Openness and Growth: Is the Relationship Non-linear?

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Abstract

Despite almost a century of studies and recommendations, there is still no consensus in the literature regarding the openness–growth nexus. 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 effects 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 human capital accumulation function, and an indirect effect of decreasing seigniorage revenue on growth through decreasing productive government expenditure on human capital. We show 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 1980-2012, we rely on a semi–parametric, data–driven empirical approach to provide empirical impetus to the theoretical outcomes reported.

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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 (2005).

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 (2002), 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 depend 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 $1980 - 2012$ employing non–parametric methods following Vaona and Schiavo (2007), augmenting the analysis with the inclusion of a new index of openness constructed by Dreher (2006).[4]

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 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

[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.

Benhabib and Spiegel (1994), Weinhold and Rauch (1997), Chang, Kaltani and Loyaza (2005), Mingyong, Shuijan and Qun (2006) 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 (2012) 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 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.

The rest of the paper is organised as follows: Section 2 describes the economic setting for our analysis; Sections 3-5, respectively, defines the com-

[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).

petitive 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[7] 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 consumer preference for holding money implying that $1 - \beta$ is the consumer preference for consumption and σ is the (constant) intertemporal elasticity of substitution[8] between consumption bundles in any two periods. Consumer maximization is subject to an inter-temporal budget constraint in per capita form (upper case variables denote the aggregate level of the variable, while its lower case counterpart denotes the per capita level), of:

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

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

[7]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).

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

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 σ=1, which is consistent with stable savings behaviour and ties the savings rate to the discount rate, as in Chen and Huang (2008). Moreover, as stated in Lucas (1988) the resultant inefficiency between the efficient and equilibrium growth rate of human capital, is small for values of $\gamma \simeq 0$. Secondly, we assume there is no population growth, or that n=0.

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 they play in human capital accumulation, is equivalent to that of Roubini and Sala-i-Martin (1992), Glomm and Ravikumar (1997), 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 τ=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[9]. h_a is the average 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 γ=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

From the relation between human capital accumulation, openness and productive public expenditure discussed herein, we have the following human capital accumulation form:

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

where $\phi(E)$ is a measure of the impact of external openness on human capital formation (or technological/knowledge spillovers resulting from openness), θ_1 is the impact of productive government expenditure on human capital formation and $(1 - u_t)$ is the time devoted to acquiring new skills by the agents.

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 is positive for all periods.

[9]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.

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:

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

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[10].

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

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 the state variables, respectively.

The optimum conditions for the consumer's problem is given by the respective first–order conditions (FOC's) of:[11]

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

[10]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 $a = k + m$.

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

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:

$$\frac{\dot{q}_1}{q_1} = (\rho) - [\alpha A k^{\alpha-1} u^{1-\alpha} h^{1-\alpha}] \tag{16}$$

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

Focusing on the steady–state, namely when $\frac{\dot{q}_1}{q_1}$ and u are constants with respect to time[12], 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:

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

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, based on the simplifying assumptions that $\sigma = 1$, $n = 0$, $\tau = 0$ and $\gamma = 0$.

[12]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.

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:

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

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.

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

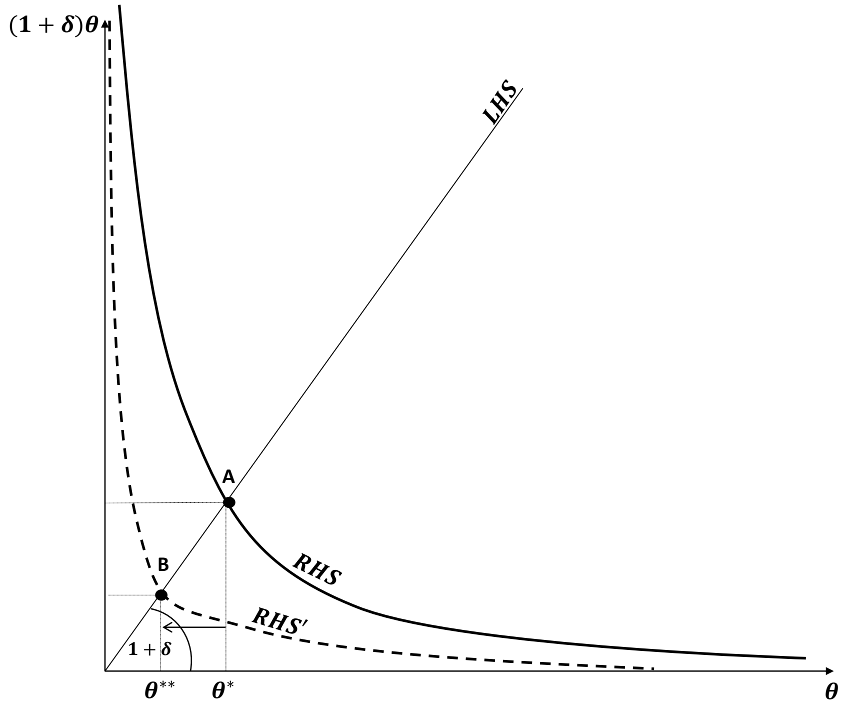


Figure 1: A plot of the decomposition of (23) to analyse movements in θ related to changes in E

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 in stead rely on a non–parametric, data–driven approach following Vaona and Schiavo (2007) and Man (2015) to determine the exact nature of the Openness–Growth relationship.

5 The empirical setting

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[13] on both sides of the openness-growth debate.

[13] 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.

Stiglitz (2003), albeit in a non–empirical way, listed *eight* channels through which globalization, 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. Eriş and Ulaşan (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.* (2005) 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 debate is on–going in the finance–growth literature, that 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, the report a positive correlation between the degree of trade openness and the level of financial development of a country. This is partially confirmed by Baltagi, Demetriadis and Law (2009), who finds that more closed economies will benefit more by opening up their economies, but that only one "type" of openness is required – financial or trade – to generate gains through financial development. Kim, Lin and Suen (2010) somewhat contradict these findings by reporting a dual impact of trade openness on financial development – a negative impact in the short–run and a positive impact only in 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. Based on our theoretical finding in (23), 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.

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 (2011)	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	Nonlinear cointegration tests & nonlinear Granger causality	ASEAN–5 countries, failed to detect significant nonlinearity in the causality relationship between export and GDP.
Cuaresma & Doppelhofer (2007)	Depends on model uncertainty and model size	Bayesian Averaging of Thresholds	Robust nonlinearity of proportion of years economy is open between 1950-1994.
Eris & Ulasan (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.

5.1 Data

Table 2 provides concise summary statistics of the main variables analysed in (28). However, our exact model–match sample selection strategy requires some detailed explanation.

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 (and deviated) period 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 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,

[14]See Shiller and Perron (1985), Hakkio and Rush (1991), Otero and Simth (2000) and

8–year averages and 8–year medians are also used.

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 (2006) 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 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 who 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 and then the seigniorage/deficit ratio. We calculate $seign_1 = \frac{nmoney2_n - nmoney2_{n-1}}{ngdp_n}$, following Cukierman, Edwards and Tabellini (1992), as the ratio of the level of seigniorage to GDP. As a robustness check we also calculate and use $seign_3 = \frac{nmoney2_n - nmoney2_{n-1}}{gdpdefin_n}$ following Obstfeld (1989), to more clearly depict the two different sources of seigniorage income.

This exact model–match sample selection strategy allows us to test 12 different scenario's encompassing a wide range of different possible model and country characteristics in our search for a nonlinear relationship between

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 values higher than the 66^{th} percentile of the entire 4–year averaged dataset.

[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.

openness and growth, although we report only some of the findings here.[18]

Table 2: Summary statistics of Main Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Growth	5064	.018	.06	-.502	.917
Openness	4903	47.669	18.031	12.257	92.836
$\text{GDP}_{\text{initial}}$	5000	9730.118	11771.95	107.803	123433.4
$\text{Population}_{\text{growth}}$	5628	.017	.016	-.073	.191
Inflation	5196	.109	.181	-.488	1
$\text{Investment}_{\text{shareGDP}}$	5162	23.323	11.203	.692	93.637
$\text{Government}_{\text{shareGDP}}$	5162	12.378	9.335	.898	67.189
$\text{Education}_{\text{years}}$	5805	6.351	.893	4	9
Capital Openness	5132	.1	1.562	-1.875	2.422
$\text{Open}_{\text{X+Z}}$	5162	76.816	46.93	6.69	433.045

Growth is calculated as the growth rate in GDP per capita, in real terms. *Openness* is our measure of the degree of openness of a country, and is taken from the Dreher (2006) Globalization index. It is a weighted composite index of (i) data on economic integration; (ii) data on political engagement; and (iii) data on social globalization. The Dreher (2006) index was constructed in response to the need for a more robust measure of openness, that simultaneously accounted for international economic, political, social and information flows along different dimensions whilst addressing the endogeneity problems that more traditional trade measures (exports, imports, exports + imports) suffered from in typical cross-country growth regressions at the turn of the millennium[19].

5.2 The empirical methodology

$$\begin{aligned} GROWTH &= \beta_1 Openness + \beta_2 GDP_{initial} + \beta_3 Population_{growth} \\ &+ \beta_4 Inflation + \beta_5 Investment_{shareGDP} + \beta_6 Government_{shareGDP} \\ &+ \beta_7 Education_{years} + \beta_8 TOT + \beta_9 TOT_{SD} + \epsilon \end{aligned} \quad (28)$$

5.3 Empirical results

6 Concluding remarks

We developed an open economy human capital-based endogenous growth model, where the role of government expenditure and openness is embedded

[18] However, all results are available from the authors on request.

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

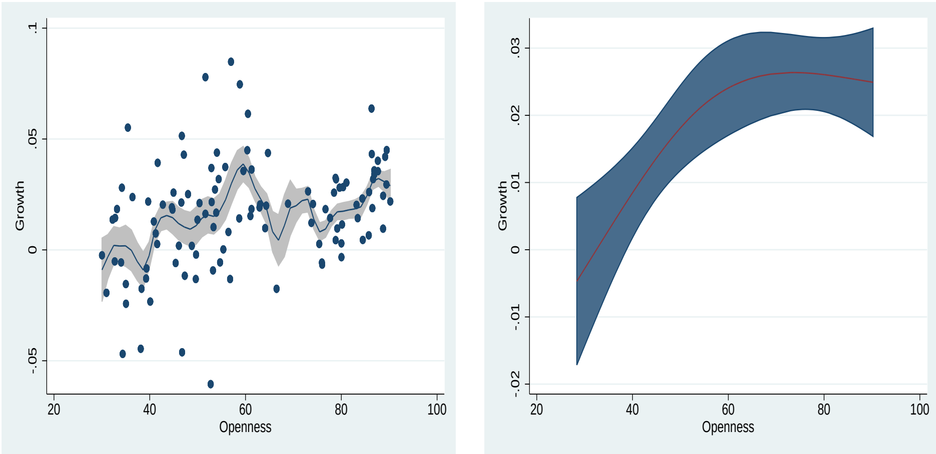
Table 3: Semi-parametric Regression Estimates with Cubic Spline

Variables	1	2	3	4	5	6	7
$GDP_{initial}$	-2.32e-06***	-2.61e-07	-2.74e-06***	-9.68e-07**	-6.30e-07**	-2.06e-06***	-1.38e-06***
	(6.46e-07)	(5.01e-07)	(7.71e-07)	(3.80e-07)	(2.54e-07)	(4.77e-07)	(3.31e-07)
$Population_{growth}$	0.31978	0.24935	0.32016	0.36106	-0.59587***	0.21409	-.4734742
	(0.51431)	(0.28521)	(0.28754)	(0.36224)	(0.10522)	(0.64724)	(.4240348)
Inflation	-0.10351***	-0.04504**	-0.05852*	-0.05282***	-0.08430***	-0.11433***	-.0712215***
	(0.02813)	(0.01784)	(0.02787)	(0.01533)	(0.02339)	(0.03565)	(.0191775)
$Investment_{shareGDP}$	-0.00123	0.00089***	0.00015	-0.00067	-0.00035	-0.00036	-.0008693
	(0.00072)	(0.00023)	(0.00049)	(0.00060)	(0.00047)	(0.00063)	(.0006036)
$Government_{shareGDP}$	-0.00139	-0.00054***	-0.00251**	-0.00030	-0.00278***	-0.00103	-.0021467***
	(0.00141)	(0.00015)	(0.00091)	(0.00020)	(0.00067)	(0.00061)	(.0007365)
$Education_{years}$	0.01064	-0.00321	-0.00259	0.00888*	-0.00210	0.01577	-.0192644*
	(0.00804)	(0.00243)	(0.00861)	(0.00463)	(0.00210)	(0.01150)	(.0098216)
TOT	1.07e-15	-1.61e-15**	1.36e-15	4.11e-15***	-1.38e-16	1.12e-15	-2.68e-16***
	(7.64e-16)	(5.62e-16)	(8.39e-16)	(1.17e-15)	(1.46e-16)	(7.52e-16)	(5.70e-17)
TOT_{sd}	2.72e-15*	2.13e-15	3.02e-15	1.27e-14***	3.35e-17	3.56e-15**	-2.82e-16**
	(1.45e-15)	(2.22e-15)	(1.89e-15)	(3.26e-15)	(6.28e-16)	(1.36e-15)	(1.34e-16)
N	444	432	476	464	612	468	784
R^2	0.470	0.311	0.404	0.579	0.399	0.498	0.696
$Adjusted-R^2$	0.449	0.298	0.381	0.562	0.386	0.479	0.684

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

Model 1: 4yr means, 75^{th} percentile, seigniorage 1.
Model 2: 8yr means, 75^{th} percentile, seigniorage 1.
Model 3: 4yr medians, 75^{th} percentile, seigniorage 1.
Model 4: 8yr medians, 75^{th} percentile, seigniorage 1.
Model 5: 4yr means, 75^{th} percentile, seigniorage 3.
Model 6: 4yr means, 75^{th} percentile, seigniorage 1, $Open_{X+Z}$ measure.
Model 7: 8yr medians, 66^{th} percentile, seigniorage 3, $Open_{X+Z}$ measure.

in the human capital accumulation function. We show the existence of a theoretical non-linear relationship between openness and growth.



(a) Semi-parametric openness on growth with only 18 significant countries

(b) Adjusted cubic spline function after removing outliers

Figure 2: The non-linear relationship between average openness and average growth

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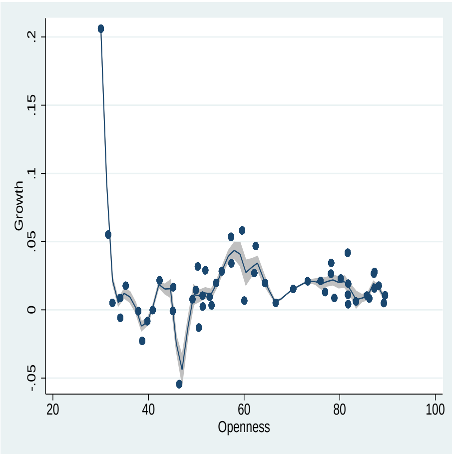

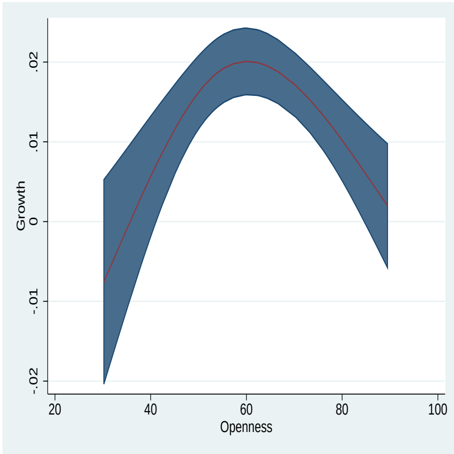

(a) Semi-parametric openness on growth with only 17 significant countries

(b) Adjusted cubic spline function after removing outliers

Figure 3: The non-linear relationship between average openness and average growth

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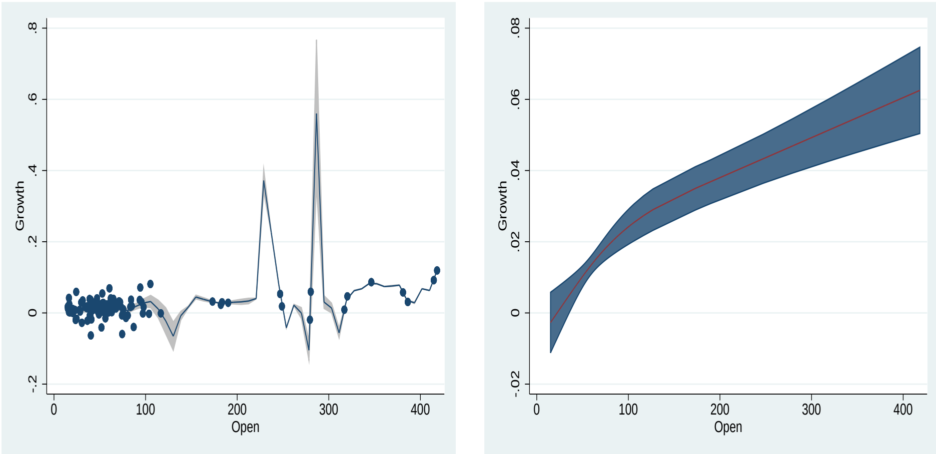

(a) Semi-parametric open_X+Z on growth with only 18 significant countries

(b) Adjusted cubic spline function after removing outliers

Figure 4: The non-linear relationship between average open_X+Z and average growth

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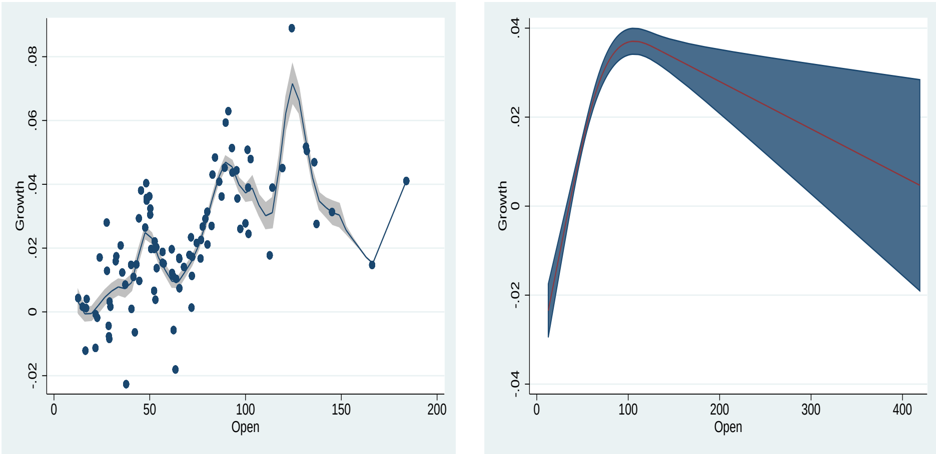

(a) Semi-parametric open_X+Z on growth with only 29 significant countries

(b) Adjusted cubic spline function after removing outliers

Figure 5: The non-linear relationship between average open_X+Z and average growth

A Appendix

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 $\frac{\dot{q_1}}{q_1} = \rho + n - [(1-\delta\tau)\alpha A k^{\alpha-1}u^{1-\alpha}h^{1-\alpha}h_a^{\gamma}]$, 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:

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

Derivation of the ratio of productive government expenditure as a percentage of GDP with $\sigma = 1$, $\gamma = 0$, $\tau = 0$ and $n = 0$

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

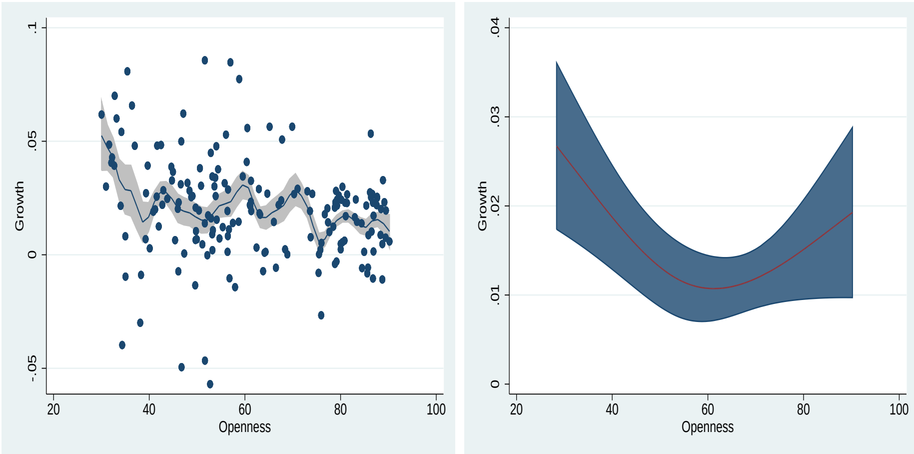

Figure 6: Semi-parametric openness on growth with only 29 significant countries and the adjusted cubic spline function, respectively.

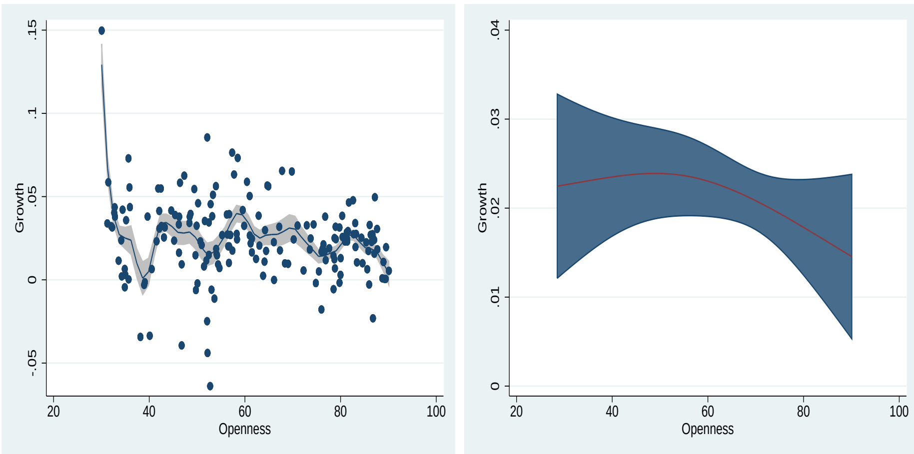

Figure 7: Semi-parametric openness on growth with only 29 significant countries and the adjusted cubic spline function, respectively.

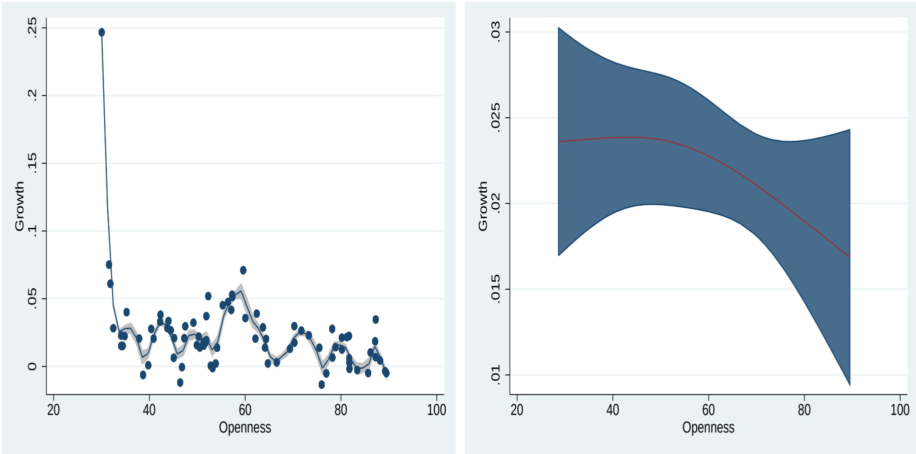

Figure 8: Semi-parametric openness on growth with only 29 significant countries and the adjusted cubic spline function, respectively.

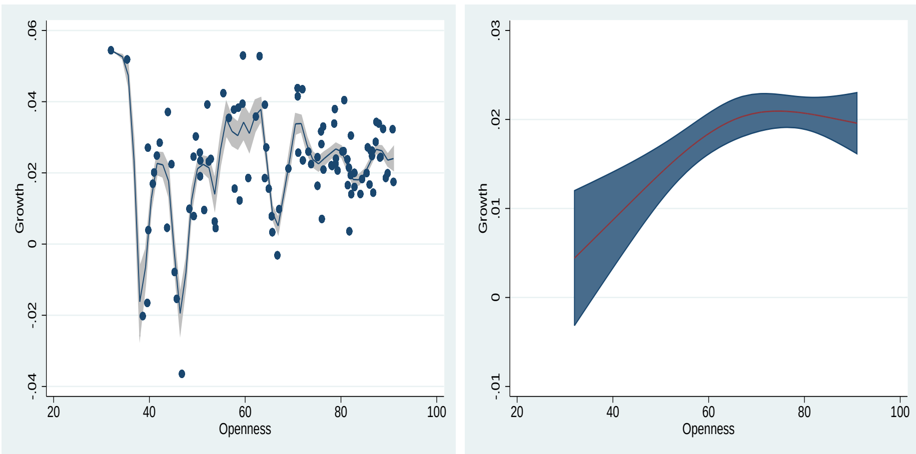

Figure 9: Semi-parametric openness on growth with only 29 significant countries and the adjusted cubic spline function, respectively.

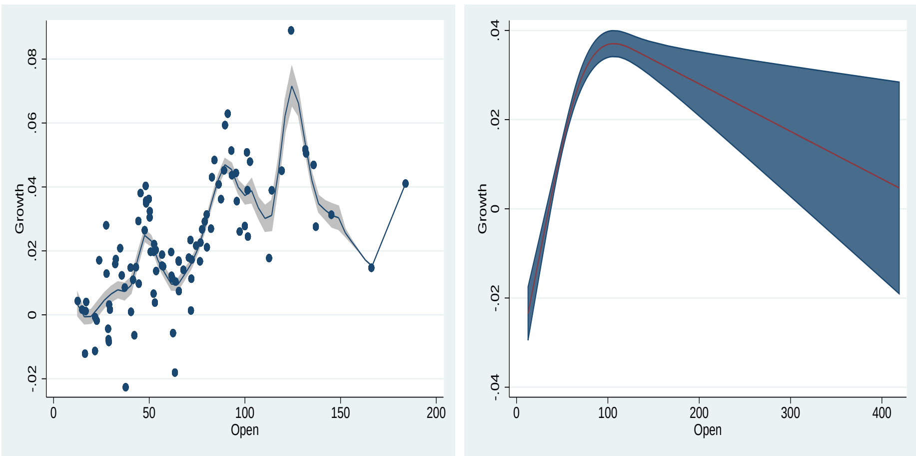

Figure 10: Semi-parametric openness on growth with only 29 significant countries and the adjusted cubic spline function, respectively.