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Openness and Growth: Is the Relationship Non-linear?

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Abstract

Using a novel, augmented two–sector endogenous growth model appropriate for a small, open economy characterised by human capital accumulation and productive government expenditure, we analyse the nature of the relationship between openness and economic growth. In the augmented form, external openness enters the human capital accumulation function directly. Productive government expenditure also affects human capital accumulation, but relies on seigniorage revenue to finance the productive expenditure where seigniorage revenue is itself dependent on the level of openness. Specifically, the findings indicate two, opposing effects of openness on growth – a direct effect of openness on growth through the 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 resultant openness–growth curve can be concave or convex, but do not specify theoretical functional forms or values to unknown parameters in the model to provide a concise theoretical result. Rather, drawing samples of exact model–match countries over a sample period of 1980–2011, we rely on a semi–parametric, data–driven empirical approach augmented with a restricted cubic spline regression function to provide empirical impetus to the theoretical outcomes reported. We show that the relationship between openness and growth is non–linear and specifically, inverted U–shaped. The result suggests that openness can only have a positive impact on the growth-rate until a certain threshold–level, beyond which, the effect is negative.

Keywords: Openness, seigniorage, knowledge spillovers, semi–parametric estimation, spline regression.
JEL Classification: C14, C61, E21, O42

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1 Introduction

"From the purely economic point of view, nothing speaks against free trade and everything against protectionism" – Ludwig von Mises (1919)[1]

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. 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 leads to higher banking sector development, which decreases the cost of borrowing and improves the intermediation of capital. It is a readily–accepted fact that financial development is a crucial determinant for long–run growth.[2] 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[3], 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

[1]Nation, State and Economy.

[2]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.

[3]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.

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

[4]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.

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

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 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.[6] This implies that $\theta_1' < 0$.

Hence, *a priori*, there exist 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

[6]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).

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.

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, we highlight only a few more recent studies[7] 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 impact 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

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

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 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 1, and is not intended as an exhaustive list of studies reporting a non–linear relationship between openness and growth.

Table 1: Related studies on Openness–Growth non–linearities

Study	O–G relationship	Method(s)	Key features
Awokuse & 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 & 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 & Ho (2013)	Undetermined	Non–linear cointegration tests & non–linear Granger causality	ASEAN–5 countries, failed to detect significant non–linearity in the causality relationship between export and GDP.
Cuaresma & 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.
Eriş & Ulaşan (2013)	No significant relationship	Bayesian Model Averaging	1960–2000 sample period, use vast number of openness measures
Dufrenot, Mignon & 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 2 describes the economic setting for our analysis; Sections 3–5, 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 and Section 6 offers some concluding remarks.

2 The economic setting

2.1 Producer–Consumers

The producer–consumer representative[8] 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:

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

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[9] 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:

$$\begin{aligned} \frac{\dot{K}}{L} + \frac{\dot{M}}{PL} + \frac{\dot{B}}{L} &= rb + y - \tau y - c + v - (ex - im) \qquad (2) \\ \frac{\dot{B}}{L} &= rb - (ex - im) \end{aligned}$$

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 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

[8]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).

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

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 $n = 0$.

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:

$$g + v = \tau y + \mu m \tag{3}$$

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.

2.3 Production Technology

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

$$y = Ak^{\alpha}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma} \tag{4}$$

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[10].

[10]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.

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 coincides. 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 $h = h_a$.

2.4 Human capital

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

$$\dot{h} = \phi(E)\theta_1(1 - u_t)h \tag{5}$$

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

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;
- The government budget constraint in (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:

$$\begin{aligned} g + v &= \mu m \\ v &= -g + \mu m \end{aligned} \tag{6}$$

and considering that

$$g = \delta(\mu m) \tag{7}$$

one has

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

Hence, we can rewrite (2) and (3) as:

$$\dot{k} + \dot{m} = y - c - [\pi - (1 - \delta)\mu]m \tag{8}$$

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[11].

$$\begin{aligned} H_c = & \, ln(c^{1-\beta} m^{\beta}) \\ & + q_1[Ak^{\alpha} u^{1-\alpha} h^{1-\alpha} - c - m(\pi - (1 - \delta)\mu)] \\ & + q_2[\phi(E)\theta_1(1 - u)h] \end{aligned} \tag{9}$$

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 is given by the respective first–order conditions (FOC's) of:[12]

$$c : (1 - \beta)c^{-1} = q_1 \tag{10}$$
$$m : \beta m^{-1} = q_1[\pi - (1 - \delta)\mu - \alpha Ak^{\alpha-1} u^{1-\alpha} h^{1-\alpha}] \tag{11}$$
$$u : q_1[(1 - \alpha)Ak^{\alpha} u^{-\alpha} h^{1-\alpha}] = q_2[\phi(E)\theta_1 h] \tag{12}$$
$$k : \rho q_1 - \dot{q_1} = q_1[\alpha Ak^{\alpha-1} u^{1-\alpha} h^{1-\alpha}] \tag{13}$$
$$h : \rho q_2 - \dot{q_2} = q_1[(1 - \alpha)Ak^{\alpha} u^{1-\alpha} h^{-\alpha}] + q_2[\phi(E)\theta_1(1 - u)] \tag{14}$$

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 (10), taking logs and time–derivatives we get:

$$\frac{\dot{q_1}}{q_1} = -z \tag{15}$$

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

From (13), we also have:

$$\frac{\dot{q_1}}{q_1} = (\rho) - [\alpha Ak^{\alpha-1} u^{1-\alpha} h^{1-\alpha}] \tag{16}$$

where the last term on the right–hand side is the marginal product of capital (MPK).

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[11] 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 $a = k + m$.

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

Focusing on the steady–state, namely when $\frac{\dot{q}_1}{q_1}$ and u are constants with respect to time[13], we take (13) and (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:

$$\frac{\dot{k}}{k} = \frac{1-\alpha}{1-\alpha}v \tag{17}$$

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 (12), we derive the following expression:

$$\frac{q_1}{q_2} = \frac{\phi(E)\theta_1}{(1-\alpha)Ak^{\alpha}u^{-\alpha}h^{-\alpha}} \tag{18}$$

and from (14) together with (18), we get:

$$\frac{\dot{q}_2}{q_2} = (\rho) - \phi(E)\theta_1 \tag{19}$$

From (18), taking logs and derivatives and combining with (19), we have:

$$\frac{\dot{q}_1}{q_1} = (\rho) - \phi(E)\theta_1. \tag{20}$$

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 (15) into (20) we derive the steady–state growth rate (where $\lambda = \frac{\dot{k}}{k} = \frac{\dot{c}}{c}$) as:

$$\lambda = \phi(E)\theta_1 - \rho \tag{21}$$

4.1 Solving the Government revenue ratio

From the government's budget constraint stated in (3), we have:

$$\theta = \frac{\mu m}{y} \tag{22}$$

[13]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.

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

$$(1+\delta)\theta = \frac{\mu\beta}{(1-\beta)(\mu+\rho)}\left[(1-\alpha)+\frac{\alpha\rho}{\phi(E)\delta\theta}\right] \tag{23}$$

with $\theta_1 = \delta\theta$, the *productive* government expenditure component following directly from the solution in (23).

From (23) it becomes clear that $\theta = f(\phi(E))$. Hence, there is a direct effect of openness on growth, as shown in (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 (23) against the right–hand side of (23) in Figure 1 to analyse changes in θ, the government expenditure given changes in E, or external openness.

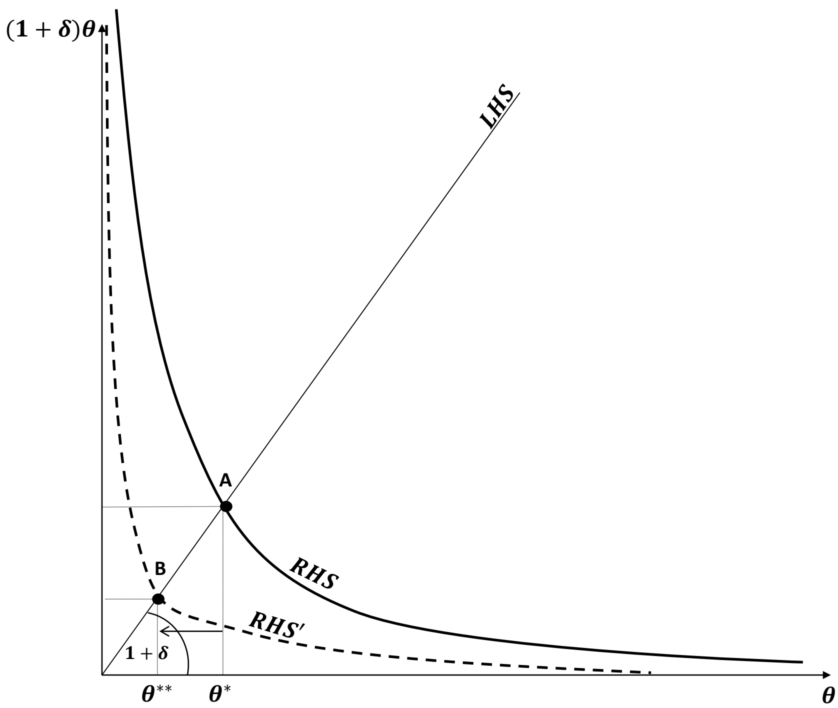


Figure 1: A plot of the decomposition of (23) to analyse movements in θ related to changes in E

The line LHS is the left–hand side of (23), with a slope of $(1+\delta)$ and the curve RHS is the right–hand side of (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 (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 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 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.

4.2 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:

$$\frac{d\lambda}{dE} = \phi'(E)\theta_1(E) + \phi(E)\theta_1'(E) = 0 \tag{24}$$

$$\phi'(E)\theta_1(E) = -\phi(E)\theta_1'(E) \tag{25}$$

$$\frac{\phi'(E)E}{\phi(E)} = -\frac{\theta_1'(E)E}{\theta_1(E)} \tag{26}$$

Hence, from the FOC there exists an extreme point (minimum or maximum) of the growth function expressed in (21), characterized by the equality of the two elasticities above.

For concavity (convexity) of the function in (21) defined on an interval X, it must hold that for any $x \; \varepsilon \; X$, given that the derivative $f''(x)$ exists, $f''(x) \leq 0$ ($f''(x) \geq 0$). The second order derivative of (21) is:

$$\frac{d^2\lambda}{dE^2} = \phi''(E)\theta_1(E) + \phi'(E)\theta_1'(E) + \phi'(E)\theta_1'(E) + \phi(E)\theta_1''(E) \tag{27}$$

From (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.

5 The empirical setting

5.1 Data description and model matching strategy

Our sample period covers 1980–2011, and we initially collect data for 176 countries. Table 2 provides concise summary statistics of the main variables analysed in (33).

In analysing the proposed growth regression in (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 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

Table 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

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.[14] 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 countries that are 'least financially open' and the upper bound representative of countries that are 'most financially open'.[15]

Our inclusion-criteria, based on the Chinn–Ito index, is countries that have a *kaopen* index–value higher than the 75^{th} percentile[16] of the entire 4–year averaged dataset.

The second assumption, found in the section on the "Government", is

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

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

[16]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.

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*[17] 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 scenario's – 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 between openness and growth, although we report only some of the findings here that we believe elucidate our theoretical findings the best.[18]

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 simultane-

[17]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.

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

ously 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.[19] 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[20], 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 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 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.

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:

$$y_i = c_i + \beta_i X_i + f(z_i) + \epsilon_i \tag{28}$$

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

[20]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.

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 (21) and (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:

$$[y_i - E(y_i|z_i)] = [X_i - E(X_i|z_i)]\beta_i + \epsilon_i \tag{29}$$

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:

$$y_i - \hat{m_y}(z_i) = [X_i - \hat{m_X}(z_i)]\beta_i + \epsilon_i \tag{30}$$

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:

$$y_i - X_i\hat{\beta}_i = c + f(z_i) + \epsilon_i \tag{31}$$

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.[21] 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:

$$\begin{aligned} f(z) = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3 + \beta_4 (X - a_1)^3_+ \\ + \beta_5 (X - a_2)^3_+ + \beta_6 (X - a_3)^3_+ \end{aligned} \tag{32}$$

[21] 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/s.

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[22], $\{a_1, a_2, a_3\}$ 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 that are smooth and continuous at each knot, and have continuous first and second derivatives.[23] 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:

$$\begin{aligned} Growth_i &= f(Openness) + \beta_2 GDP_{initial} + \beta_3 Popgrow \\ &+ \beta_4 Inflation + \beta_5 Investment_{GDP} + \beta_6 Govex_{GDP} \\ &+ \beta_7 Education_{yrs} + \beta_8 Terms_{gr} + \beta_9 Terms_{sd} + \epsilon_i \end{aligned} \tag{33}$$

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

[22]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.

[23]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/p.

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:

$$\begin{aligned} Growth_i &= \beta_1 Openness + \beta_2 Openness^2 + \beta_3 Popgrow \\ &+ \beta_4 Inflation + \beta_5 Investment_{GDP} + \beta_6 Govex_{GDP} \\ &+ \beta_7 Education_{yrs} + \beta_8 TOT + \epsilon_i \end{aligned} \tag{34}$$

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.[24]

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.[25] We already know from our theoretical findings that there is one extreme point, depicted by (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

[24]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/u.

[25]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).

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 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[26]. 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.

5.3 Empirical results

5.3.1 4–year Results

Table 3 contains the results from the exact model–match sample selection strategy, using the 4–year averaged data as described earlier[27].

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 the different sub–samples.[28] In general, the prevailing economy within which these estimates

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

[27] The detailed qualifying criteria and variables used in each sub–sample is explained in the footnote of Table 3.

[28] 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

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.

Table 3: 4–year Semi-parametric and Restricted Cubic Spline Regression Estimates

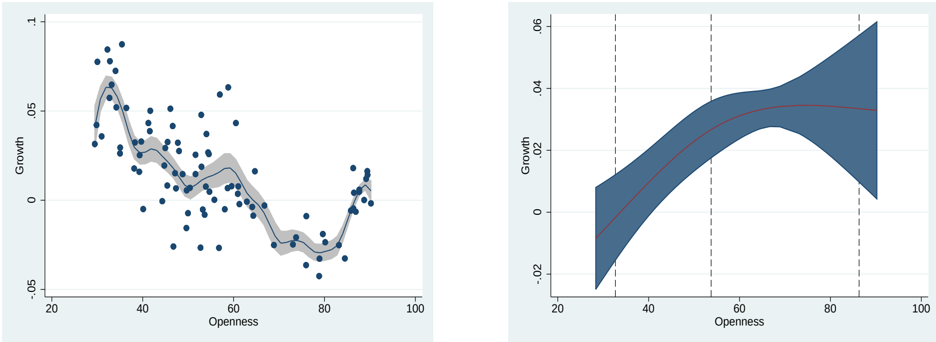
Variables	1a	1b	2a	2b	3a	3b	4a	4b
$GDP_{initial}$	-0.00000***	-0.00000***	-0.00000**	-0.00000***	-0.00001***	-0.00000***	-0.00000***	-0.00000***
	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)	(0.00000)
Popgrow	0.11219	0.92068***	-0.47617***	-0.72705***	0.19922	0.06113	-0.21779	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 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 suggest that the parametric and non–parametric fits are not significantly different. For the restricted cubic spline estimation – depicted in panel *b*[29] –

and 2008–2011.

[29] Based on the leverage–versus–squared–residual plot, the outlying or influential obser-

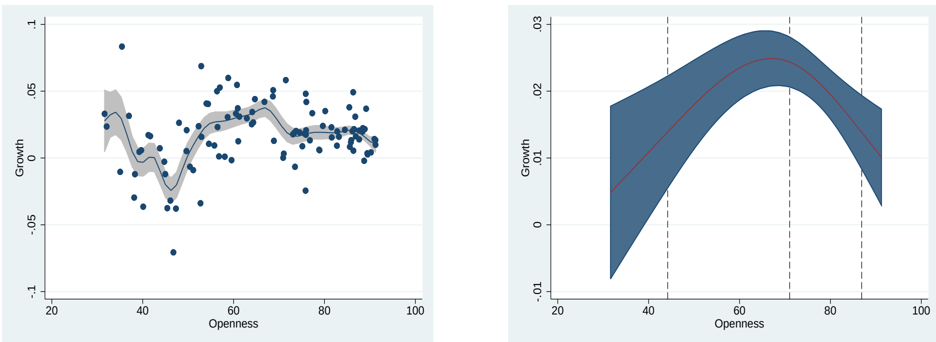


(a) Semi–parametric openness on growth with 18 qualifying countries

(b) Adjusted cubic spline function after removing outliers

Figure 2: Non–linear Openness and Growth: 4–year means

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.



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

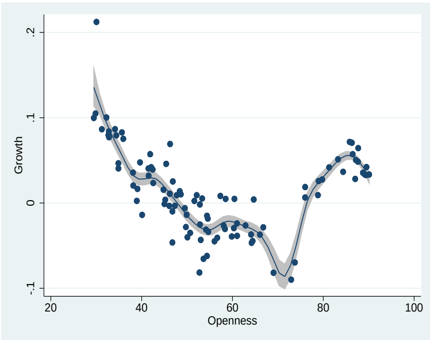
(b) Adjusted cubic spline function after removing outliers

Figure 3: Non–linear Openness and Growth: 4–year means

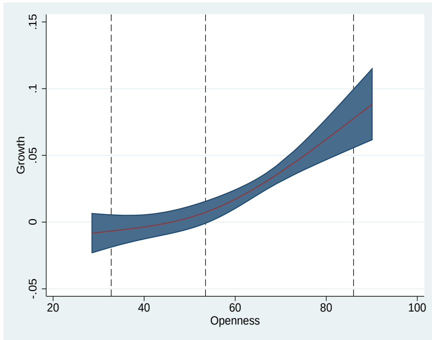
Panel *a* in Figure 3 again clearly depicts the non–linear fit of *Openness* with *Growth* for the sub–sample of 23 countries, using the Obstfeld–type seigniorage as the qualifying criteria. The associated Hardle and Mammen (1993) test suggest that the parametric and non–parametric fits are not

vations for Chile during 1980–1983 and Qatar during 2000–2003, are dropped.

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 this sub–sample of countries is significantly higher than in sub–sample 1.[30] 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: Non–linear Openness and Growth: 4–year medians

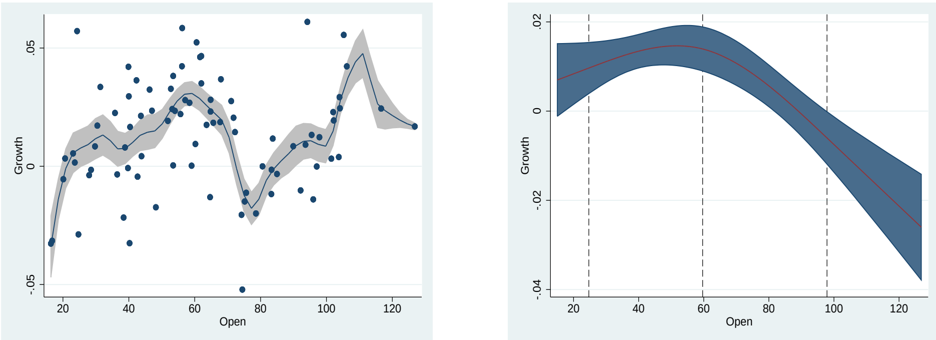
From Figure 4, the non–linear fit of *Openness* with *Growth* for this sub–sample of 19 countries based on the 75th percentile of the *median values*, is suggestive of the opposite relationship. Compared to the first sub–sample reported in Column 1 of Table 3, it is not only the addition of Mauritius[31] 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

[30] 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.

[31] 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.

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.[32] 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 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 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 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.[33] 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.

[32] 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.

[33] 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).

5.3.2 8–year Results

Table (4) contains the results from the exact model–match sample selection strategy, using the 8–year averaged data as described earlier[34].

Again, the same cautionary explained earlier applies to the interpretation of the results listed in Table (4) in that these should not be interpreted in a "line–by–line" fashion.[35]

Panel *a* in Figure 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.[36] 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 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

[34] The detailed qualifying criteria and variables used in each sub–sample is explained in the footnote of Table (4).

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

[36] 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.

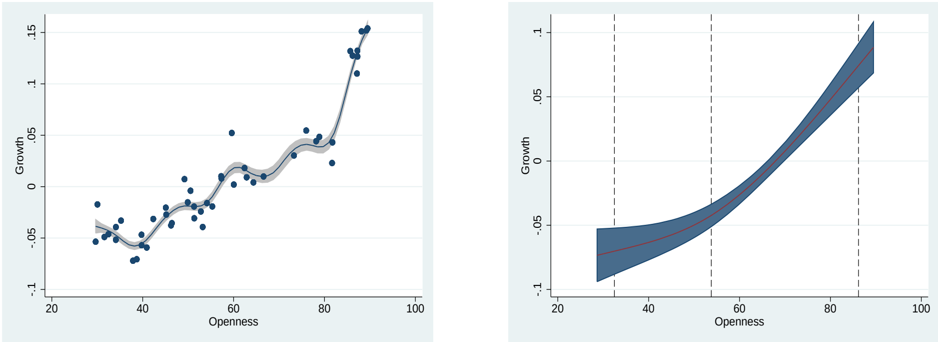
Table 4: 8–year Semi-parametric and Restricted Cubic Spline Regression Estimates

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; 75*th* percentile *kaopen*; 75*th* percentile seigniorage/deficit ratio (Cukierman-type); *Openness*; 8–year means.
Column 2: 18 countries; 75*th* percentile *kaopen*; 75*th* percentile seigniorage/deficit ratio (Cukierman-type); *Openness*; 8–year medians.
Column 3: 29 countries; 66*th* percentile *kaopen*; 66*th* percentile seigniorage/deficit ratio (Obstfeld-type); $Open_{(X+Z)}$; 8–year medians.

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 (4.2), is that the marginal benefit of human capital investment in these economies is high enough to sustain continued increases in productive government expenditure.

From Figure 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



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

(b) Adjusted cubic spline function after removing outliers

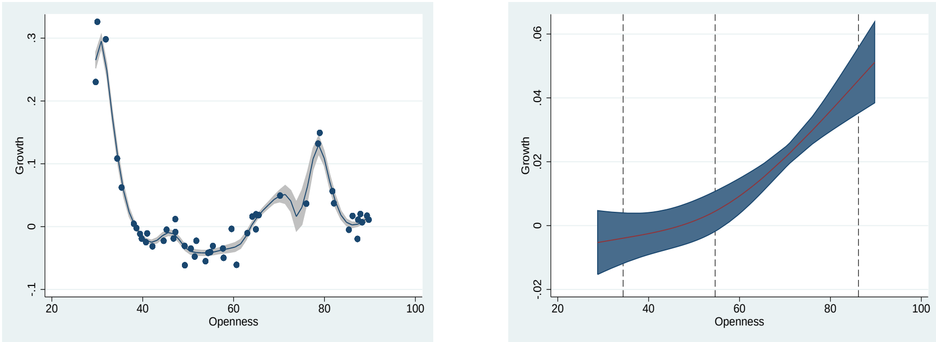
Figure 6: Non–linear Openness and Growth: 8–year means

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.[37] 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.

For sub–sample 3 in Table (4), Figure (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.[38] The coefficient on the first spline is positive and statistically significant, and the coefficient on the second spline is negative and statistically significant, sug-

[37]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.

[38]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.

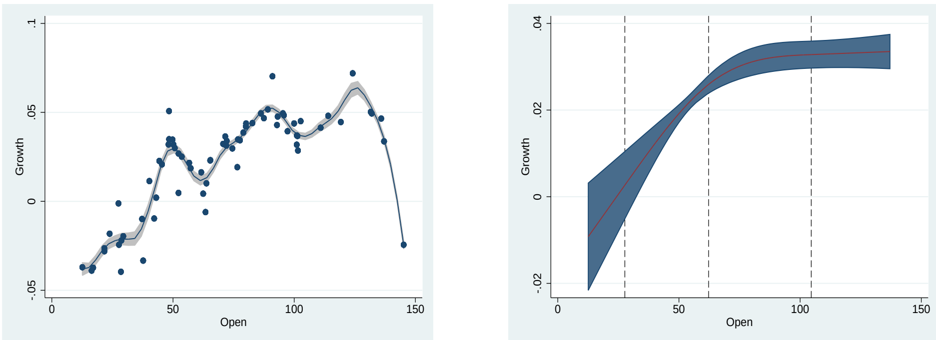


(a) Semi–parametric openness on growth with 18 qualifying countries

(b) Adjusted cubic spline function after removing outliers

Figure 7: Non–linear Openness and Growth: 8–year medians

gesting 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 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.[39] 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 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 3 and Table 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 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

[39]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.

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 its 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.

5.3.3 Full Sample Results

Table (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 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 (5) 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.[40]

[40]The leverage–versus–squared–residual plot identifies the outlying or influential ob-

Table 5: Semi–Parametric & 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)
$\text{Investment}_{\text{GDP}}$	0.00114***	0.00100***	0.00070***	0.00099***	0.00082***	0.00057***
	(0.00025)	(0.00020)	(0.00025)	(0.00021)	(0.00019)	(0.00022)
$\text{Govex}_{\text{GDP}}$	-0.00070*	-0.00039	-0.00158***	-0.00113***	-0.00102***	-0.00162***
	(0.00035)	(0.00028)	(0.00053)	(0.00030)	(0.00026)	(0.00048)
$\text{Education}_{\text{yrs}}$	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]

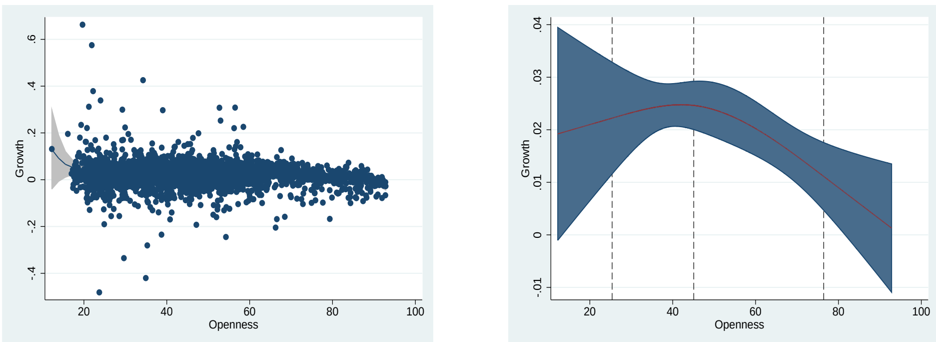
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Country- and Time dummies are suppressed to save space.

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 statistically significant. Graphically, the inverted–U shape holds as depicted in panel b of Figure (9). In Column 1c, 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

servations 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.

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

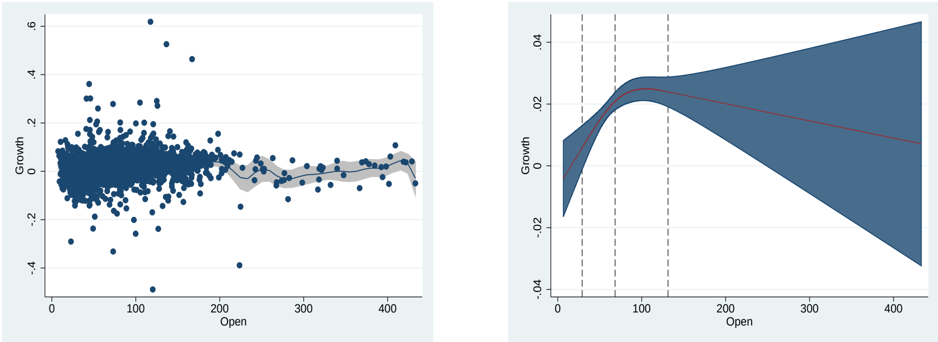
Even more robust evidence in support of the non–linear inverted–U relationship between openness and growth emerge when the more traditional trade openness measure is used. From Figure 10, the non–linear fit of *Openness* with *Growth* for the entire sample of 176 countries is clear. The associated Hardle and Mammen (1993) test for Column 2a in Table (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. [41]

The coefficient in 2*b* 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 (10). In Column 2*c*, 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 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.

In this large panel of 176 countries, the expected empirical relationship detailed in much of the literature on economic growth, holds. *Inflation*

[41] 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.



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

(b) Adjusted cubic spline: Full sample

Figure 10: Non–linear relationship between Trade Openness and Growth, 1980–2009

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.

6 Concluding remarks

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 supports 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.

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A Appendix

A.1 Derivation of the steady-state growth rate

Recall that the current–value Hamiltonian of the consumer is stated in (9) as:

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

where $a = k + m$, and the resulting first-order conditions described in (8)-(12) are:

$$\frac{\mathrm{d}H_c}{\mathrm{d}c} : (1-\beta)c^{-\beta}m^{\beta}(c^{1-\beta}m^{\beta})^{-\sigma} = q_1 \tag{A.2}$$

$$\frac{\mathrm{d}H_c}{\mathrm{d}m} : \beta c^{1-\beta}m^{\beta-1}(c^{1-\beta}m^{\beta})^{-\sigma} = q_1[n+\pi-(1-\delta)\mu-(1-\delta\tau)\alpha Ak^{\alpha-1}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma}] \tag{A.3}$$

$$\frac{\mathrm{d}H_c}{\mathrm{d}u} : q_2\phi(E)\theta_1 h = q_1[(1-\delta\tau)(1-\alpha)Ak^{\alpha}u^{-\alpha}h^{1-\alpha}h_a^{\gamma}] \tag{A.4}$$

$$\frac{\mathrm{d}H_c}{\mathrm{d}k} : \dot{q_1} = \rho q_1 - q_1[(1-\delta\tau)\alpha Ak^{\alpha-1}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma} - n] \tag{A.5}$$

$$\frac{\mathrm{d}H_c}{\mathrm{d}h} : \dot{q_2} = \rho q_2 - q_1[(1-\delta\tau)(1-\alpha)Ak^{\alpha}u^{1-\alpha}h^{-\alpha}h_a^{\gamma}] - q_2\phi(E)\theta_1(1-u) \tag{A.6}$$

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

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

From $(A.5)$ 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 $(A.7)$, taking logs and the time–derivative yields

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

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

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

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

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

Substituting $(A.7)$ and $(A.8)$ into $(A.10)$, gives

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

and together with $\frac{\dot{y}}{y} = \frac{\dot{k}}{k}$ from the production function in (4), we finally have the steady–state growth rate, λ^* as:

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

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:

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

A.2 Derivation of the ratio of productive government expenditure as a percentage of GDP

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

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

Substituting $(A.13)$ into $(A.14)$ yields

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

Combining the first–order conditions for consumption and money in $(A.2)$ and $(A.3)$, 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

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

Then, from the government budget constraint in (3) we define the ratio of total government expenditure to GDP as:

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

which can then be rewritten as

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

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

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

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

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

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

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

B Appendix

B.1 Countries included in sub–samples for Table 3 and Table 4

Table 6: 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