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GROWING THROUGH TRADE: THE ROLE OF FOREIGN GROWTH AND DOMESTIC TARIFFS

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ABSTRACT

This paper studies the role of trading partner' growth and a domestic import tariff in the possibility of growing through trade. To this purpose, a Ricardian model is developed in which a backward economy seeks to increase its long-run growth rate simply by trading with a faster growing partner. It is found that domestic growth may be either negatively affected or unaffected by a domestic import tariff, while it is always positively impacted by foreign growth. Furthermore, convergence in growth rate can emerge both with an import tariff and under free trade. Ours results are consistent with the empirical evidence.

Keywords: growing through trade, technological differences, trading partner' growth, import tariff

JEL classification: F43, O24, O41

I. INTRODUCTION

Despite the profusion of studies on the connection between trade and economic growth, no conclusive results have been obtained on this issue (e.g. Rodríguez and Rodrik, 2001; Singh, 2010). However, some of the empirical literature indicates that domestic features are not the only ones playing a role, but also foreign conditions. Indeed, the econometric findings in Arora and Vamvakidis (2005b) reveal that the trading partners' growth has a greater impact on domestic growth than trade openness. They separated countries between closed and open ones, according to Sachs and Warner (1995) definition, and in both cases obtained that a country's growth is positively affected by their partners' growth rate.[1] While empirical studies have found a positive linkage between domestic and foreign growth (e.g. Easterly, 2001; Calderón *et al.*, 2004; Arora and Vamvakidis, 2005a, 2006 and 2011), the findings regarding the relationship between trade policy and growth are mixed (e.g. Rodríguez and Rodrik, 2001; Clements and Williamson, 2004; DeJong and Ripoll 2006; Madsen, 2009).

Based on this empirical evidence, this paper aims to contribute to the literature on trade as an engine for long-run growth, by studying how the possibility of growing through trade is affected by the trading partner's growth rate and a domestic import tariff. To do so, we build on Ventura's model (1997) and consider two technologically different countries: a backward economy (country B) that seeks to increase its long-run growth rate simply by trading with a faster growing partner (country P). Our model belongs to the rather scarce literature on trade and growth that involves neither international technology transfers nor international spillovers,[2] where the impacts of

[1] They followed a panel data approach covering the period 1960-1999 and including 100 countries.

[2] We do not address the reasons why country B does not adopt advanced technologies from abroad. According to Parente and Prescott (2000), the reason lies in the barriers to technology adoption raised to protect vested interests of some economic groups.

trade on growth operate solely via the comparative advantage. In addition, in the long-run countries exchange increasing amounts of goods at constant terms of trade (e.g. Manresa and Pigem-Vigo, 1999; Acemoğlu and Ventura, 2002; Álvarez-Albelo, Manresa and Pigem-Vigo, 2009; Ji and Seater, 2014).

Whether in autarky or in a trade situation, country P grows at the same exogenous rate, while for country B trade becomes the only possibility of achieving higher growth than in autarky by boosting investment in physical capital.[3] Lastly, we consider an import tariff established by country B which could never be growth enhancing[4] (e.g. Grossman and Helpman,1990; Rivera-Batiz and Romer, 1991; Lee, 2011), though it might be welfare-increasing for the backward economy.

The economies produce a non-traded final good with two traded intermediate inputs, goods x and z.[5] The final good technologies in countries may differ in input shares, reflecting different input intensities. This assumption is crucial for the purpose of our study, since it allows any growth outcome in country B, going from autarky growth to convergence in growth rate with the partner.

The production of intermediate goods uses capital and labour. The countries have the same AK technology in sector z, which is the result of an external learning-by-doing (LBD) process à la Arrow (1962). The LBD process plays a key role in the backward economy because it represents a latent engine of growth for taking advantage of trade gains in terms of long-run growth. In sector x there is exogenous labour-augmenting

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[3] Empirical results have shown that trade impacts growth mainly via capital investment (e.g. Levine and Renelt, 1992; Wacziarg and Welch, 2008).

[4] Some of the empirical literature has found a negative relationship between tariffs and growth (e.g. Connolly and Yi, 2009).

[5] Trade in intermediate goods entails a large share of trade flows among countries. As reported in Miroudot, Lanz and Ragoussis (2009), for OECD countries trade in intermediate inputs represents 56% (in 2006) and 73% (in 2005 or last year available) of trade flows of goods and services, respectively. The figures for Brazil, China and India are 72% and 67%, 75% and 87%, 80% and 46%, respectively.

technical progress, with productivity gains being greater in country P than in country B.[6] Thus, there are two sources of growth in the world: exogenous productivity gains in sector x and a LBD process in sector z. In addition, we assume that markets are competitive, international factor flows are not allowed and foreign and domestic intermediate goods are homogenous. Our analysis is mainly focused on the long-run equilibrium, though we also perform some numerical exercises to offer some insight on short-term effects.

The comparative advantages of countries in the long-run rely on exogenous productivity gains in sector x and input intensities in the final good sector. Since relative prices reflect the relative scarcity of intermediate goods, identical input shares in countries would result in country P (country B) having comparative advantage in good x (good z). However, comparative advantages may reverse when country P is less intensive in good x than country B.

For benefiting from trade in terms of faster growth, country B must get rid of sector x, with exogenous productivity gains, and being specialised in sector z, with LBD. This is equivalent to saying that, by importing good x, the backward economy can "use" the more productive technology of the partner. Remarkably, we obtain that such comparative advantage is facilitated by a high enough intensity in good x and faster growth in country P. Otherwise, country B would not benefit from foreign productivity gains, so its long-run growth rate would remain unchanged.

Thus, faster growth emerges in country B because of specialisation and a more favourable relative price than in autarky, which raises the interest rate and hence capital

[6] Empirical evidence has documented differences in sectoral total factor productivity between countries (e.g. Fadinger and Fleiss, 2011).

accumulation. Yet, the import tariff might be growth impairing, since it introduces a wedge between international and domestic relative prices.

When country B has the growth-enhancing comparative advantage, the trade equilibrium in the long-run can be characterised by either complete or incomplete specialisation of country P while, by construction, the backward economy will only produce good z. The specialisation regime of country P relies on whether or not trade leads to the equalisation of interest rates which, in turn, depends on the input shares in the final good production.

Trade gives rise to an equilibrium with incomplete specialisation when country P is less intensive in good x than country B. As a result, country B eventually faces the more favourable autarky price of the partner, which raises its growth. Nonetheless, country B cannot reach the partner's growth rate as long as both countries have an AK technology in sector z, which prevents the equalisation of interest rates. Moreover, the growth rate of country B is affected by both foreign growth and a domestic import tariff. On one hand, an acceleration of foreign growth improves country B's terms of trade, yielding a raise in the interest rate and hence in the growth rate. On the other, an increase in the tariff rate reduces the internal relative price and interest rate, thus leading to slower growth. For getting some insight on the net impact, we perform numerical exercises using empirically plausible parameter values, and obtain that domestic growth is more affected by a variation of foreign growth than by a change in a domestic tariff.

Country P is completely specialised in good x when its economy is sufficiently more intensive in this good than country B. This specialisation regime allows the equalisation of interest rates and hence converge in growth rate. This is so because there is an AK technology in sector z and a Cobb-Douglas technology —involving decreasing returns— in sector x. Owing to the AK technology in sector z, the domestic relative price in country B does not depend on the import tariff, so there is room for placing the international relative price above the one arising under free trade. Consequently, a higher growth rate in country P increases the growth rate of country B, but changes in the import tariff have no impact on domestic growth. Thus, convergence in growth rate can be an outcome in the presence of an import tariff and also under free trade, but in both cases growth acceleration in country P has a positive impact on country B's growth. Our results are then consistent with the aforementioned empirical evidence.

Our work is closely related to previous studies on trade as an engine for growth. Manresa and Pigem-Vigo (1999) and Álvarez-Albelo et al. (2009) showed that a stagnated economy can converge in growth rate with a growing country simply by trading in intermediate goods. The mechanism of convergence is similar to ours. However, their models entail the same technology to accumulating capital in countries, so they are unable to deliver different growth outcomes in the backward economy. With a multi-country model involving AK-type economies, Acemoğlu and Ventura (2002) obtained that trade and specialisation yield convergence in growth rates even in the absence of decreasing returns. The mechanism of convergence lies in the fact that countries that accumulate capital faster (slower) than the world average experience a worsening (an improvement) of their terms of trade. Ji and Seater (2014) developed a model involving R&D and endogenous market structures that can endogenously deliver any growth outcome in countries. Their framework accounts for the effects of trade on growth —operating via comparative advantage— and also on growth on trade —operating via changes in the trading regime. The mechanism through which trade impacts growth is different from ours, since their model does not include capital accumulation.

The remainder of the paper is organised as follows. The second section presents the model. The third section solves the autarky equilibrium. The role of comparative advantage for growing through trade is analysed in the fourth section. The fifth section finds the conditions for country B to have the growth-enhancing comparative advantage and characterises the trade equilibrium. The sixth section analyses the impact of the partner's growth and an import tariff on growth of country B. The seventh section concludes.

II. THE MODEL

The model involves two technologically different countries: country B, a backward economy that seeks to increase its growth rate simply by trading with a faster growing partner, country P. In an autarky situation they grow at an exogenous rate θ_i, $i = B, P$, with $0 \leq \theta_B < \theta_P$. In this context, the countries engage in trade relationships according to their long-run comparative advantages, which might only affect the growth potential of the backward economy. In addition, country B sets an import tariff that can never be growth-enhancing.

In each period, $t \in [0,\infty)$, both economies are inhabited by a continuum of identical households that is normalised to one. The households are endowed with one unit of time that can be only allocated to work, so the labour input is equal to the unity. The countries produce a non-traded final good with two traded intermediate inputs. The final good can be used for consumption and investment in physical capital. The factor inputs labour and capital are allocated to the production of intermediate goods. In addition, markets are competitive, international factor flows are not allowed and foreign and domestic intermediate goods are homogeneous.

The non-traded final good, $y^i(t)$, is produced with the Cobb-Douglas technology:

$$y^i(t) = \left(x^i(t)\right)^{\alpha_i} \left(z^i(t)\right)^{1-\alpha_i}, \quad \alpha_i \in (0,1), \tag{1}$$

where $x^i(t)$ and $z^i(t)$ denote the total productions of intermediate inputs. However, this notation will adequately change in the trade situation. We purposely assume that input shares may be different in countries, i.e. $\alpha_B \neq \alpha_P$. Under this assumption convergence in growth rate is not guaranteed, since it may impede the equalisation of countries' interest rates. Henceforth, it is convenient to keep in mind that good x is chosen as the numeraire. Thus, one unit of final good costs $p^i(t)$ units of good x, while one unit of good z costs $p_z^i(t)$ units of good x.

We consider the following technologies for intermediate goods:

$$x^i(t) = \left(k_x^i(t)\right)^{\beta} \left(e^{\theta_i t} l^i(t)\right)^{1-\beta}, \ \beta \in (0,1), \ 0 \leq \theta_B < \theta_P, \tag{2}$$

$$z^i(t) = \left(k_z^i(t)\right)^{\beta} \left(k^i(t)\left(1 - l^i(t)\right)\right)^{1-\beta}, \ \beta \in (0,1), \tag{3}$$

where $k_x^i(t)$ and $l^i(t)$ denote capital and labour allocated to sector x, respectively, and $k_z^i(t)$ and $1 - l^i(t)$ represents the amount of factor inputs used in sector z.[7] In sector z productivity gains come from an external LBD process linked to capital per capita of the economy, $k^i(t) = k_x^i(t) + k_z^i(t)$, and hence the technologies become of AK type. The LBD process entails a latent engine of productivity gains that may allow country B to take advantage of trade gains in terms of growth. The variable $e^{\theta_i t}$ represents labour-augmenting technical progress with exogenous growth rate θ_i. Since $0 \leq \theta_B < \theta_P$, in

[7] For notational simplicity, the equilibrium condition of the labour market has been introduced.

autarky country P will enjoy a higher long-run growth rate than country B. We consider identical factor shares between countries and across sectors. This simplifying assumption allows us to identify β and $1-\beta$ with aggregate capital and labour shares which, according to some of the empirical literature, do not differ much between countries (e.g. Gollin, 2002). Moreover, it allows us to obtain closed-form solutions.

Furthermore, in a trade situation country B sets an import tariff with tax rate $\tau \geq 0$, and distribute the tax revenues among the households in the form of lump sum transfers, $T^B(t) \geq 0$. In the presence of an import tariff the price of the good produced domestically might differ from the one imported. However, in our model market forces lead to price equalisation provided that domestic and foreign goods are homogenous.

Preferences are identical in both countries. The representative household derives utility from consumption, $c^i(t)$, and maximises its intertemporal utility discounted at the rate ρ:

$$U^i(0) = \int_0^\infty e^{-\rho t} \frac{\left(c^i(t)\right)^{1-\sigma} - 1}{1-\sigma} dt, \quad \sigma > 0, \tag{4}$$

subject to the budget constraint:

$$\dot{a}^i(t) \leq r^i(t) a^i(t) + w^i(t) + T^i(t) - p^i(t) c^i(t), \tag{5}$$

and the initial condition, $a^i(0) > 0$.[8] The variable $r^i(t)$ denotes interest rate and $w^i(t)$ is the wage. Moreover, in a trade situation it holds that $T^B(t) \geq 0$ and $T^P(t) = 0$.

[8] In equilibrium the household's wealth $a^i(t)$ will be equal to $p^i(t) k^i(t)$.

III. AUTARKY EQUILIBRIUM

The maximisation of profits in the final good sectors implies that the prices of intermediate goods are equal to their respective values of marginal productivities. Thus, $p_z^i(t)$ can be expressed in terms of the relative production of intermediate goods:

$$\left.\begin{array}{l} 1 = p^i(t)\alpha_i \dfrac{y^i(t)}{x^i(t)} \\ p_z^i(t) = p^i(t)(1-\alpha_i)\dfrac{y^i(t)}{z^i(t)} \end{array}\right\} \rightarrow \ p_z^i(t) = \frac{1-\alpha_i}{\alpha_i}\frac{x^i(t)}{z^i(t)}. \tag{6}$$

The maximisation of profits in the intermediate good sectors allows interest rate and the wage to be written as:

$$r^i(t) = \beta \frac{1}{p^i(t)}\frac{x^i(t)}{k_x^i(t)} - \delta + \frac{\dot{p}^i(t)}{p^i(t)} = \beta \frac{p_z^i(t)}{p^i(t)}\frac{z^i(t)}{k_z^i(t)} - \delta + \frac{\dot{p}^i(t)}{p^i(t)}, \tag{7}$$

$$w^i(t) = (1-\beta)\frac{x^i(t)}{l^i(t)} = (1-\beta)\, p_z^i(t)\frac{z^i(t)}{1-l^i(t)}, \tag{8}$$

where $\delta > 0$ is the depreciation rate of capital. Moreover, the equation driving consumption through time comes from solving the household's problem:

$$\frac{\dot{c}^i(t)}{c^i(t)} = \frac{1}{\sigma}\left(r^i(t) - \rho - \frac{\dot{p}^i(t)}{p^i(t)} \right). \tag{9}$$

The competitive equilibrium is a set of allocations and prices that satisfy firms and household problems, and clear all markets in the economy. The relative prices in (6) and factor price equalisation in (7) yield the factor allocation:

$$\frac{k_x^i(t)}{k^i(t)} = l^i(t) = \alpha_i. \tag{10}$$

Using equations (2), (3), (6) and (10), $p_z^i(t)$ can be expressed as:

$$p_z^i(t) = \left(\frac{e^{\theta_i t}}{k^i(t)} \right)^{1-\beta}. \tag{11}$$

Also, using equations (1), (2), (3), (6), (7) and (10) we can write the interest rate as:

$$\begin{aligned} r^i(t) = \beta A_i \left(p_z^i(t) \right)^{-(1-\alpha_i)} \left(\frac{e^{\theta_i t}}{k^i(t)} \right)^{1-\beta} - \delta + (1-\alpha_i) \frac{\dot{p}_z^i(t)}{p_z^i(t)} = \\ \beta A_i \left(p_z^i(t) \right)^{\alpha_i} - \delta + (1-\alpha_i) \frac{\dot{p}_z^i(t)}{p_z^i(t)}, \end{aligned} \tag{12}$$

where $A_i \equiv \alpha_i^{\alpha_i} (1-\alpha_i)^{1-\alpha_i}$. After introducing (12) in the growth rate of consumption in (9), we obtain:

$$\begin{aligned} \frac{\dot{c}^i(t)}{c^i(t)} = \frac{1}{\sigma} \left(\beta A_i \left(p_z^i(t) \right)^{-(1-\alpha_i)} \left(\frac{e^{\theta_i t}}{k^i(t)} \right)^{1-\beta} - \delta - \rho \right) = \\ \frac{1}{\sigma} \left(\beta A_i \left(p_z^i(t) \right)^{\alpha_i} - \delta - \rho \right). \end{aligned} \tag{13}$$

The long-run equilibrium is a balanced growth path (BGP) where the growth rate is θ_i and $p_z^i(t)$ becomes equal to:

$$p_z^i = \left(\frac{\sigma\theta_i + \delta + \rho}{\beta A_i} \right)^{\frac{1}{\alpha_i}}. \tag{14}$$

IV. THE ROLE OF COMPARATIVE ADVANTAGE FOR GROWING THROUGH TRADE

From the autarky prices in equation (14) it follows that country B might have comparative advantage in good z or in good x. By solving the trade equilibrium in country B at exogenously given terms of trade, we show that growing through trade with country P is only possible when the former economy has comparative advantage in good z.

Comparative Advantage in Good z

Trade may allow country B to get rid of lower productivity gains in sector x by importing good x, and so "using" the more efficient technology of country P. The final good production can be then written as $y^B(t)=\left(x_B^P(t)\right)^{\alpha_B}\left(z_B^B(t)\right)^{1-\alpha_B}$, where $x^B(t)$ is the domestic production of good x, $x_B^P(t)$ is the imported production of good x (produced in country P and used in country B). The amount of good z produced and used within country B is denoted as $z_B^B(t)$, and hence the exported production is denoted as $z_P^B(t)$. We will maintain these notation criteria throughout the paper. The equilibrium in the trade balance implies that $x_B^P(t)=p_z(t)z_P^B(t)$, where the omission of the country superscript denotes international price. Moreover, the interest rate can be expressed as:

$$r^B(t)=\beta A_B\left(p_z^{B,D}\right)^{\alpha_B}-\delta+(1-\alpha_B)\frac{\dot{p}_z(t)}{p_z(t)}, \tag{15}$$

where $p_z^{B,D}\equiv p_z/(1+\tau)$ is the domestic relative price. After introducing the interest rate in the equation (9), we obtain the growth rate of country B in the long-run, ϑ^B:

$$\vartheta^B=\frac{\beta A_B\left(p_z^{B,D}\right)^{\alpha_B}-\delta-\rho}{\sigma}>\theta_B \quad \text{iff} \quad p_z^{B,D}>p_z^B. \tag{16}$$

The equation (16) reveals that a growth increase will emerge from trade provided that country B enjoys a more favourable domestic relative price than in autarky, i.e.

$p_z^{B,D} > p_z^B$. More remarkably, faster growth in the partner's economy improves the terms of trade of country B which leads to a higher interest rate and growth rate. However, an increase in the import tariff may impair growth unless this economy can influence the international relative price. This issue will be analysed later on.

Comparative Advantage in Good x

The final good production can be written as $y^B(t) = \left(x_B^B(t)\right)^{\alpha_B}\left(z^B + z_B^P(t)\right)^{1-\alpha_B}$, while the equilibrium in the trade balance is $x_P^B(t) = p_z(t) z_B^P(t)$. Since the terms of trade become constant in the long-run, country B enjoys its own productivity gains in sector x and hence growth at the same rate as in autarky:

$$\theta_B = \frac{1}{\sigma}\left(\beta A_B\left(p_z^{B,D}\right)^{-(1-\alpha_B)}\left(\frac{e^{\theta_B t}}{k^B(t)}\right)^{1-\beta} - \delta - \rho\right), \tag{17}$$

where $p_z^{B,D} \equiv p_z(1+\tau)$ is the domestic relative price.

V. GROWTH-ENHANCING COMPARATIVE ADVANTAGE AND THE TRADE EQUILIBRIUM

In this section we address four questions. We first identify the conditions for country B to have the growth-enhancing comparative advantage. We then characterise the trade equilibrium arising under this specialisation pattern. The trade equilibrium allows us to undertake the third task, namely to study the potential impacts of trade on the long-run growth rate of country B. Lastly, we show that an import tariff may enhance welfare in country B.

The Comparative Advantages of Countries

Figure 1 illustrates the determinants of countries' comparative advantages. The autarky price of country P as a function of α_P, $p_z^P(\alpha_P, \theta_P, \cdot)$, is indicated with a solid line. The dashed/dotted line represents country B's autarky price as a function of α_B, $p_z^B(\alpha_B, \theta_B, \cdot)$. The functions reach a maximum at $\alpha_i^{max} \equiv 1 - (\sigma\theta_i + \delta + \rho)/\beta$, which is smaller than one for empirically plausible parameter values. We set $\alpha_B = \tilde{\alpha}_B$, so have chosen a particular value for country B's autarky price, $p_z^B(\tilde{\alpha}_B)$. Thus, we can define a threshold value $\bar{\alpha}_P(\tilde{\alpha}_B, \theta_P, \cdot) < \tilde{\alpha}_B$ such that $p_z^B(\tilde{\alpha}_B) = p_z^P(\bar{\alpha}_P(\tilde{\alpha}_B, \theta_P, \cdot), \theta_P, \cdot)$.[9]

FIGURE 1 ABOUT HERE

Consequently, the condition $\alpha_P < \bar{\alpha}_P(\tilde{\alpha}_B, \theta_P, \cdot)$ implies that country B has comparative advantage in good x, while $\alpha_P > \bar{\alpha}_P(\tilde{\alpha}_B, \theta_P, \cdot)$ leads to the opposite result. Remarkably, faster growth in country P ($\hat{\theta}_P > \theta_P$) moves its autarky price upwards, $p_z^P(\alpha_P, \hat{\theta}_P, \cdot)$ (indicated with a dashed line), thus amplifying the range of values for α_P that allows country B to have comparative advantage in good z.

The Trade Equilibrium

As commented earlier, country B will eventually be completely specialised in good z, since country P has absolute advantage in good x. Country P, however, might produce

[9] The autarky prices might also coincide for a higher α_P. We leave aside this possibility since it involves extreme values for α_P. For example, the parameter values in Table 1 from Cooley and Prescott (1995) (at the end of the section) and $\theta_B = 0$ yield $\alpha_B^{max} = 0.74$ and $p_z^B(\alpha_B^{max}) = 0.35$, and autarky prices become

both goods (incomplete specialisation), or just good x (complete specialisation), which relies on the input shares of countries in the final good production.

The production of final good in country B has been indicated in the previous section, while country P's can be written as $y^P(t) = \left(x_P^P(t)\right)^{\alpha_P}\left(z^P(t)+z_P^B(t)\right)^{1-\alpha_P}$. The maximisation of profits in the final good sector of countries and the equilibrium in the trade balance yield the equilibrium expression for the international relative price:

$$p_z(t) = \frac{(1-\alpha_P)\,x^P(t)}{\Omega_B\, z^B(t) + \alpha_P\, z^P(t)}, \tag{18}$$

where $\Omega_B \equiv \alpha_B \big/ \left(\alpha_B + (1-\alpha_B)(1+\tau)\right)$. The interest rate of country B appeared in (15), while country P's come from the equation (12) after removing the country superscript in the relative price of good z. The interest rate and wage equalisation between sectors in country P yields the factor allocation:

$$\frac{k_x^P(t)}{k^P(t)} = l^P(t) = \alpha_P + \Omega_B \frac{k^B(t)}{k^P(t)}. \tag{19}$$

Lastly, the exported proportions by countries come from (18) and (19):

$$\frac{z_P^B(t)}{z^B(t)} = \Omega_B, \tag{20}$$

$$\frac{x_B^P(t)}{x^P(t)} = 1 - \alpha_P - \alpha_P \frac{1-l^P(t)}{l^P(t)}. \tag{21}$$

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equal for $\alpha_P = 0.49$ and $\alpha_P = 0.94$. A value $\theta_B = 0.0056$ yield $\alpha_B^{max} = 0.73$ and $p_z^B\left(\alpha_B^{max}\right) = 0.38$, and prices are equal for $\alpha_P = 0.53$ and $\alpha_P = 0.90$.

The Long-run Growth Rate of Country B

We set an import tariff that allows a growth increase in country B which, according to (16), requires that:

$$\frac{p_z^P}{1+\tau} > p_z^B \quad \rightarrow \quad \tau \in \left[0, \tau^{max}\right), \quad \tau^{max} \equiv \frac{p_z^P - p_z^B}{p_z^B} \tag{22}$$

The growth possibilities of country B depend on whether or not trade leads to interest rate equalisation between countries. The interest rates, in turn, hinge on international relative prices. Thus, to study the growth potential outcomes of country B we rely on the trade equilibrium just computed and also on the relative prices depicted in Figure 2. In the figure, autarky prices $p_z^B\left(\tilde{\alpha}_B\right)$ and $p_z^P\left(\alpha_P\right)$ are denoted with dotted lines, while international and domestic relative prices of good z, p_z and $p_z/\left(1+\tau\right)$, are indicated with solid lines.

FIGURE 2 ABOUT HERE

Let us first consider a trade equilibrium with incomplete specialisation of the partner, where country B faces country P's autarky price, i.e. $p_z = p_z^P$. As both economies produce good z with an AK technology, the growth rates of countries P and B converge to:

$$\vartheta^P = \frac{\beta A_P \left(p_z^P\right)^{\alpha_P} - \delta - \rho}{\sigma} = \theta_P, \tag{23}$$

$$\vartheta^B = \frac{\beta \tilde{A}_B \left(\dfrac{p_z^P}{1+\tau}\right)^{\tilde{\alpha}_B} - \delta - \rho}{\sigma} \leq \theta_P, \tag{24}$$

respectively. For better understanding the results in equation (24), it is convenient to notice that in a free trade (FT) equilibrium with no tariff the interest rates (growth rates) of countries would equalise when $\alpha_P = \tilde{\alpha}_B$, yielding an international price:

$$p_z^{FT} = \left(\frac{\sigma\theta_P + \delta + \rho}{\beta \tilde{A}_B} \right)^{\frac{1}{\tilde{\alpha}_B}} \tag{25}$$

However, since the tariff reduces the domestic price of country B this equalisation would require a higher α_P ($\hat{\alpha}_P > \tilde{\alpha}_B$), which depends on the tariff size, and hence an international price $(1+\tau)\, p_z^{FT}$ and a domestic price p_z^{FT}.

Let us assume that $\bar{\alpha}_P < \alpha_P < \hat{\alpha}_P$, so the autarky price of country P and the domestic price of country B are such that $p_z^B < p_z^P / (1+\tau) < p_z^P < (1+\tau)\, p_z^{FT}$. From equation (24) it follows that country B grows faster than in autarky, i.e. $\vartheta_B > \theta_B$, because its domestic price is higher than its autarky price. Nonetheless, it would need a domestic price as p_z^{FT} to converge in growth rate with the partner; so the backward economy grows more slowly than country P, i.e. $\vartheta_B < \theta_P$. Accordingly, factor allocation in country P in equation (19) converge to that in autarky, and the exported proportions by countries B and P in (20) and (21) approach to $\tilde{\Omega}_B$ and zero, respectively.

Under incomplete specialisation of country P, convergence in growth rate (interest rate) is only possible when $\alpha_P = \hat{\alpha}_P$. In this case, the factor allocation in country P would be equal to $\alpha_P + \tilde{\Omega}_B < 1$, and the exported proportions by countries B and P would be $\tilde{\Omega}_B$ and $\alpha_P / (\alpha_P + \tilde{\Omega}_B)$, respectively.

The condition $\alpha_P = \hat{\alpha}_P$ may also lead to incomplete specialisation of country P provided that $\alpha_P + \tilde{\Omega}_B \geq 1$. So does the condition $\alpha_P > \hat{\alpha}_P$. Since there is a Cobb-

Douglas technology in sector x involving decreasing returns, capital of country P is adjusted to enable the equalisation of interest rates and hence of growth rates:

$$\vartheta^P = \frac{\beta A_P \left(\left(1+\tau \right) p_z^{FT} \right)^{-\left(1-\alpha_P\right)} \left(k^P \left(t \right) / e^{\theta_P t} \right)^{-\left(1-\beta\right)} - \delta - \rho}{\sigma} = \theta_P , \tag{26}$$

$$\vartheta^B = \frac{\beta \tilde{A}_B \left(p_z^{FT} \right)^{\tilde{\alpha}_B} - \delta - \rho}{\sigma} = \theta_P \tag{27}$$

The exported proportions by countries B and P become equal to $\tilde{\Omega}_B$ and $1-\alpha_P$, respectively.

Welfare Impacts as a Rationale for an Import Tariff

A question that must be addressed refers to the rationale of setting a tariff in this context. The results just exposed rely on country B's capability to affect the international relative price. Under incomplete specialisation, country B faces the autarky price of the partner, so an import tariff will harm its growth and welfare.

However, under complete specialisation the international price comes from the interplay between countries. This consideration has a significant implication, namely an import tariff might enhance welfare of country B. Therefore, there could be a rationale for such a policy. This possibility can be analysed by computing long-run capital and the allocation of final output between consumption and gross investment. The Appendix contains the details on the computation. Detrended capital stocks of countries in the long-run, $\bar{k}^i \equiv k^i \left(t \right) / e^{\theta_P t}$, can be written as:

$$\bar{k}^P = \left(p_z^P \right)^{-\frac{\alpha_P}{1-\beta}} \left(\left(1+\tau \right) p_z^{FT} \right)^{-\frac{1-\alpha_P}{1-\beta}} \quad \rightarrow \quad \frac{\partial \bar{k}^P}{\partial \tau} < 0, \tag{28}$$

$$\underbrace{\bar{k}^B}_{\bar{z}^B} = \frac{1-\alpha_P}{\Omega_B} \underbrace{\left(p_z^P\right)^{-\frac{\beta\alpha_P}{1-\beta}} \left(\left(1+\tau\right) p_z^{FT}\right)^{-\frac{1-\beta\alpha_P}{1-\beta}}}_{\bar{x}^P / p_z} \quad \to \quad \frac{\partial \bar{k}^B}{\partial \tau} < 0. \tag{29}$$

From now on detrended variables will be denoted with a bar. The tariff acts reducing the interest rate of country P in (26), thus leading to lower capital accumulation in both economies. However, the smaller exported proportion Ω_B attenuates the fall of capital in country B.

The allocation of final output allows analysing the tariff impact on consumption and hence on welfare:

$$\bar{c}^P = \underbrace{A_P \left(p_z^P\right)^{-\frac{\beta\alpha_P}{1-\beta}} \left(\left(1+\tau\right) p_z^{FT}\right)^{-\frac{1-\alpha_P}{1-\beta}}}_{\bar{y}^P = \alpha_P^{\alpha_P} \Omega_B^{1-\alpha_P} \left(\bar{k}^P\right)^{\beta\alpha_P} \left(\bar{k}^B\right)^{1-\alpha_P}} - \underbrace{\left(\delta + \theta_P\right) \bar{k}^P}_{\overline{gi}^P} \tag{30}$$

$$\bar{c}^B = \underbrace{\frac{1-\alpha_P}{\alpha_B} A_B \left(1+\tau\right)^{-\frac{1-\beta\alpha_P}{1-\beta}+1} \left(p_z^P\right)^{-\frac{\beta\alpha_P}{1-\beta}} \left(p_z^{FT}\right)^{-\frac{1-\beta\alpha_P}{1-\beta}+\alpha_B}}_{\bar{y}^B = \left(1-\alpha_P\right)^{\alpha_B} \left(1-\Omega_B\right)^{1-\alpha_B} \left(\bar{k}^P\right)^{\beta\alpha_B} \left(\bar{k}^B\right)^{1-\alpha_B}} - \underbrace{\left(\delta + \theta_P\right) \bar{k}^B}_{\overline{gi}^B} \tag{31}$$

where $\overline{gi}^i$ denotes gross investment. Equation (28) and (30) reveal that the tariff reduces country P's final output and gross investment by the same proportion, so this economy experiences a fall in consumption and welfare. Final output is reduced because of lower capital stocks and imported proportion of good z, i.e. Ω_B. An inspection of equations (29) and (31) shows quite different results for country B. Indeed, final output decreases by a lower proportion than gross investment since the fall in capital stocks is attenuated by the higher proportion of good z that is used within the country, $1-\Omega_B$. Consequently, the tariff has an ambiguous effect on consumption. An increase in consumption and hence in welfare might take place when the tariff has a little impact on capital accumulation, which may occur when country P is highly intensive in good x, i.e. for high enough α_P. This is so because the international price barely affects the interest rate of country P. Next, we explore this possibility through numerical examples.

We compute the long-run values of detrended capital, consumption, final output and international and domestic prices of good z under free trade and with an import tariff. To do so, we consider the calibration by Cooley and Prescott (1995) (CP,1995) for the USA, which provides us with reliable parameter values reflecting actual behaviour of an economy. In addition, we set $\theta_B = 0$, $\alpha_B = 0.5$, $\alpha_P = \{0.6, 0.85\}$ and $\tau = 0.1$. Table 1 contains the results.

TABLE 1 ABOUT HERE

Consistently with our theoretical analysis, the fall in countries' capital stock and final output caused by the tariff is lower under $\alpha_P = 0.85$ than with $\alpha_P = 0.6$. Moreover, the former value yields a decrease in country B's consumption while an increase is obtained in the latter one.

VI. THE GROWTH IMPACTS OF FOREIGN GROWTH AND A DOMESTIC IMPORT TARIFF

This section analyses the relative impacts of changes in foreign growth and a tariff on the long-run growth rate of country B. In addition, we also compute numerically the transition under complete specialisation to get some insight of temporary growth impacts of a tariff.

Foreign Growth and Tariff Effects on Long-Run Growth

The previous analysis has shown that country B benefited from trade in terms of growth simply because of specialisation and a more favourable relative price than in autarky.

Notwithstanding, an import tariff set domestically can either impair growth (incomplete specialisation) or leave country B's growth rate unchanged (complete specialisation). Thus, the growth possibilities of country B rely on the determinants of the domestic relative price.

Under incomplete specialisation, the growth rate of country B in equation (24) is positively related to the international price p_z^P —in equation (14)— which in turn is an increasing function of the partner's growth rate. However, the import tariff is growth-reducing since country B cannot influence the international price. For assessing the relative growth impacts of changes in these two variables, we compute the percentage variation of country B's domestic relative price in response to a percentage point change in the partner's growth rate (growth elasticity, $\varepsilon_{p_z^{B,D},\theta_P}$) and in the import tariff (tariff elasticity, $\varepsilon_{p_z^{B,D},\tau}$):

$$\varepsilon_{p_z^{B,D},\theta_P} \equiv \frac{\partial p_z^{B,D}}{\partial \theta_P}\frac{\theta_P}{p_z^{B,D}} = \frac{1}{\alpha_P}\frac{\sigma\theta_P}{\sigma\theta_P+\delta+\rho} > 0, \tag{32}$$

$$\varepsilon_{p_z^{B,D},\tau} \equiv \frac{\partial p_z^{B,D}}{\partial \tau}\frac{\tau}{p_z^{B,D}} = -\frac{\tau}{1+\tau} < 0. \tag{33}$$

The elasticity in (32) shows that a growth acceleration in the partner's economy has a positive impact on the growth rate of country B, since it entails an increase in the international price and hence in the interest rate. The growth elasticity becomes greater the higher θ_P and the lower α_P. Contrariwise, a rise in the import tariff reduces the domestic price, the interest rate and hence the growth rate of the backward economy. The tariff elasticity (in absolute) value is greater the higher the tariff rate. Therefore, a reduction (an increase) in the domestic import tariff might be compensated by an increase (a reduction) in foreign growth, thus keeping the growth rate of country B unchanged. This result reveals that domestic conditions are not the only ones that matter for assessing the impact of trade on growth, but also the foreign ones, as shown by empirical evidence. The relative growth impacts can be summarised as follows:

$$\frac{\partial \vartheta^B}{\partial \theta_P}\frac{\theta_P}{\vartheta^B} \begin{matrix} > \\ = \\ < \end{matrix} \left| \frac{\partial \vartheta^B}{\partial \tau}\frac{\tau}{\vartheta^B} \right| \quad \text{if} \quad \tau \begin{matrix} < \\ = \\ > \end{matrix} \frac{\sigma\theta_P}{\alpha_P\left(\sigma\theta_P + \delta + \rho\right) - \sigma\theta_P} \equiv \tau^*. \tag{34}$$

It is worthwhile to notice that the relationship in (34) can be clarified by comparing the maximum tariff τ^{max} in equation (22) with τ^*. Indeed, the tariff rate must be lower than τ^{max} for country B to benefit from trade in terms of growth, so the condition $\tau^{max} \leq \tau^*$ would directly lead to $\varepsilon_{p_z^{B,D},\theta_P} > \left|\varepsilon_{p_z^{B,D},\tau}\right|$, while $\tau^{max} > \tau^*$ would be consistent with any relationship between these elasticities. By way of illustration, we compute numerically τ^{max} and τ^* under several α_i covering its value range. The parameters and results are displayed in Table 2.

TABLE 2 ABOUT HERE

In the table, we have set $\theta_B = 0$ and $\alpha_B = \alpha_P$ to amplify the distance between p_z^P and p_z^B thus allowing a sizeable τ^{max}. In other words, we establish favourable conditions for τ^{max} to exceed τ^*. Even though, for all α_i we obtain that $\tau^{max} < \tau^*$, so in our examples foreign growth turns out to have a greater impact on domestic growth than the import tariff. Moreover, it should be highlighted that, according World Bank data,[10] tariff rates in Table 2 are well above actual figures of most countries, so a greater growth impact could be expected from faster foreign growth than from a tariff increase.

[10] The World Bank data refer to "the average of effectively applied rates weighted by the product import shares corresponding to each partner country."

By contrast, when the partner is completely specialised in good x the growth rate of country B in equation (27) does not depend on the import tariff. However, domestic and foreign growth rates exhibit a positive one-to-one relationship because countries converge in growth rate. It is also worth noticing that convergence in growth rate may take place in the presence of an import tariff and under free trade. Indeed, in the former case the domestic price is lower than the international price, $p_z^{FT} < (1+\tau)\, p_z^{FT}$, while in the latter one both countries face the international price p_z^{FT}.[11]

Short-run Growth Effects of a Tariff

Under incomplete specialisation of the partner country B becomes negligible in terms of income inasmuch as it grows at a lower rate. Thus, in a neighbourhood of the long-run equilibrium country B becomes an AK-type of economy facing a constant international price.

By contrast, the long-run equilibrium under complete specialisation is a BGP where both economies grow at the same rate θ_P. Therefore, the trade interaction between the countries may give rise to sizeable short-run growth effects in both economies that deserve to be analysed. In this respect, it should be noticed that though a tariff does not affect the long-run growth rate it does have temporary growth impacts. For analysing these impacts, we compute numerically the transitional dynamics in a neighbourhood of the BGP under free trade and with a tariff rate of 10%. The set of differential equations that compose the dynamic system can be found in the Appendix.

[11] Of course, this could be the case for retaliation by country P in order to pay the lowest relative price of good z, p_z^{FT}. However, and unlike in Devereux (1993), growth in country B would remain unchanged since this economy cannot affect the growth rate of the partner.

Figures 3 and 4 depict time paths of the growth rates of capital and final output and also of international and domestic prices of good z for $\alpha_P = 0.6$ and $\alpha_P = 0.85$, respectively. Initial detrended capital stocks are set lower than their long-run values so capital and final output will increase along the transition.

FIGURES 3 AND 4 ABOUT HERE

The figures show that the introduction of a tariff yields temporary growth declines of capital and hence of final output in both economies. This behaviour can be better understood by looking at the dynamic system in the Appendix. Given capital stocks, the tariff causes a permanent increase in the international price and a temporary decrease in the domestic price, which reduces the interest rate and hence the incentives to accumulate capital in both economies. Moreover, Figure 4 shows a smaller decline in the growth rates of capital and final output of the partner than Figure 3, which is consistent with our analysis on the welfare impacts of a tariff under complete specialisation.

VII. CONCLUSION

Some of the empirical literature have showed that the trading partners' growth matters more for explaining the impact of trade on domestic growth than trade openness. Based on this empirical evidence, we have explored how the possibility of growing through trade is affected by foreign growth and a domestic import tariff. To this aim, we have developed a two-country model based on Ventura's (1997), where a backward economy seeks to increase its long-run growth rate simple by trading with a faster growing partner. Our model involves neither international spillovers nor technology transfers, and trade impacts growth solely via the comparative advantage. Owing to countries' differences in the technology to accumulate capital, the model can deliver any growth outcome in the backward economy, ranging from autarky growth to convergence in growth rate with the partner. In addition, the backward economy sets an import tariff that could never be growth enhancing, though it might be welfare-increasing.

We have obtained that growing through trade requires having comparative advantage in a sector with constant returns to capital, which is facilitated by a higher growth rate of the partner. Thus, the backward economy benefits from trade in terms of sustained growth because of specialisation and a more favourable relative price than in autarky. Consistent with the empirical evidence, growth acceleration in the partner's economy always improves the terms of trade of the backward economy, thus leading to higher domestic growth. By contrast, domestic growth can be either negatively affected or unaffected by a tariff raise, which depends on the specialisation regime (incomplete or complete) of the partner. Moreover, under complete specialisation of the partner, convergence in growth rate takes place both under free trade and with an import tariff.

Despite its simplicity, our model can deliver results that agree with the abovementioned empirical findings. We then conclude that, as the empirical evidence suggests, considering foreign conditions could be more fruitful when analysing the connection between trade and growth than just focusing on domestic ones, such as the degree of openness.

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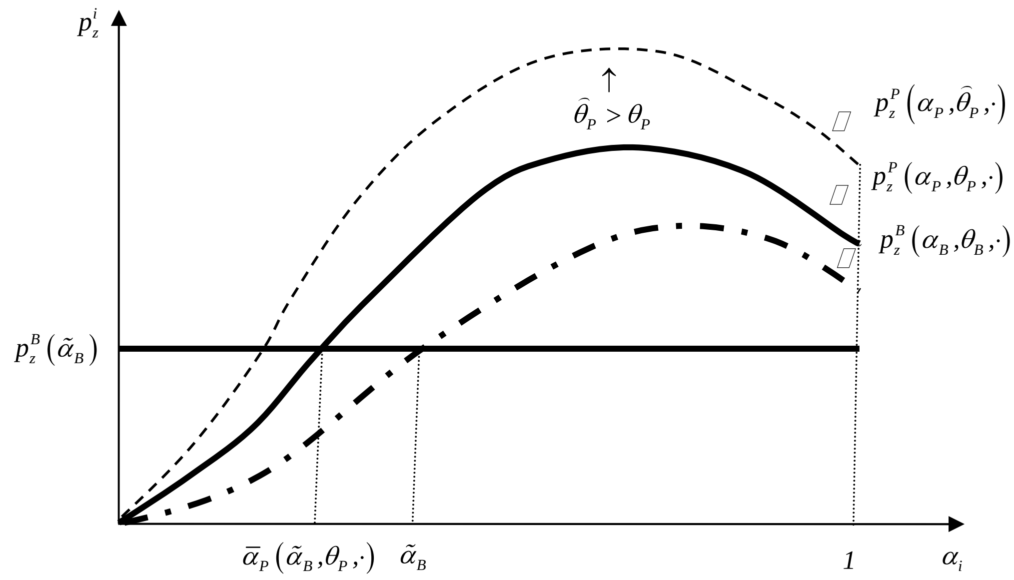

Fig.1. The comparative advantages according to intermediate input shares and the growth rate of country P

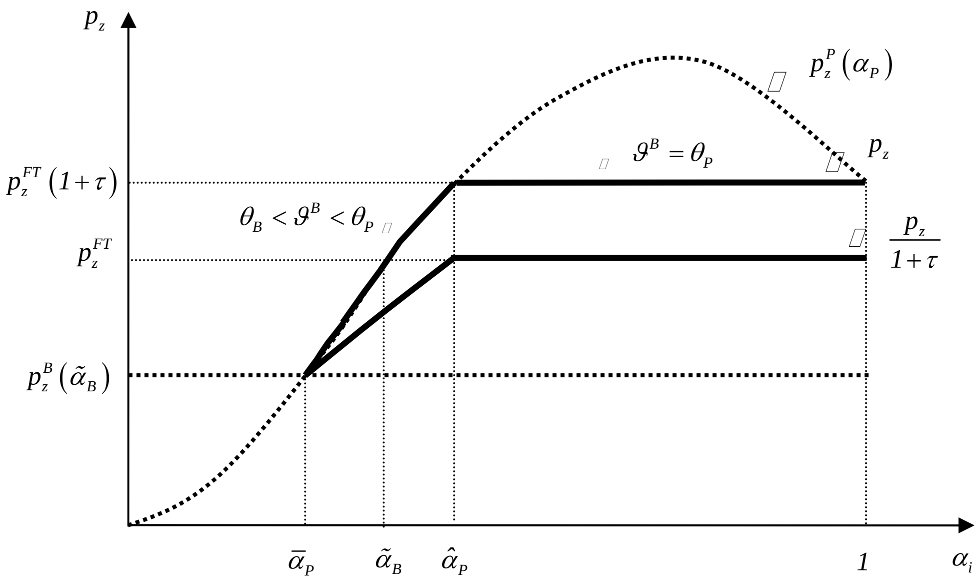

Fig. 2. International and domestic relative prices and the growth potential outcomes of country B

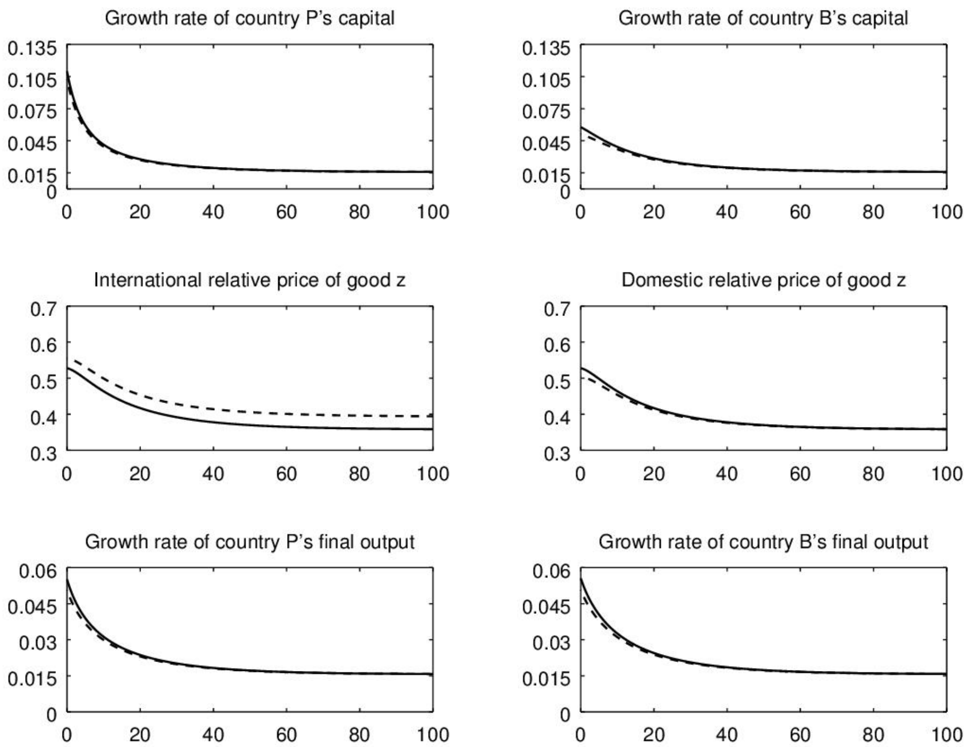

Fig. 3. Short-run growth effects of a tariff under incomplete specialisation: $\alpha_P = 0.6$

Note: Transitional paths are computed with the parameter values in Table 1. Initial de-trended capital stocks are $\overline{k}_0^P = \overline{k}_0^B = 2$. The solid lines refers to the case $\tau = 0$ and the dashed lines refer to $\tau = 0.1$.

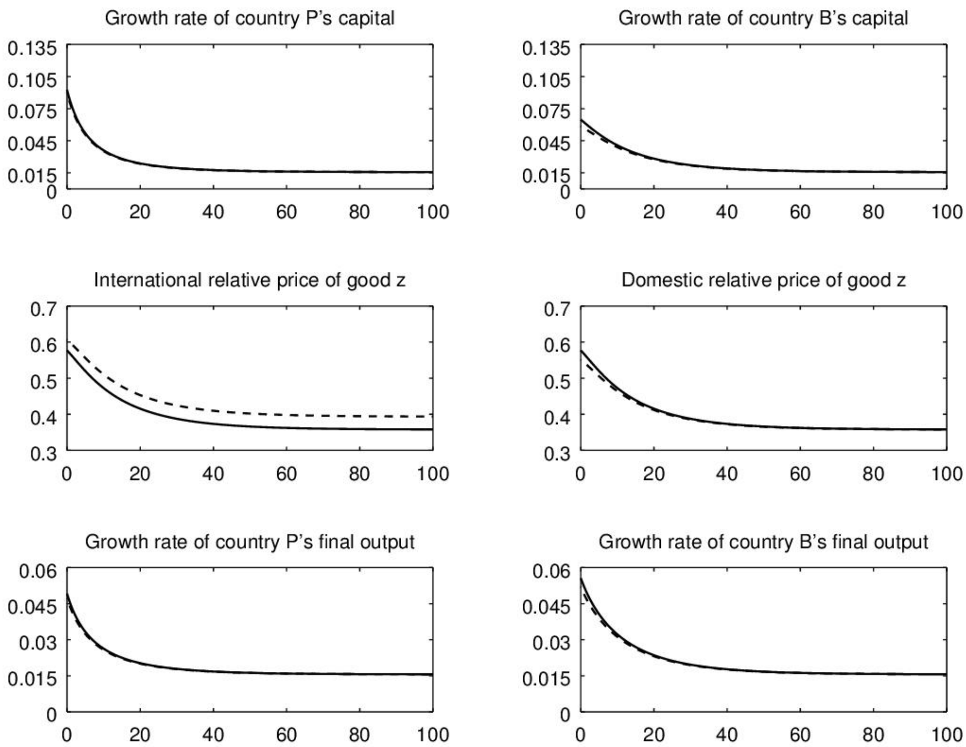

Fig. 4. Short-run growth effects of a tariff under incomplete specialisation: $\alpha_P = 0.85$

Note: Transitional paths are computed with the parameter values in Table 1. Initial de-trended capital stocks are $\bar{k}_0^P = 2.5$ and $\bar{k}_0^B = 0.75$. The solid lines refers to the case $\tau = 0$ and the dashed lines refer to $\tau = 0.1$.

TABLE 1

Welfare impact of a tariff under complete specialisation: Numerical examples

Parameter values									
Preferences: $\sigma = 1$, $\rho = 0.056$ (CP, 1995)									
Technology: $\beta = 0.4$, $\delta = 0.048$, $\theta_P = 0.0156$ (CP, 1995), $\theta_B = 0$, $\alpha_B = 0.5$									
Long-run equilibrium									
α_P	τ	$\bar{k}^P$	$\bar{k}^B$	$\bar{c}^P$	$\bar{c}^B$	$\bar{y}^P$	$\bar{y}^B$	p_z	$p_z^{B,D}$
0.60	*0.0*	*4.836*	*4.202*	*1.138*	*0.989*	*1.446*	*1.256*	*0.358*	*0.358*
	0.1	*4.538*	*3.911*	*1.068*	*0.976*	*1.357*	*1.225*	*0.393*	*0.358*
	τ/FT	*0.938*	*0.931*	*0.938*	*0.987*	*0.938*	*0.975*	*1.100*	*1.000*
0.85	*0.0*	*4.782*	*1.569*	*1.126*	*0.369*	*1.430*	*0.469*	*0.358*	*0.358*
	0.1	*4.669*	*1.483*	*1.099*	*0.370*	*1.396*	*0.465*	*0.393*	*0.358*
	τ/FT	*0.976*	*0.945*	*0.976*	*1.003*	*0.976*	*0.991*	*1.100*	*1.000*

Note: τ/FT refers to value in a trade equilibrium with tariff over value under free trade.

TABLE 2

Growth impacts of foreign growth and a tariff under incomplete specialisation: Numerical examples

Parameter values								
Preferences: $\sigma = 1$, $\rho = 0.056$ (CP, 1995)								
Technology: $\beta = 0.4$, $\delta = 0.048$, $\theta_P = 0.0156$ (CP, 1995), $\theta_B = 0$								
$\alpha_P = \alpha_B$	*0.2*	*0.3*	*0.4*	*0.5*	*0.6*	*0.7*	*0.8*	*0.9*
Results								
p_z^B	*0.015*	*0.086*	*0.185*	*0.270*	*0.325*	*0.349*	*0.347*	*0.321*
p_z^P	*0.029*	*0.137*	*0.263*	*0.358*	*0.410*	*0.427*	*0.413*	*0.375*
τ^{max}	*1.011*	*0.593*	*0.418*	*0.323*	*0.262*	*0.221*	*0.191*	*0.168*
τ^*	*1.875*	*0.769*	*0.484*	*0.353*	*0.278*	*0.229*	*0.195*	*0.169*

Note: $\alpha_P = \alpha_B = 0.1$ leads to prices close to zero and negative τ^*.

Appendix. Trade equilibrium under complete specialisation of countries

Country P

Firms in the final good sector solve the problem:

$$\underbrace{p^P(t)\left(x_P^P(t)\right)^{\alpha_P}\left(z_P^B(t)\right)^{1-\alpha_P}}_{y^P(t)} - x_P^P(t) - p_z(t)\,z_P^B(t)$$

The first order conditions (FOCs) are:

$$\left.\begin{aligned} p^P(t)\,\alpha_P\frac{y^P(t)}{x_P^P(t)} &= 1 \\ p^P(t)(1-\alpha_P)\frac{y^P(t)}{z_P^B(t)} &= p_z(t) \end{aligned}\right\} \rightarrow p_z(t) = \frac{1-\alpha_P}{\alpha_P}\frac{x_P^P(t)}{z_P^B(t)} \tag{35}$$

Firms in sector x maximise the present value of net cash flows:

$$\int_0^\infty e^{-\int_0^t r^P(v)dv}\left(\left(k^P(t)\right)^\beta\left(e^{\theta_P t}\right)^{1-\beta} - w^P(t) - p^P(t)\,gi^P(t)\right)dt$$

subject to the change of capital stock $\dot{k}^P(t) \le gi^P(t) - \delta k^P(t)$, where $gi^P(t)$ denotes gross investment. The FOCs are:

$$w^P(t) = (1-\beta)\,x^P(t) \tag{36}$$

$$p^P(t) = \lambda_x^P(t) \tag{37}$$

$$\dot{\lambda}_x^P(t) = \lambda_x^P(t)\left(r^P(t)+\delta\right) - \beta\frac{x^P(t)}{k^P(t)} \tag{38}$$

where $\lambda_x^P(t)$ is capital shadow price, which is equal to the price of final good. The interest rate comes from equations (37) and (38):

$$r^P(t) = \beta\frac{1}{p^P(t)}\frac{x^P(t)}{k^P(t)} - \delta + \frac{\dot{p}^P(t)}{p^P(t)} \tag{39}$$

The representative household maximises discounted utility $\int_0^\infty e^{-\rho t}\frac{\left(c^P(t)\right)^{1-\sigma}-1}{1-\sigma}dt$,

subject to the budget constraint:

$$\dot{a}^P(t) \le r^P(t)\,a^P(t) + w^P(t) - p^P(t)\,c^P(t) \tag{40}$$

The FOCs of the problem are:

$$\left(c^P(t)\right)^{-\sigma} = \lambda_h^P(t)\,p^P(t) \tag{41}$$

$$\dot{\lambda}_h^P(t) = \lambda_h^P(t)\left(\rho - r^P(t)\right) \tag{42}$$

where $\lambda_h^P(t)$ is the shadow price of wealth. The equation driving consumption is obtained from (41) and (42):

$$\frac{\dot{c}^P(t)}{c^P(t)} = \frac{1}{\sigma}\left(r^P(t) - \rho - \frac{\dot{p}^P(t)}{p^P(t)}\right) \tag{43}$$

Country B

Firms in the final good sector solve the problem:

$$p^B(t)\left(x_B^P(t)\right)^{\alpha_B}\left(z_B^B(t)\right)^{1-\alpha_B} - (1+\tau)x_B^P(t) - p_z(t)z_B^B(t)$$

The first order conditions (FOCs) are:

$$\left.\begin{aligned} p^B(t)\alpha_B\frac{y^B(t)}{x_B^P(t)} &= 1+\tau \\ p^B(t)(1-\alpha_B)\frac{y^B(t)}{z_B^B(t)} &= p_z(t) \end{aligned}\right\} \to p_z^{B,D}(t) \equiv \frac{p_z(t)}{1+\tau} = \frac{1-\alpha_B}{\alpha_B}\frac{x_B^P(t)}{z_B^B(t)} \tag{44}$$

where $p_z^{B,D}(t)$ is the domestic relative price.

Firms in sector z maximise the present value of net cash flows:

$$\int_0^\infty e^{-\int_0^t r^B(v)dv}\left(p_z(t)\left(k^B(t)\right)^{\beta}\left(\hat{k}^B(t)\right)^{1-\beta} - w^B(t) - p^B(t)gi^B(t)\right)dt$$

subject to the change of capital stock $\dot{k}^B(t) \le gi^B(t) - \delta k^B(t)$, where $gi^B(t)$ denotes gross investment and $\hat{k}^B(t)$ is an externality. The FOCs are:

$$w^B(t) = p_z(t)(1-\beta)z^B(t) \tag{45}$$

$$p^B(t) = \lambda_z^B(t) \tag{46}$$

$$\dot{\lambda}_z^B(t) = \lambda_z^B(t)\left(r^B(t) + \delta\right) - p_z(t)\beta\frac{z^B(t)}{k^B(t)} \tag{47}$$

where $\lambda_z^B(t)$ is capital shadow price, which is equal to the price of final good. The interest rate comes from equations (46) and (47):

$$r^B(t) = \beta\frac{p_z(t)}{p^B(t)}\frac{z^B(t)}{k^B(t)} - \delta + \frac{\dot{p}^B(t)}{p^B(t)} \tag{48}$$

The representative household maximises discounted utility $\int_0^\infty e^{-\rho t} \frac{\left(c^B(t)\right)^{1-\sigma}-1}{1-\sigma} dt$, subject to the budget constraint:

$$\dot{a}^B(t) \le r^B(t) a^B(t) + w^B(t) + T^B(t) - p^B(t) c^B(t) \tag{49}$$

where the lump-sum transfer is $T^B(t) = \tau x_B^P(t)$.

The FOCs of the problem are:

$$\left(c^B(t)\right)^{-\sigma} = \lambda_h^B(t)\, p^B(t) \tag{50}$$

$$\dot{\lambda}_h^B(t) = \lambda_h^B(t)\left(\rho - r^B(t)\right) \tag{51}$$

where $\lambda_h^B(t)$ is the shadow price of wealth. The equation driving consumption is obtained from (50) and (51):

$$\frac{\dot{c}^B(t)}{c^B(t)} = \frac{1}{\sigma}\left(r^B(t) - \rho - \frac{\dot{p}^B(t)}{p^B(t)}\right) \tag{52}$$

Equilibrium

The equilibrium in the trade balance is:

$$x_B^P(t) = p_z(t) z_P^B(t) \;\rightarrow\; p_z(t) = \frac{x_B^P(t)}{z_P^B(t)} \tag{53}$$

The exported proportions of goods come from (35), (44) and (53):

$$\frac{x_B^P(t)}{x^P(t)} = 1 - \alpha_P, \quad \frac{z_P^B(t)}{z^B(t)} = \Omega_B \tag{54}$$

where $\Omega_B \equiv \alpha_B \big/ \left(\alpha_B + (1-\alpha_B)(1+\tau)\right)$. Equations (53) and (54) allow writing the relative price of good z as:

$$p_z(t) = \frac{1-\alpha_P}{\Omega_B} \frac{\left(k^P(t)\right)^\beta \left(e^{\theta_P t}\right)^{1-\beta}}{k^B(t)} \;\rightarrow\; p_z(t) = \frac{1-\alpha_P}{\Omega_B} \frac{\left(\bar{k}^P(t)\right)^\beta}{\bar{k}^B(t)} \tag{55}$$

where $\bar{k}^i(t) \equiv k^i(t) \big/ e^{\theta_P t}$ denote detrended capital. From now on detrended variables will be denoted with a bar.

From equations (35), (39), (44) and (48), the interest rate of countries can be expressed as:

$$r^P(t)=\beta A_P\left(\frac{1}{p_z(t)}\right)^{1-\alpha_P}\left(\frac{1}{\bar{k}^P(t)}\right)^{1-\beta}-\delta+\frac{\dot{p}^P(t)}{p^P(t)},$$
$$r^B(t)=\beta A_B\left(\frac{p_z(t)}{1+\tau}\right)^{\alpha_B}-\delta+\frac{\dot{p}^B(t)}{p^B(t)} \tag{56}$$

From equations (9), (18), (21) and (22), we obtain the law of motion of detrended consumption:

$$\frac{\dot{\bar{c}}^P(t)}{\bar{c}^P(t)}=\frac{1}{\sigma}\left(\beta A_P\left(\frac{\Omega_B}{1-\alpha_P}\right)^{1-\alpha_P}\frac{\left(\bar{k}^B(t)\right)^{1-\alpha_P}}{\left(\bar{k}^P(t)\right)^{1-\beta\alpha_P}}-\delta-\rho\right)-\theta_P \tag{57}$$

$$\frac{\dot{\bar{c}}^B(t)}{\bar{c}^B(t)}=\frac{1}{\sigma}\left(\beta A_B\left(\frac{1-\alpha_P}{\Omega_B(1+\tau)}\right)^{\alpha_B}\frac{\left(\bar{k}^P(t)\right)^{\beta\alpha_B}}{\left(\bar{k}^B(t)\right)^{\alpha_B}}-\delta-\rho\right)-\theta_P \tag{58}$$

Combining equations (1), (2), (3), (5), (10), (11), (12), (14), (15), (19) and (20), detrended capital accumulation in country i can be written as $\dot{\bar{k}}^i(t)=\bar{y}^i(t)-\bar{c}^i(t)-(\delta+\theta_P)\bar{k}^i(t)$. Substituting per capita income we obtain:

$$\dot{\bar{k}}^P(t)=\alpha_P^{\alpha_P}(\Omega_B)^{1-\alpha_P}\left(\bar{k}^P(t)\right)^{\beta\alpha_P}\left(\bar{k}^B(t)\right)^{1-\alpha_P}-\bar{c}^P(t)-(\delta+\theta_P)\bar{k}^P(t) \tag{59}$$

$$\dot{\bar{k}}^B(t)=(1-\alpha_P)^{\alpha_B}(1-\Omega_B)^{1-\alpha_B}\left(\bar{k}^P(t)\right)^{\beta\alpha_B}\left(\bar{k}^B(t)\right)^{1-\alpha_B}$$
$$-\bar{c}^B(t)-(\delta+\theta_P)\bar{k}^B(t) \tag{60}$$

The dynamic system is composed of equations (57) through (60).

We can compute per capita income of countries, expressed in units of good x, using (35), (44), (54) and (55):

$$p^P(t)y^P(t)=x^P(t)=\left(k^P(t)\right)^{\beta}\left(e^{\theta_P t}\right)^{1-\beta}, \tag{61}$$

$$p^B(t)y^B(t)=\frac{1-\Omega_B}{1-\alpha_B}p_z(t)z^B(t)=\frac{1-\alpha_P}{\alpha_B}(1+\tau)\left(k^P(t)\right)^{\beta}\left(e^{\theta_P t}\right)^{1-\beta} \tag{62}$$

The shares of countries of world per capita income are:

$$\frac{p^P(t)y^P(t)}{\sum_i p^i(t)y^i(t)}=\frac{\alpha_B}{\alpha_B+(1-\alpha_P)(1+\tau)},\quad \frac{p^B(t)y^B(t)}{\sum_i p^i(t)y^i(t)}=\frac{(1-\alpha_P)(1+\tau)}{\alpha_B+(1-\alpha_P)(1+\tau)} \tag{63}$$

Therefore, the tariff allows country B to obtain a greater portion of world per capita income at the expense of country P's share.

The growth rates of per capita income, expressed in final good units, are:

$$\begin{aligned}\frac{\dot{y}^P(t)}{y^P(t)}&=\beta\alpha_P\frac{\dot{\bar{k}}^P(t)}{\bar{k}^P(t)}+(1-\alpha_P)\frac{\dot{\bar{k}}^B(t)}{\bar{k}^B(t)}+\theta_P,\\ \frac{\dot{y}^B(t)}{y^B(t)}&=\beta\alpha_B\frac{\dot{\bar{k}}^P(t)}{\bar{k}^P(t)}+(1-\alpha_B)\frac{\dot{\bar{k}}^B(t)}{\bar{k}^B(t)}+\theta_P\end{aligned} \tag{64}$$

Long-run equilibrium

In the long-run equilibrium $\dot{\bar{c}}^i(t)=\dot{\bar{k}}^i(t)=0$, and detrended variables become constant. From (55), (56), (57) and (58), international and relative price of good z become and equal to:

$$\left.\begin{aligned}p_z^{B,D}&=\frac{p_z}{1+\tau}=\underbrace{\left(\frac{\sigma\theta_P+\delta+\rho}{\beta A_B}\right)^{\frac{1}{\alpha_B}}}_{p_z^{FT}}\\ p_z&=(1+\tau)\underbrace{\left(\frac{\sigma\theta_P+\delta+\rho}{\beta A_B}\right)^{\frac{1}{\alpha_B}}}_{p_z^{FT}}\end{aligned}\right\}\rightarrow\ \frac{\partial p_z^{B,D}}{\partial\tau}=0,\ \frac{\partial p_z}{\partial\tau}>0 \tag{65}$$

and detrended capital stocks of countries are:

$$\bar{k}^P=\left(p_z^P\right)^{-\frac{\alpha_P}{1-\beta}}\left((1+\tau)p_z^{FT}\right)^{-\frac{1-\alpha_P}{1-\beta}}\ \rightarrow\ \frac{\partial\bar{k}^P}{\partial\tau}<0 \tag{66}$$

$$\underbrace{\bar{k}^B}_{\bar{z}^B}=\frac{1-\alpha_P}{\Omega_B}\underbrace{\frac{\left(\bar{k}^P\right)^{\beta}}{p_z}}_{\bar{x}^P/p_z}=\frac{1-\alpha_P}{\Omega_B}\left(p_z^P\right)^{-\frac{\beta\alpha_P}{1-\beta}}\left((1+\tau)p_z^{FT}\right)^{-\frac{1-\beta\alpha_P}{1-\beta}}\ \rightarrow\ \frac{\partial\bar{k}^B}{\partial\tau}<0 \tag{67}$$

An increase in the import tariff reduces capital stocks of both countries. Indeed:

$$
\begin{aligned}
&\overline{k}^{B}=\frac{1-\alpha_{P}}{\alpha_{B}}\frac{1+\left(1-\alpha_{B}\right)\tau}{\left(1+\tau\right)^{\frac{1-\beta\alpha_{P}}{1-\beta}}}\left(p_{z}^{P}\right)^{-\frac{\beta\alpha_{P}}{1-\beta}}\left(p_{z}^{FT}\right)^{-\frac{1-\beta\alpha_{P}}{1-\beta}}\\
&\frac{\partial\overline{k}^{B}}{\partial\tau}=-\frac{1-\alpha_{P}}{\alpha_{B}}\left(p_{z}^{P}\right)^{-\frac{\beta\alpha_{P}}{1-\beta}}\left(p_{z}^{FT}\right)^{-\frac{1-\beta\alpha_{P}}{1-\beta}}\frac{\left(1-\beta\right)\alpha_{B}+\beta\left(1-\alpha_{P}\right)\left(1+\left(1-\alpha_{B}\right)\tau\right)}{\left(1+\beta\right)\left(1+\tau\right)^{\frac{1-\beta\alpha_{P}}{1-\beta}+1}}<0
\end{aligned}
\tag{68}
$$

Detrended consumption of countries is obtained from (59), (60), (66) and (67):

$$
\overline{c}^{P}=\underbrace{A_{P}\left(p_{z}^{P}\right)^{-\frac{\beta\alpha_{P}}{1-\beta}}\left(\left(1+\tau\right)p_{z}^{FT}\right)^{-\frac{1-\alpha_{P}}{1-\beta}}}_{\overline{y}^{P}}-\underbrace{\left(\delta+\theta_{P}\right)\left(p_{z}^{P}\right)^{-\frac{\alpha_{P}}{1-\beta}}\left(\left(1+\tau\right)p_{z}^{FT}\right)^{-\frac{1-\alpha_{P}}{1-\beta}}}_{\overline{gi}^{P}}
\tag{69}
$$

$$
\begin{aligned}
\overline{c}^{B}=&\underbrace{\frac{1-\alpha_{P}}{\alpha_{B}}A_{B}\left(1+\tau\right)^{-\frac{\beta(1-\alpha_{P})}{1-\beta}}\left(p_{z}^{P}\right)^{-\frac{\beta\alpha_{P}}{1-\beta}}\left(p_{z}^{FT}\right)^{\frac{-(1-\alpha_{B})+\beta(\alpha_{P}-\alpha_{B})}{1-\beta}}}_{\overline{y}^{B}}-\\
&\underbrace{\left(\delta+\theta_{P}\right)\frac{1-\alpha_{P}}{\Omega_{B}}\left(p_{z}^{P}\right)^{-\frac{\beta\alpha_{P}}{1-\beta}}\left(\left(1+\tau\right)p_{z}^{FT}\right)^{-\frac{1-\beta\alpha_{P}}{1-\beta}}}_{\overline{gi}^{B}}
\end{aligned}
\tag{70}
$$

An import tariff reduces final output, gross investment and consumption of country P by the same proportion. However, it reduces final output of country B by a lower proportion than gross investment. As a result, the variation of country B's consumption is ambiguous.

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Di Paolo, A. (GEAP & IEB)
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"Technology, Business Models and Network Structure in the Airline Industry"
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Oppedisano, V., **Turati, G.**
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Canova, L., **Vaglio, A.**
"Why do educated mothers matter? A model of parental help"
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Fageda, X. (GiM-IREA), **Perdiguero, J.** (GiM-IREA)
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"¿Afecta la sobreeducación de los padres al rendimiento académico de sus hijos?"
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Varela-Irimia, X-L. (GRIT)
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"The Innovation and Imitation Dichotomy in Spanish firms: do absorptive capacity and the technological frontier matter?"
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"Evaluating Antitrust Leniency Programs"
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"A territorial approach to R&D subsidies: Empirical evidence for Catalonian firms"
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Ramos, R. (AQR-IREA); **Sanromá, E.** (IEB); **Simón, H.**
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"The environmental effects of changing speed limits: a quantile regression approach"
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Bolance, C. (Riskcenter-IREA); **Bahraoui, Z.** (Riskcenter-IREA), **Alemany, R.** (Risckcenter-IREA)
"Estimating extreme value cumulative distribution functions using bias-corrected kernel approaches"
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Ramos, R. (AQR-IREA); **Sanromá, E.** (IEB), **Simón, H.**
"An analysis of wage differentials between full- and part-time workers in Spain"
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Cappellari, L.; **Di Paolo, A.** (AQR-IREA)
"Bilingual Schooling and Earnings: Evidence from a Language-in-Education Reform"
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