeting and characterised by lagged capital in the production structure, and analyse growth dynamics that arise endogenously. The growth process is endogenized through productive government expenditure that is necessary for producing the consumption good. Money is introduced into the model through a banking sector that intermediates between depositors (consumers) and borrowers (firms) in a competitive environment, but are subjected to a cash reserve requirement on deposits. This obligation leads to a distortion in financial intermediation, driving a wedge between the real loan rate and the real deposit rate in equilibrium. If we introduced a simple money growth rule, with no lagged inputs there would be no growth dynamics. If we account for lagged inputs, but do not introduce an IT–regime, we could still admit endogenous fluctuations. An IT regime with no lagged inputs would produce convergent growth dynamics, without any oscillations. Growth dynamics are introduced through an inflation targeting monetary authority regime.

Within this framework, different equilibrium growth paths emerge once we have a strictly non–negative cash reserve requirement ratio. We detail the existence of multiple equilibria, both high-growth and low-growth where the low–growth equilibria are unstable and locally determinate. The opposite emerge for the high-growth equilibria. In addition, we find that endogenous fluctuations and topological chaos are possible around the high-growth equilibrium, due to the monetary authority following an inflation targeting regime and output depending on lagged capital inputs. Specifically, when the monetary authority sets a high inflation target, we can observe possible convergent or divergent endogenous fluctuations – and even chaotic behaviour – around the high-growth equilibrium on this growth path, if the value of α is sufficient. Additionally, if the monetary authority sets a low inflation target, the resultant equilibria do not display any oscillations or chaotic behaviour, but the low–growth, low–welfare equilibrium for this growth path is unstable.

Most importantly, we highlight the critical role of a strictly non–zero cash reserve requirement in starting the growth process, and the subsequent but equally critical role that a *low–inflation* inflation targeting policy plays in ensuring certainty in the growth process.

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APPENDIX A TAX EVASION, FINANCIAL DEVELOPMENT AND INFLATION: THEORY AND EMPIRICAL EVIDENCE

Table A.1: Estimation results of Fixed Effects Estimators for OECD and Latin American countries

Variables	ALL_FEIVbm	ALL_FEIVfull	OECD_FEIV1	LA_FEIV1	OECD_FEIV2	LA_FEIV2
moneygr	0.00068***	-0.0001	-0.00042	0.00039*	-0.00073	0.00037*
	(0.0002)	(0.00008)	(0.00026)	(0.00023)	(0.00047)	(0.00021)
log_bnkcost	-0.00068	0.00017	0.00056	0.00097	0.00040	0.00005
	(0.0018)	(0.001)	(0.00111)	(0.00245)	(0.00197)	(0.00256)
log_gdppc		-0.0446***	-0.04016***	-0.0496***	-0.04981***	-0.0432***
		(0.0045)	(0.00723)	(0.0132)	(0.01526)	(0.0125)
L.log_shadow2	0.929***	0.917***	0.96272***	0.8638***	0.96298***	0.8374***
	(0.013)	(0.00996)	(0.02972)	(0.0311)	(0.04740)	(0.0386)
instit		-0.0036**	0.00670*	0.000036	0.01472*	0.000069
		(0.00144)	(0.00374)	(0.00267)	(0.00840)	(0.0027)
findev2					0.00215	-0.0045*
					(0.00260)	(0.0027)
R^2	0.89	0.95	0.99	0.96	0.99	0.95
Obs	1,271	1,510	333	217	268	200
F	420.33	1,010.63	563.72	266.61	188.83	202.82
Instruments	log_cba*	log_cba	domsave**	domsave*	domsave*	domsave**
	log_intsprd***	log_intsprd***				

1. A *, **, *** indicates the 10%, 5% and 1% significance level, respectively.
2. Robust standard errors in parenthesis. Two-stage FE estimates are reported.
3. Time dummies are suppressed to save space.

Table A.2: Variable Description Summary Table

Variables	Description	Database	Values	Interpretation
Shadow1	New estimates of the size of the informal/shadow economy as a percentage of GDP using the MIMIC method as adopted by Schneider et al., (2010). Runs for most countries from 1999-2007.	Schneider, Buehn and Montenegro (2010).	% of GDP	Higher values correspond to larger shadow/informal economies.
Shadow2	New estimates of the size of the informal/shadow economy as a percentage of GDP using DGE model estimates, as provided by Elgin and Öztunali (2012). Runs for most countries from 1980-2008/9.	Elgin and Öztunali (2012).	% of GDP.	Higher values correspond to larger shadow/informal economies.
Bnkcost	Accounting value of a bank's overhead costs as a share of its total assets.	Financial Structure dataset, Beck and Demirgüç-Kunt (2009).	% of total assets of Bank.	
Moneygr	Money and quasi-money growth, annual %.	World Development Indicators, World Bank, 2011.	Annual %	Higher values imply a higher money growth rate.
Cba	Claims on domestic, real non-financial sector by the Central Bank as a share of GDP, calculated using the following deflation method: $(0.5)*[F_t/P_{et}+F_{t-1}/P_{et-1}]/[GDP_t/P_{at}]$ where F is Central Bank claims, P_e is end-of period CPI, and P_a is average annual CPI.	Financial Structure dataset, Beck and Demirgüç-Kunt (2009).	% of GDP.	Higher numbers imply a bigger Central Bank balance sheet.
Gdppc	Real GDP per capita, constant prices (2000 USD).	World Development Indicators, World Bank, 2011.		
Dcpb	Domestic credit provided by banking sector as % of GDP.	World Development Indicators, World Bank, 2011.	% of GDP	Higher values imply more active bank lending activity.
Prvcrt	Domestic credit provided to the private sector as % of GDP.	World Development Indicators, World Bank, 2011.	% of GDP	Higher values imply a more developed financial intermediary sector.
Intsprd	Lending rate minus deposit rate, in annual %.	World Development Indicators, World Bank, 2011.	%	Higher values imply a bigger wedge between the loan and deposit rate.
M3	Liquid Liabilities as % of GDP.	Financial Structure dataset, Beck and Demirgüç-Kunt (2009).	% of GDP.	
Stmk	Market capitalization of listed companies, expressed as % of GDP.	World Development Indicators, World Bank, 2011.	% of GDP.	Higher values imply a more developed stock market/financial market with more investment activities.
Regquality	Captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	World Governance Indicators, World Bank, 2011.	Index normalised, values are -2.5 to 2.5.	Higher values correspond to better governance.
Ruleoflaw	Captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	World Governance Indicators, World Bank, 2011.	Index normalised, values are -2.5 to 2.5.	Higher values correspond to better governance.
Fiscfreed	Measure of the tax burden imposed by government. It includes both the direct tax burden in terms of the top tax rates on individual and corporate incomes and the overall amount of tax revenue as a percentage of GDP. Thus, the fiscal freedom component is composed of three quantitative factors: the top tax rate on individual income, the top tax rate on corporate income and total tax revenue as a percentage of GDP.	Index of Economic Freedom, The Heritage Foundation, 2011.	Index normalised, values are 0 to 100.	Higher number implies lower/lighter tax burden and conversely, lower number implies a heavier tax burden.

APPENDIX B SOCIAL STATUS, INFLATION AND ENDOGENOUS GROWTH IN A CASH-IN-ADVANCE ECONOMY: A RECONSIDERATION USING THE CREDIT CHANNEL

Recall that the Hamiltonian of the consumer is stated in (3.4) as:

$$H_c = log(c) + \beta log(d) + \lambda[r_d d + \tau - c - \pi m_1 - \dot{d}] + q[m_1 - c] \tag{B.1}$$

and the resulting first-order conditions described in (3.5)-(3.7) is:

$$\frac{dH_c}{dc} : \frac{1}{c} - \lambda - q = 0 \tag{B.2}$$

$$\frac{dH_c}{dm_1} : -\lambda\pi + q = \rho\lambda - \dot{\lambda} \tag{B.3}$$

$$\frac{dH_c}{dd} : \frac{\beta}{d} + \lambda r_d = \rho\lambda - \dot{\lambda} \tag{B.4}$$

For the banks, given that deposits and loans are one-period contracts, the solution that results directly from the zero profit condition due to competition, is:

$$\Pi_B = [i_l l - i_d d] = 0 \tag{B.5}$$

Imposing the two constraints in (3.9) and (3.10) and substituting into (3.8), we have:

$$i_l(1-\gamma)d = i_d d \tag{B.6}$$

$$i_l = \frac{i_d}{(1-\gamma)} \tag{B.7}$$

which is the banks' solution, stated in (3.11). Based on the solution to the firm's static problem, given in (2.16), the net real deposit rate is obtained by substituting (3.16) into (3.11):

$$i_l = \frac{i_d}{(1-\gamma)} \tag{B.8}$$

$$(i_l - \pi) = \frac{i_d}{(1-\gamma)} - \pi \tag{B.9}$$

$$(i_l - \pi) = \frac{i_d - \pi + \pi\gamma}{(1-\gamma)} \tag{B.10}$$

$$A(1-\gamma) = r_d + \gamma\pi \tag{B.11}$$

$$r_d = A(1-\gamma) - \gamma\pi \tag{B.12}$$

For the balanced growth path (BGP) solutions, first calculate the endogenous inflation rate using (3.5)-(3.7):

$$-\lambda\pi + q = \frac{\beta}{d} + \lambda r_d \tag{B.13}$$

$$\lambda\pi = q - \frac{\beta}{d} - \lambda r_d \tag{B.14}$$

$$\lambda\pi = \frac{1}{c} - \lambda - \frac{\beta}{d} - \lambda r_d \tag{B.15}$$

$$\lambda\pi = \frac{1}{c} - \frac{\beta}{d} - (1 + r_d)\lambda \tag{B.16}$$

$$\pi = \frac{1}{c\lambda} - \frac{\beta}{d\lambda} - (1 + r_d) \tag{B.17}$$

then using (3.5) rearranged into (3.6), together with the inflation expression in (3.20), the evolution of the shadow price of real money balances is:

$$\rho\lambda - \dot{\lambda} = -\lambda\pi + \frac{1}{c} - \lambda \tag{B.18}$$

$$\rho\lambda - \dot{\lambda} = -\lambda\left(\frac{1}{c\lambda} - \frac{\beta}{d\lambda} - (1 + r_d)\right) + \frac{1}{c} - \lambda \tag{B.19}$$

$$-\dot{\lambda} = \frac{\beta}{d} + (r_d - \rho) \tag{B.20}$$

$$-\frac{\dot{\lambda}}{\lambda} = \frac{\beta}{d\lambda} + (r_d - \rho) \tag{B.21}$$

The evolution of real money balances, after substituting (3.20) into (3.19) and using the consumer's CIA constraint, $m_1 = c$, becomes:

$$\frac{\dot{m}}{m} = \mu - \pi \tag{B.22}$$

$$= \mu - \frac{1}{c\lambda} + \frac{\beta}{d\lambda} + (1 + r_d) \tag{B.23}$$

$$\frac{\dot{m}}{m} = \mu - \frac{1}{m_1\lambda} + \frac{\beta}{d\lambda} + (1 + r_d) \tag{B.24}$$

and additionally, from the equilibrium condition for the goods market $c + i = y$, and the binding CIA constraint $m_1 = c$, we have:

$$\frac{\dot{d}}{d} = A - \frac{m_1}{(1-\gamma)d} \tag{B.25}$$

For a valid BGP solution, (3.24) must hold such that:

$$-\frac{\dot{\lambda}}{\lambda} = \frac{\dot{m}}{m} = \frac{\dot{d}}{d} = g^* \tag{B.26}$$

which presents a system of equations from which to solve for g^*. Using both the evolution of the shadow price and the evolution of the real money balances expressions:

$$g = \frac{\beta}{d\lambda} + (r_d - \rho) \tag{B.27}$$

$$= \mu - \frac{1}{m_1\lambda} + \frac{\beta}{d\lambda} + (1 + r_d) \tag{B.28}$$

$$\mu + 1 + \rho = \frac{1}{m_1\lambda} \tag{B.29}$$

$$\frac{1}{\lambda} = (1 + \mu + \rho)m_1 \tag{B.30}$$

and substituting the above into $g^* = -\frac{\dot{\lambda}}{\lambda}$ yields:

$$g = (r_d - \rho) + \frac{\beta(1 + \mu + \rho)m_1}{d} \tag{B.31}$$

$$\frac{m_1}{d} = \frac{g - r_d + \rho}{\beta(1 + \mu + \rho)} \tag{B.32}$$

and hence, using the fact that $g^* = \frac{\dot{d}}{d}$ and $r_d = A(1-\gamma) - \gamma\pi$, an explicit expression for g^* is derived:

$$g = A - \left(\frac{g - r_d + \rho}{\beta(1 + \mu + \rho)}\right)\frac{1}{1 - \gamma} \tag{B.33}$$

$$g(1-\gamma)\beta(1 + \mu + \rho) = A(1-\gamma)\beta(1 + \mu + \rho) - g + (r_d - \rho) \tag{B.34}$$

and, in simplifying

$$g^* = A - \frac{\rho + \gamma\mu}{(1-\gamma)[1 + \beta(1 + \mu + \rho)]} \tag{B.35}$$

APPENDIX C OPENNESS AND GROWTH: IS THE RELATIONSHIP NON-LINEAR?

C.0.1 Derivation of the steady-state growth rate

Recall that the current–value Hamiltonian of the consumer is stated in (4.9) as:

$$H_c = \frac{(c^{1-\beta}m^{\beta})^{1-\sigma}-1}{1-\sigma}$$
$$+q_1[(1-\delta\tau)Ak^{\alpha}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma}-c-na-(n+\pi-(1-\delta)\mu)m]$$
$$+q_2[\phi(E)\theta_1(1-u)h] \tag{C.1}$$

where $a = k+m$, and the resulting first-order conditions described in (4.8)-(4.12) are:

$$\frac{H_c}{c}:(1-\beta)c^{-\beta}m^{\beta}(c^{1-\beta}m^{\beta})^{-\sigma} = q_1 \tag{C.2}$$
$$\frac{H_c}{m}:\beta c^{1-\beta}m^{\beta-1}(c^{1-\beta}m^{\beta})^{-\sigma} = q_1[n+\pi-(1-\delta)\mu-(1-\delta\tau)\alpha Ak^{\alpha-1}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma}] \tag{C.3}$$
$$\frac{H_c}{u}:q_2\phi(E)\theta_1 h = q_1[(1-\delta\tau)(1-\alpha)Ak^{\alpha}u^{-\alpha}h^{1-\alpha}h_a^{\gamma}] \tag{C.4}$$
$$\frac{H_c}{k}:\dot{q_1} = \rho q_1 - q_1[(1-\delta\tau)\alpha Ak^{\alpha-1}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma}-n] \tag{C.5}$$
$$\frac{H_c}{h}:\dot{q_2} = \rho q_2 - q_1[(1-\delta\tau)(1-\alpha)Ak^{\alpha}u^{1-\alpha}h^{-\alpha}h_a^{\gamma}]-q_2\phi(E)\theta_1(1-u) \tag{C.6}$$

Since in steady–state $\frac{\dot{m}}{m} = \frac{\dot{c}}{c}$, from $(C.2)$ and $(C.3)$ we obtain

$$-\sigma\frac{\dot{c}}{c} = \frac{\dot{q_1}}{q_1} \tag{C.7}$$

From $(C.5)$ we have $\frac{\dot{q_1}}{q_1} = \rho+n-[(1-\delta\tau)\alpha Ak^{\alpha-1}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma}]$, and substituting this into $(C.7)$, taking logs and the time–derivative yields

$$\frac{\dot{k}}{k} = (\frac{1-\alpha+\gamma}{1-\alpha})\frac{\dot{h}}{h} \tag{C.8}$$

To derive the market equilibrium, we use (C.4) and (C.6) to get

$$\frac{\dot{q}_2}{q_2} = \rho - \phi(E)\theta_1 \tag{C.9}$$

and then from combining (C.4), (C.8) and (C.9) we have

$$\frac{\dot{q}_1}{q_1} = \rho - \phi(E)\theta_1 - \frac{\gamma}{1-\alpha+\gamma}\frac{\dot{k}}{k} \tag{C.10}$$

Substituting (C.7) and (C.8) into (C.10), gives

$$-\sigma\frac{\dot{c}}{c} = \rho - \phi(E)\theta_1 - \frac{\gamma}{1-\alpha+\gamma}\frac{\dot{k}}{k} \tag{C.11}$$

and together with $\frac{\dot{y}}{y} = \frac{\dot{k}}{k}$ from the production function in (4.4), we finally have the steady–state growth rate, λ^* as:

$$\lambda^* = [\phi(E)\theta_1 - \rho]\frac{1-\alpha+\gamma}{\sigma(1-\alpha+\gamma)-\gamma} \tag{C.12}$$

In equilibrium, it must hold that $h = h_a$. This reduces the steady–state growth rate $\lambda^* = \frac{\dot{c}}{c} = \frac{\dot{m}}{m} = \frac{\dot{k}}{k} = \frac{\dot{h}}{h} = \frac{\dot{y}}{y}$ to:

$$\lambda^* = \phi(E)\theta_1 - \rho \tag{C.13}$$

C.0.2 Derivation of the ratio of productive government expenditure as a percentage of GDP

From (C.5) and (C.7), on a balanced growth path, we have:

$$\frac{\dot{c}}{c} = \alpha A k^{\alpha-1}u^{1-\alpha}h^{1-\alpha} - \rho = \alpha\frac{y}{k} - \rho \tag{C.14}$$

Substituting (C.13) into (C.14) yields

$$\frac{k}{y} = \frac{\alpha}{\phi(E)\theta_1} \tag{C.15}$$

Combining the first–order conditions for consumption and money in (C.2) and (C.3), together with the endogenous value for inflation, $\pi = \mu + \rho - \alpha\frac{y}{k}$ (recall that $\frac{\dot{m}}{m} = \frac{\dot{c}}{c}$), we get

$$m = \frac{\beta c}{(1-\beta)(\mu+\rho)} \tag{C.16}$$

Then, from the government budget constraint in (4.3) we define the ratio of total government expenditure to GDP as:

$$\theta = \tau + \frac{\mu m}{y} \tag{C.17}$$

which can then be rewritten as

$$\theta = \frac{\mu\beta}{(1-\beta)(\mu+\rho)}\frac{c}{y} \tag{C.18}$$

and since $\frac{\dot{m}}{m} = \mu - n - \pi$, the budget constraint yields:

$$\frac{\dot{k}}{k} = \frac{y}{k} - \frac{c}{k} - \frac{\delta \mu m}{k} \tag{C.19}$$

Using (C.13) together with (C.19) we first derive an explicit expression for $\frac{c}{k}$ and subsequently, yield

$$\frac{c}{y} = \frac{c}{k}\frac{k}{y} = \Big(\frac{\phi(E)\theta_1(E)(1-\alpha)+\alpha\rho}{\alpha}\Big)\Big(\frac{(1-\beta)(\mu+\rho)}{(1-\beta)(\mu+\rho)+\delta\mu\beta}\Big)\Big(\frac{\alpha}{\phi(E)\theta_1}\Big) \tag{C.20}$$

Finally, substituting (C.20) into (C.18), we have the steady–state value of the ratio of total government expenditure as:

$$(1+\delta)\theta^* = \frac{\mu\beta}{(1-\beta)(\mu+\rho)}\Big[(1-\alpha) + \frac{\alpha\rho}{\phi(E)\theta_1}\Big] \tag{C.21}$$

C.0.3 Countries included in sub–samples for Table 4.3 and Table 4.4

Table C.1: Sub–sample Countries Details

Columns	Initial Countries	Outlier Countries removed
Table 3 Column 1	Armenia, Canada, Chile, Denmark, Gambia, Guatemala, Hong Kong, Japan, Liberia, Nicaragua, New Zealand, Peru, Qatar, Singapore, Switzerland, Trinidad & Tobago, Vanuatu, Zambia	Chile, Qatar
Table 3 Column 2	Canada, Chile, Czech Republic, Denmark, Guatemala, Hong Kong, Indonesia, Israel, Japan, Netherlands, Norway, New Zealand, Peru, Qatar, Romania, Singapore, Sweden, Switzerland, Trinidad & Tobago, United Arab Emirates, United Kingdom, United States of America, Zambia	Peru, Qatar, Trinidad & Tobago, United Arab Emirates
Table 3 Column 3	Armenia, Canada, Chile, Denmark, Gambia, Guatemala, Hong Kong, Japan, Liberia, Mauritius, Nicaragua, New Zealand, Peru, Qatar, Singapore, Switzerland, Trinidad & Tobago, Vanuatu, Zambia	Liberia, Qatar
Table 3 Column 4	Armenia, Canada, Chile, Denmark, Gambia, Guatemala, Hong Kong, Japan, Liberia, Nicaragua, New Zealand, Peru, Qatar, Singapore, Switzerland, Trinidad & Tobago, Vanuatu, Zambia	Chile, Qatar, Trinidad & Tobago
Table 4 Column 1	Canada, Chile, Cyprus, Denmark, Gambia, Guatemala, Hong Kong, Liberia, Nicaragua, New Zealand, Peru, Qatar, Singapore, Switzerland, Trinidad & Tobago, Vanuatu, Zambia	Guatemala, Liberia
Table 4 Column 2	Canada, Cyprus, Denmark, Guatemala, Hong Kong, Jordan, Japan, Liberia, Mauritius, Nicaragua, New Zealand, Peru, Qatar, Singapore, Switzerland, Trinidad & Tobago, Vanuatu, Zambia	Liberia, Nicaragua, Qatar
Table 4 Column 3	Australia, Bulgaria, Canada, Chile, Cyprus, Czech Republic, Denmark, Egypt, Guatemala, Hong Kong, Hungary, Indonesia, Israel, Japan, Mauritius, Netherlands, Norway, New Zealand, Peru, Qatar, Romania, Singapore, Sweden, Switzerland, Trinidad & Tobago, United Kingdom, United States of America, Zambia	Trinidad & Tobago, United Arab Emirates

APPENDIX D ENDOGENOUS FLUCTUATIONS IN AN ENDOGENOUS GROWTH MODEL: AN ANALYSIS OF INFLATION TARGETING AS A POLICY

D.0.1 Optimisation solutions for all economic agents

Note that from the solution to the consumer's problem, we have:

$$d_t = w_t \tag{D.1}$$

$$c_{t+1} = (1 + r_{dt+1})d_t \tag{D.2}$$

from (5.2) and (5.3). The bank's solution follows directly from its net profit function, and the fact that (5.5) and (5.6) holds. We also obtain, from putting (5.6) into (5.5) that:

$$l_t = (1 - \gamma_t)d_t \tag{D.3}$$

Recall the firm's optimisation problem, in recursive form:

$$V(k_{t-1}) = \max_{k_t, n_t} \left[p_t A k_{t-1}^{\alpha} (n_t g_t)^{1-\alpha} - p_t w_t n_t - p_t (1 + i_{Lt})(k_t - (1 - \delta_k) k_{t-1}) \right] + \rho V(k_t) \tag{D.4}$$

which yields the following first order conditions (FOC):

$$k_t: \quad p_t(1 + i_{Lt}) = \rho V'(k_t) \tag{D.5}$$

$$n_t: \quad w_t = (1 - \alpha) A (\frac{k_{t-1}}{n_t})^{\alpha} g_t^{1-\alpha} \tag{D.6}$$

with the solution to the FOC for k_t found in the derivative of the value function with respect to k_{t-1}, updated for one period. Formally:

$$V'(k_t) = p_{t+1} \alpha A \Big(\frac{n_{t+1} g_{t+1}}{k_t}\Big)^{1-\alpha} + p_{t+1}(1 + i_{Lt+1})(1 - \delta_k) \tag{D.7}$$

which results in (5.15). Simply substituting $\delta_k = 1$ and n_{t+1} into (5.15), yields:

$$(1 + r_{Lt}) = \rho\big[\alpha A\big(\frac{g_{t+1}}{k_t}\big)^{1-\alpha}\big] \tag{D.8}$$

and because $(1 + r_{Lt})$ is constant, it implies that $\big(\frac{g_{t+1}}{k_t}\big)^{1-\alpha}$ must be constant as well. From (5.7), we can show that $(1 + r_{dt}) = (1 + r_{lt})(1 - \gamma_t) + \frac{\gamma_t}{\hat{\Pi}}$. From (5.15) it is also clear that $(1 + r_{lt}) = \rho[\alpha A(\frac{g_{t+1}}{k_t})^{1-\alpha}]$, hence a higher inflation target would lead to a lower $(1 + r_{lt})$ and due to the real rate on loans and the real rate on deposits being tied, in equilibrium, would also lead to lower $(1 + r_{dt})$.

From the government's budget constraint in (5.16), we have:

$$g_t = \frac{M_t - M_{t-1}}{p_t} \tag{D.9}$$

$$= m_t - \frac{M_{t-1}}{M_t}\frac{M_t}{p_t} \tag{D.10}$$

$$= m_t - \frac{1}{\Omega_t \hat{\Pi}} m_t \tag{D.11}$$

$$= \gamma_t d_t \left(1 - \frac{1}{\Omega_t \hat{\Pi}}\right) \tag{D.12}$$

with $m_t = \gamma_t d_t$ and Ω_t defined as the gross growth rate in period t, and because the government targets inflation in this setting, i.e. $\Pi_t = \hat{\Pi}$, we can define $\hat{\Pi}$ as the gross inflation rate $\forall\ t$. Further, from (2.16), we also have $\frac{g_{t+1}}{k_t} = (\gamma_t(1-\alpha)A[1 - \frac{1}{\Omega_{t+1}\hat{\Pi}}])^{\frac{1}{\alpha}}$, which implies the government responds to the growth rate as well, in addition to its inflation targeting goal.

D.0.2 Derivation of the BGP gross growth rate

From the government's budget constrain in (2.17), and $\delta_k = 1$ and $n_{t+1} = 1$ we have:

$$g_t = \gamma_t d_t \left(1 - \frac{1}{\Omega_t \hat{\Pi}}\right) \tag{D.13}$$

and using the fact that $d_t = w_t$ and using a rearranged (2.14) twice, we first have:

$$g_t = \gamma_t (1-\alpha) A k_{t-1}^{\alpha} g_t^{1-\alpha} \left(1 - \frac{1}{\Omega_t \hat{\Pi}}\right) \tag{D.14}$$

which simplifies to:

$$g_t = \left(\gamma_t (1-\alpha) A k_{t-1}^{\alpha} \left[1 - \frac{1}{\Omega_t \hat{\Pi}}\right]\right)^{\frac{1}{\alpha}} \tag{D.15}$$

Plugging this expression for g_t back into the rearranged (5.14), along with realising that $w_t = \frac{k_{t+1}-(1-\delta_k)k_t}{(1-\gamma_t)}$, we have:

$$\frac{k_{t+1}-(1-\delta_k)k_t}{(1-\gamma_t)} = (1-\alpha)A\left[\gamma_t(1-\alpha)A\left(1-\frac{1}{\Omega_t\hat{\Pi}}\right)\right]^{\frac{1-\alpha}{\alpha}} k_{t-1} \tag{D.16}$$

Recall that $\delta_k = 1$ and dividing both sides with k_t, yields the expression for the gross growth rate found in (5.18):

$$\Omega_{t+1} = (1-\gamma_t)(1-\alpha)A\left[\gamma_t(1-\alpha)A\left(1-\frac{1}{\Omega_t\hat{\Pi}}\right)\right]^{\frac{1-\alpha}{\alpha}} \frac{1}{\Omega_t} \tag{D.17}$$

which clearly makes $\Omega_{t+1} = f(\Omega_t)$.

The derivative of Ω_{t+1} is given as:

$$\frac{\partial\Omega_{t+1}}{\partial\Omega_t} = \frac{(\gamma_t-1)[A(1-\alpha)\gamma_t(1-\frac{1}{\Omega_t\hat{\Pi}})]^{\frac{1}{\alpha}}(\alpha\Omega_t\hat{\Pi}-1)}{(\hat{\Pi}\Omega_t-1)\alpha\gamma_t\Omega_t} \tag{D.18}$$

with the optimal solution for $\Omega_t* = \frac{1}{\hat{\Pi}\alpha}$.

D.0.3 The BGP gross growth rate with g_{t-1}

When lagged public capital is included, together with lagged private capital, the resultant ratio of public and private capital inputs from the government's budget constraint, is:

$$\frac{g_t}{k_t} = \left(\gamma_t(1-\alpha)A\left[1-\frac{1}{\Omega_{t+1}\hat{\Pi}}\right]\frac{1}{\Omega_{t+1}}\right)^{\frac{1}{\alpha}} \tag{D.19}$$

The expression for the gross growth rate becomes:

$$\Omega_{t+1} = (1-\gamma_t)(1-\alpha)A\left[\gamma_t(1-\alpha)A\left(1-\frac{1}{\Omega_t\hat{\Pi}}\right)\right]^{\frac{1-\alpha}{\alpha}} \frac{1}{\Omega_t^{\frac{1}{\alpha}}} \tag{D.20}$$

which still implies that $\Omega_{t+1} = f(\Omega_t)$. The related optimal solution for $\Omega_t* = \frac{2-\alpha}{\hat{\Pi}}$, with the gross growth rate again inversely related to the gross inflation rate.