The Impact of Vertical Specialization on Openness ratios. A Barrier for Empirical Tasks

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Abstract

The different orders of integration of openness and economic growth have been suggested as one reason for the failure of some empirical attempts to link these two variables in developed countries. However, this paper illustrates how this stochastic inconsistency (growth series are stationary while openness series exhibit unit roots) is something of a mirage which disappears when we consider vertical specialization. The advance of vertical specialized trade means that inputs cross borders several times during the productive process, thus introducing an upward bias into the openness ratio (exports over GDP) because the numerator is gross valued while the denominator is value-added. But, with scattered data on the percentage of imports embodied in domestic exports, we generate unbiased yearly series of openness and find that they become stationary. So, this paper shows how the use of a more representative measure of the true contribution of exports to domestic economies may reconcile the stochastic properties of the two variables in the endogenous growth theory framework.

JEL classification: F15, C22

Keywords: vertical specialization, value-added, openness, unit root

1 Introduction

In a recent survey, Singh (2011) claims that, due to the selection of different geographic or temporal samples, different measures of trade openness and alternative model specifications, the effects of international trade on economic growth remain controversial. The author reviews the empirical literature to disentangle the responsibility of measurement and methodological decisions in finding more or less compelling evidence of the economic gains of trade. On the measurement side, one criticism is that most exercises, given the lack of accurate temporal or geographical coverage, use the trade shares of GDP as proxies for openness, instead of measures of tariffs and non-tariff barriers [1]. The openness measures not only reflect a country's economic structure, but also do not consider the bias that country size introduces into comparisons. Big countries, as pointed out by Frankel and Romer (1999), tend to trade less internationally than smaller countries, independently of their levels of barriers to trade [2].

On the methodological side, Singh (2011) mentions the problem of the different order of integration of the variables embodied in the endogenous growth model specifications. This is a problem about which Jones (1995) had already warned when analyzing a sample of OECD countries in the second half of last century. He draws attention to how, according to the endogenous growth theory, permanent changes in certain policy variables, among them trade openness, should have permanent effects on the rate of economic growth. In practice, given the lack of persistence exhibited by the growth rate series under examination, the theory implicitly requires that the determinants of growth do not exhibit persistence either, unless the persistence in the movements of these determinants, which is quite unlikely, offset

[1] Problems with the dynamics of the econometric specification and with the use of different tariff barriers had already been mentioned in Greenaway et al.(2002) when testing for the short-run growth effects of liberalization episodes for a sample of developing countries in the eighties/nineties.

[2] To overcome this shortcoming, Squally and Wilson (2011) have proposed a composite measure that includes the domestic share of world trade.

each other. Otherwise, says Jones (1995), the endogenous growth models are inconsistent with the time series evidence. This is his conclusion when he finds that the time series properties of growth rates do not support the presence of unit roots while, for the post-WWII OECD economies, many of the potential explanatory variables (durable investment, years of education and openness to international trade) have exhibited persistent upward movements.

Focusing on the role of openness, in this paper, we take advantage of the most advanced econometric tools and apply time series and panel data analyses to the traditional ratio of exports over GDP for 57 countries in 1948-2007. The analyses establish a clear difference between the stochastic properties of openness in Less Developed Countries (LDC) and Developed Countries (DC). Both methodologies show that the openness ratios of LDC do not exhibit unit roots, while confirming their presence in the ratios of DC. For the latter countries, we posit that the inconsistency between growth theory and the time series properties of the openness measure can be solved considering that the ratio of exports over GDP, the most common measure of openness, has been strongly biased by the advance of vertical specialized trade[3].

The sharp drop in trade costs over the last four decades (in tariffs, transport costs and, above all, in information and communication costs) (Anderson and van Wincoop, 2004; Hummels, 2007) has allowed industrial companies to outsource a number of tasks abroad, especially in DC, which have stronger participation as finished good exporters in the international networks. The result has been a geographical segmentation of productive processes (Jones and Kierzkowski, 1990) and the appearance of a new international trade pattern with an increasing exchange of intermediate goods that cross borders several times. There has been a change of paradigm and, unlike the horizontal specialization (specializa-

[3]See Johnson and Noguera (2012a, 2012b) for a theoretical and empirical analysis about differences between gross and value-added exports.

tion in goods) that dominated the First Era of Globalization (1870-1913), the advance of vertical specialization (specialization in stages of the production process) has characterized the Second Era of Globalization (from 1948, specially from the seventies, until the crisis that started in 2008).

The advance of vertical specialization means that inputs cross borders several times during the productive process, which introduces an upward bias into the openness ratio because the numerator is gross valued (in the official export statistics) while the denominator is value-added (GDP). If a country's openness ratio relates its gross-valued exports to value-added GDP, then, the more important the vertical specialized trade, the bigger will be the exaggeration of the importance of foreign trade for the national economy [4]. In this paper, starting from scattered data of vertical specialization (as the percentage of imports embodied in domestic exports) for about five different years between 1968 and 1998 in ten OECD countries (Hummels *et al.* (2001) and Chen *et al.* (2005)), we obtain new ratios of openness free from the multi-accounting bias. Then, by interpolating data into these new ratios, we generate ten yearly series, which we assume are representative of the evolution of the export value actually added in each country between 1948 and 2007 and, consequently, more representative of the importance of foreign trade for countries that actively participated in global production networks. According to these new series, for a country like Denmark, the contribution of exports to GDP has increased by 18% instead of the 64% indicated by its traditional openness ratio; in the case of France, the contributions were 39 and 108%, respectively; and, in the case of Germany, 59 and 108%. Therefore, it is not surprising that, once the multiple-accounting effect of the vertical specialization is removed, the export share of output becomes stationary for all the ten countries, in

[4] As the World Trade Organization (2011) has warned in the presentation of the WTO and IDE-JETRO joint publication, *Trade patterns and global value chains in East Asia: From trade in goods to trade in tasks*, launched in June 2011.

contrast to the results obtained for the original openness series, where only three countries out of the ten exhibited a stationary trend.

In sum, this paper shows how, in terms of stochastic properties, there is an essential change depending whether the multi-accounting bias resulting from the foreign value added in exports is removed or is not, which, in turn, helps us to match the lack of persistence of growth rate series in DC with their equally non-persistent series of openness. The remainder of the paper is organised as follows. Section 2 introduces some features of vertical specialized trade. Section 3 includes a broad analysis of the stochastic properties of the traditional openness ratio series. Section 4 presents our proposal of unbiased openness ratios and compares their stochastic properties with those of the traditional series. Finally, on the basis of these comparisons, Section 5 concludes.

2 Changes in international trade. The concept of Vertical Specialisation (VS)

For a long time, the dominant paradigm in the pure theory of international trade only considered exchanges in final consumer goods, occasionally augmented by trade in natural resources. The trade theory has focused on explaining trade in end products and topics, such as the international division of labor and the role of specialization, were studied mainly in terms of final goods. Even though Robert Mundell (1957) challenged this scenario by considering a trading world in which real factor mobility provided an alternative to goods trade, thus laying the foundations for research on the positive and normative consequences of allowing trade in productive factors and intermediate goods, in practice, it took time for the literature on intra-industry trade and intermediate products to be considered as more than an appendix to the main paradigm.

The first theoretical works started by introducing intermediate goods into Heckscher-Ohlin type models, as in Breda and Casas (1973) and Dixit and Grossman (1982). Afterwards, other authors considered intermediate goods in other traditional models [Arndt (1997), Venables (1999), Yi (2003), Jones and Kierzkowski (2001, 2005), Deardorf (2001a, b; 2005) and Baldwin and Robert-Nicoud (2007), among others]. Moreover, there are the recent contributions of Grossman and Rossi-Hansberg (2006a, b; 2008) in which, moving away from the traditional international trade approaches, they suggest a new paradigm where tasks trade takes the central stage and relegates goods trade to a supporting role.

This endeavor to model the new trade pattern has gone hand in hand with empirical efforts to measure the size of international segmentation. The literature suggests different data sources to quantify the phenomenon, among them, international trade statistics on parts and components and Input-Output tables[5]. A first rough measure of the progress of segmentation can be proxied by the performance of trade in parts and components. In the nineties, this kind of trade grew much faster than total world trade, even faster than intra-industry trade [Jones, Kierzkowsky and Lurong, 2005], and despite the slow-down of recent years, data document a more dynamic performance of trade in intermediate inputs than trade in final goods during 1988-2006 [World Trade Organization, 2008][6].

The same advance of international fragmentation can be inferred from two, more accurate, measures of external orientation based on Input-Output information. The first measure concentrates on the foreign content of domestic production by using the index share of direct imported inputs in production or in total inputs. It was developed by Feenstra and Hanson (1996) and has been widely used to assess the consequences of seg-

[5]See Bauman and di Mauro (2007) for a wide review of different methods and data, and Amador and Cabral (2008) for a review of the three main different data sources and methods used by the empirical trade literature to quantify the fragmentation phenomenon.

[6]Yeats (2001), although restricted to the machinery sector, goes back further and provides evidence of the advance of trade in parts and components in the OECD countries from 1978 to 1995.

mentation on wages and employment, as in Egger and Egger (2003), Bardhan and Kroll (2003), Wei (2004), Hijzen (2005) and Geishercker *et al.* (2008) [7]. It has also been used to assess the degree of external orientation by Campa and Goldberg (1997) who, focusing on U.S., U.K., Canada and Japan, observe an increase in imported inputs into production for all countries except Japan. One more example is Feenstra (1998), who presents results for the whole manufacturing sector and several disaggregated industries across a wider range of developed countries. This measure also provides evidence that international segmentation has progressed recently, as the world percentage of imported intermediate inputs over total inputs increased from 18.8 to 22 between 1995 and 2000 [World Trade Organization, 2008].

The second type of Input-Output measure focuses on the foreign content of exports. Whereas the first measure only captures the direct import content of exports (imported intermediate inputs), the second measure reflects the direct and indirect import content of exports. This second measure is proposed by Hummels *et al.* (1998) and Hummels *et al.* (2001), who labelled it vertical specialization (VS). Compared to the first Input-Output measure, Hummels *et al.*'s (2001) vertical specialization measure is narrower, because it only considers the imported inputs embodied in the exported output. Nevertheless, it is the best measure to approach the exaggeration bias that the change in the nature of international trade might have introduced into the openness series[8].

This measure of VS is defined as the importation of intermediate goods used by a country to make goods or goods in process which are, in turn, exported to another country. So, three conditions have to hold for VS to occur. Firstly, the good has to be produced in

[7] See Horgos (2007) for a detailed analysis of this index.

[8] Johnson and Noguera (2012a) generalize the work by Hummels *et al.* (2001) for the bilateral trade case. They relax the assumption that a country's exports are entirely absorbed in final demand abroad to take into account scenarios in which a country exports intermediates that are used to produce final goods absorbed at home.

at least two sequential stages. Secondly, two or more countries have to add value during the productive process and, finally, the country that uses the imported inputs must export some of the resulting output. Therefore, VS offers a complete perspective of the changed nature of international trade since it captures, on the import side, the essence of international outsourcing (the decision of firms to substitute domestic value added through the import of intermediate goods) and, on the export side, the trading of either intermediate or final goods. [9].

Analytically, the VS trade for country k is the sum of across all i-sectors:

$$VS_k = \sum_i VS_{ki} = \sum_i \left(\frac{IIM_{ki}}{gross\ output_{ki}} \right) \cdot X_k \tag{1}$$

where IIM denotes the value of imported intermediate inputs in sector i and X represents the merchandise exports. In Hummels *et al.* (2001) and Chen *et al.* (2005), there is scattered information about the VS trade share of exports in nine developed countries between 1968 and 1998. Minondo and Ruber (2002) provide similar scattered information for Spain. Consequently, we have information about the percentage of imports embodied in domestic exports:

$$\frac{VS_k}{X_k} = \frac{\sum_i VS_{ki}}{\sum_i X_{ki}} \tag{2}$$

for the countries and years specified in Table 1. For all these countries the advance of VS has been clear and, at the end of the twentieth century, the percentage of imports embodied in exports was over 20% for most of them.

[9]Originally, the term vertical specialization was used by Balassa (1967) to refer to the process by which, to take advantage of market size and scale economies, manufacturing parts, components, and accessories were produced in separate establishments.

3 Stochastic properties of the traditional trade openness ratios

Trying to make our analysis as comprehensive as possible, we work with a set of 57 economies from 1948 to 2007 consisting of two sub-samples, one of 35 LDC and the other of 22 DC, according to the World Bank criteria. The yearly data on exports, gross domestic product and exchange rates needed to build the traditional openness ratio of exports over gross domestic product (X/GDP) come from the International Financial Statistics provided by the International Monetary Fund.

We start the analysis by testing for unit roots with the MZGLS test α_τ developed by Ng and Perron (2001) because they prove this test has a better performance than the popular Augmented Dickey-Fuller test. According to the results of Ng and Perron's test, we cannot reject the null hypothesis of a unit root for most of the countries at the conventional significance levels. Nevertheless, taking into account the outcomes obtained by Ben-David and Papell (1997), we consider the possibility that, in the second half of the twentieth century, the market integration prompted by trade liberalization and a decrease

TABLE I

VERTICAL SPECIALIZATION: AVAILABLE DATA

Australia	Canada	Denmark	France	Germany	Japan	Netherlands	Spain	UK	US
1968	1971	1972	1972	1978	1970	1972	1970	1968	1972
1974	1976	1977	1977	1986	1975	1977	1990	1978	1977
1986	1981	1980	1980	1988	1980	1981	1994	1983	1982
1989	1986	1985	1985	1990	1985	1986	-	1990	1985
1995	1990	1990	1990	1995	1990	1995	-	1998	1990
-	-	1997	1995	-	1996	-	-	1997	
-	-	-	-	-	1996	1997	-	-	-
-	-	-	-	-	1997	1998	-	-	-

Source: Chen *et al.*(2005) and Minondo and Rubert (2002) in transport costs, caused breaks in the X/GDP ratios. Perron (1989) demonstrated the non consideration of structural breaks might impede the rejection of the unit root hypothesis even if the alternative hypothesis of stationarity is true. For this reason, we test for the presence of breaks in the series by using the new method proposed by Perron and Yabu (2009) as a pre-test to obtain certain information on the existence or not of structural changes in the series [10].

This test, that considers the three traditional models (A,B and C) proposed in Perron (1989), is able to detect the presence of one structural break in the trend function without any prior knowledge as to whether the noise component is stationary or contains an autoregressive unit root [11]. When this test is applied, we observe, in the second and fourth columns of Table 2, that there is at least one structural break in most of the series. Countries with no breaks are those for which we do not reject the null hypothesis of a stable trend function in the test of Perron and Yabu (2009).

Consequently, the next step is to test again for a unit root with a test that allows for the presence of structural changes. We use the test developed by Lee and Strazicich (LS) (2004) that considers the presence of one structural break in the series under both the null hypothesis of a unit root and the alternative hypothesis of stationarity. These authors showed the negative consequences of considering structural breaks only under the alternative hypothesis in unit root tests and, in an attempt to avoid these problems, developed a new LM type test. This test determines the break points endogenously [12].

[10] This test improves the finite sample properties by using the bias corrected version of the OLS estimate of proposed by Roy and Fuller (2001). It is also more powerful than Vogelsang's (1997) test that is widely used in the empirical literature.

[11] Model A (the "crash" model) permits a change in the levels of the series; model B permits a change in the rate of growth; and model C allows both changes.

[12] Lee and Strazicich (2003) show that, if we do not consider breaks under the null in tests with endogenous breaks, the test statistics may diverge and lead to a rejection of the null when the data generating process is integrated with structural breaks, as in the Lumsdaine and Papell (1997) test. In addition, these approaches, derived by assuming no structural breaks under the null, might present problems in empirical applications because the rejection of the null does not necessarily imply the rejection of a unit root per se, but may

So, with the LS test, the rejection of the null hypothesis unambiguously implies that the series are trend stationary. LS (2004) propose two of the three above mentioned structural break models considered in Perron (1989), A and C, to simulate the data generating process [13]. To choose between these two models, we use the information criteria of Akaike (AIC) and Swartz (SBIC).

First, we apply the LS (2004) test that allows for one structural break, the outcomes of which are reported in Table 2. As we can see, there is an overwhelming presence of trend stationary series in the group of LDC, where 65% exhibit a broken stationary trend. Conversely, in the group of DC, only 36% of the series have a stationary trend and the results do not change when we allow for two breaks by applying the unit root test of Lee and Strazicich (2003). Thus, we find an overwhelming presence of unit roots in the group of DC that does not seem to be a consequence of the presence of structural breaks. On the other hand, the majority of the unit roots found in the group of LDC become stationary trends when we allow for structural changes in the series [14].

Looking for additional support for the previous univariate time series approach, we repeat the analysis with panel data methodology. The attractiveness of panel analysis lies in its jointly exploiting the time structure and the cross-sectional dimension of the data, thus mitigating the disadvantages, in terms of power, that the time series-based unit root tests show when they are applied to small samples. Here, we use the panel unit root test with structural changes developed by Carrion-i-Silvestre et al. (2005) [15].

imply the rejection of a unit root without breaks. Similarly, the alternative hypothesis does not necessarily imply trend stationarity with breaks, but may indicate a unit root with breaks. For a complete description of the test, see Lee and Strazicich (2003 and 2004).

[13]They omit Model B, without any risk of losing generality, as it is commonly held that most economic time series can be adequately described by models A or C.

[14]There are few cases where the series changes from I(0) to I(1) when two breaks are taken into account. This is because considering an unnecessary structural break in the data generation process could introduce some noise in the model invalidating the outcomes of the test.

[15]The test proposed by Carrion-i-Silvestre et al. (2005) is based on the KPSS panel data version developed by Hadri (2000) and generalizes existing proposals in the field. The null hypothesis implies stationarity so

TABLE II

X/GDP Unit Root Tests

LDC	t-statistic	no. breaks	DC	t-statistic	no. breaks
Algeria	-7.295^a	2	Australia	-6.763^a	1
Barbados	-2.588	0	Austria	-4.920	2
Burkina Faso	-4.514^a	1	Canada	-3.658	1
China (P.R. Hong Kong)	-4.433^c	1	Denmark	-4.286^c	1
Colombia	-4.814	2	Finland	-2.267	0
Congo, Rep.	-4.858	2	France	-2.805	1
Costa Rica	-4.428^c	1	Germany	-3.934	1
Cyprus	-4.618^b	1	Greece	-5.127	2
Dominican, Rep.	-4.202^c	1	Iceland	-5.414^a	1
Egypt	-4.761^b	1	Ireland	-4.796^b	1
El Salvador	-5.960^b	2	Italy	-2.047	0
Fiji	-1.252	0	Japan	-3.585	1
Guatemala	-4.605^b	1	Korea, Rep.	-5.252	2
Guyana	-4.206^c	1	Netherlands	-3.575	1
Haiti	-4.622	2	New Zeland	-5.335^a	1
Honduras	-5.209	2	Norway	-5.517^a	1
India	-0.833	0	Portugal	-5.022^b	1
Jamaica	-4.463	1	Spain	-3.975	2
Mali	-4.971	2	Sweden	-2.212	1
Malta	-4.662^b	1	Switzerland	-4.196	1
Mauritius	-4.880^b	1	United Kingdom	-3.614	1
Mexico	-6.125^a	1	United States	-4.190^c	1
Morocco	-5.261^a	1			
Nigeria	-4.464^c	1			
Pakistan	-5.352^a	1			
Panama	-4.478	2			
Paraguay	-4.581^b	1			
Philippines	-8.818^a	1			
South Africa	-1.056	0			
Sri Lanka	4.364^c	1			
Sudan	-4.853^b	1			
Thailand	-4.213	2			
Trinidad y Tobago	-12.760^a	1			
Venezuela	-2.351^b	0			
Zambia	-3.786^b	1			

[1] Ng and Perron (2001) and Lee and Strazicich (2003, 2004)unit root tests.
[2] We apply the general-to-specific procedure [Ng and Perron, 1995] to select the number of lags with a $kmax = T^{1/3}$.
[3] Countries with no breaks are those for which we do not reject the null hypothesis of a stable trend function in the test of Perron and Yabu (2009). Then, Ng ad Perron's (2001) unit root test is reported.
[4] a, b, and c denote a statistic significant at the 1%, 5% and 10% respectively.

This test allows for multiple structural breaks that can differ in time, intensity and location across individuals. We test the null hypothesis of panel stationarity with multiple structural breaks against the alternative of first order integrated, since some authors have proposed using the two types of test statistics –unit root and stationary tests- to carry out a sort of confirmatory analysis [16]. Two kinds of models are considered in the analysis. First, we consider Model 1 [Perron and Vogelsang, 1992], with neither time effects nor structural breaks in the time trend. Model 2 is the model C developed in Perron (1989) and allows a time trend and structural changes affecting either the trend or the level [17]. In practice, we set a maximum of two breaks to obtain comparable outcomes to those of the time series analysis. Then, we select the optimum number of breaks for each country with the LWZ information criterion [18]. The results, in Table 3, report the impossibility of rejecting the null hypothesis of stationarity in the whole panel at a significance level of 10%. In other words, the analysis shows evidence in favour of stationarity for the whole sample of X/GDP series. However, when repeating the analysis with the panel divided into two sub-panels, one for LDC and the other for DC, the results change substantially, in line with the outcomes of the previous time series analysis. We find evidence in favour of stationarity in the panel for LDC, but strong evidence against stationarity in the panel for DC.

Thus, when jointly exploiting the time structure and the cross-sectional dimension of the data and, consequently, enhancing the power of the tests, we obtain additional support for the presence of unit roots in the traditional openness series of DC and, consequently,

there has to be strong evidence against trend stationarity to conclude in favour of the non-stationarity of the panel.

[16] See Maddala and Kim (1998) for a summary.

[17] The use of model C (Perron, 1989) lets us obtain homogeneous outcomes if we compare it with those of the time series analysis.

[18] We work with a balanced panel from 1954 to 2007 for reasons of simplicity. We eliminate Algeria, Congo, Germany, Haiti, Malawi, Netherlands, Paraguay and Sudan from the panel due to lack of data.

for the inconsistency of this variable with the stationary economic growth series.

TABLE III

X/GDP Stationary panel data test

	Bartlet
Whole panel	1.837 (0.033)
LDC	0.108 (0.457)
DC	6.168 (0.000)

[1] p-values reported in brackets.

[2] The long run variance is estimated assuming homogeneity.

4 The effects of Vertical Specialization on the stochastic properties of the openness ratios

In Section 2, we presented the measure of VS as defined by Hummels *et al.* (2001) and the sample of ten OECD countries for which there is enough information to appreciate the progress of the phenomenon. These countries are Australia, Canada, Denmark, France, Germany, Japan, Netherlands, Spain, the UK and the USA. For each country k and several years between 1968 and 1998, we know the percentage of imports embodied in domestic exports:

$$\frac{VS_k}{X_k} = \frac{\sum_i VS_{ki}}{\sum_i X_{ki}} \tag{3}$$

So, by discounting this VS trade from the gross-valued exports in the International Financial Statistics of the IMF, we can proxy the value-added exports for each available year:

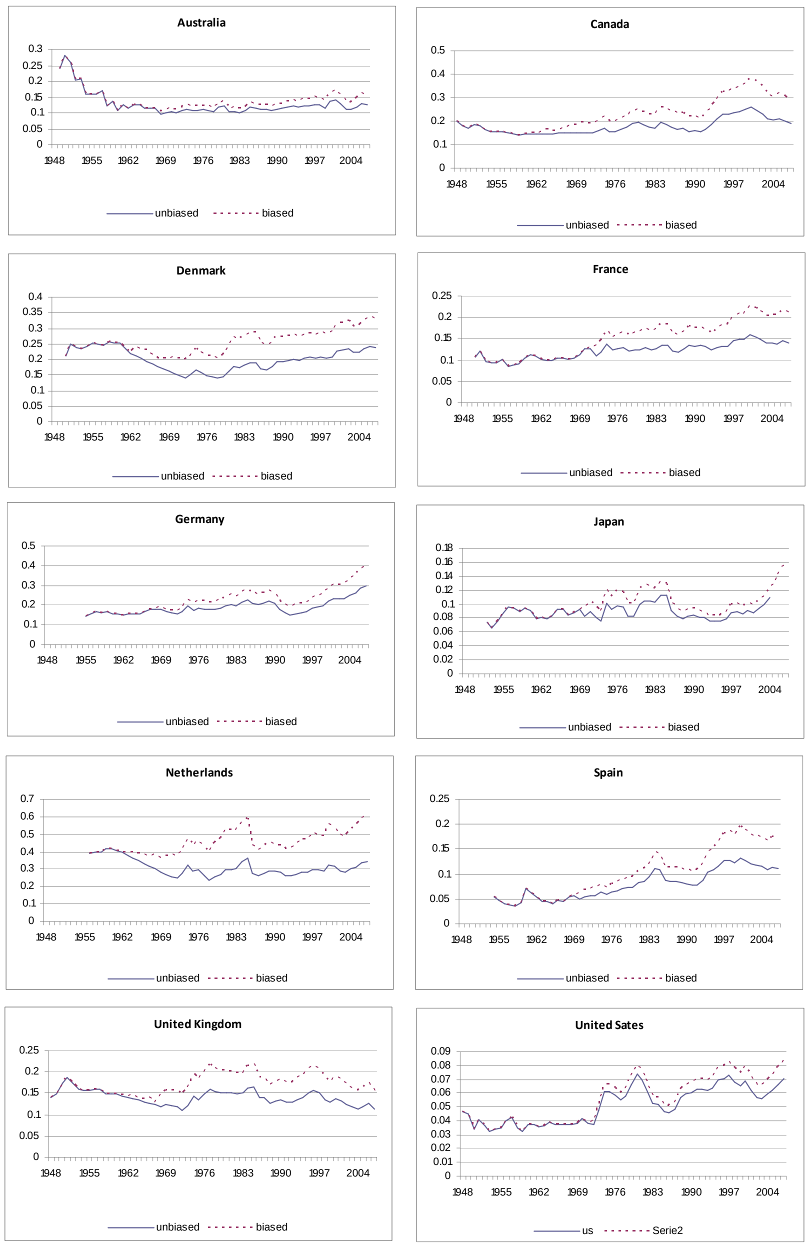
$$X_k^* = X_k - VS_k \tag{4}$$

We can then interpolate these data to generate ten yearly country value-added export series from 1968 to 2007. We use cubic spline polynomials, which are the approximating functions of choice when a smooth function is to be approximated locally and are preferable to the method of truncated Taylor series. The general idea of any interpolation method is to compute the values of $f(x)$ in the interval $[a, b]$ knowing $f(a)$ and $f(b)$ [19].

The new export series over GDP ($\frac{X_k - VS_k}{GDP_k}$) are displayed in Figure 1, together with the traditional ones ($\frac{X_k}{GDP_k}$), the gap showing the bias introduced by VS in the latter. The next step is to investigate whether this bias has any consequences for the stochastic properties of the traditional openness ratios. To that end, we carry out the same time series analysis as in Section 3, applied to the new series, which are free from the multi-accounting bias. We cannot reject the null hypothesis of a unit root in the traditional openness measure for any of the countries at the conventional significance levels. By contrast, there are two countries (France and UK) with a stationary trend in the unbiased openness measure.

Moreover, when we test for the presence of breaks in the series by using the method proposed by Perron and Yabu (2009), we observe that there is at least one structural break in all the series. Consequently, the next step is to test again for a unit root with a test that allows for the presence of structural changes. We use the test developed by Lee and Strazicich (LS) (2004) that, as we said before, considers the presence of one structural break

[19] The truncated Taylor series provides a satisfactory approximation for the series at each point x if its path is sufficiently smooth and the interpolation point is sufficiently close to a or b. But if a function is to be approximated on a larger interval, the degree, of the approximating polynomial may have to be chosen unacceptably large. The alternative is to subdivide the interval $[a, b]$ of approximation into sufficiently small intervals $[\zeta_j, ..., \zeta_{j+1}]$, with $a = \zeta_1 < ... < \zeta_{j+1} = b$, so that, on each of them, a polynomial P_j of relatively low degree can provide a good approximation to the time series. This can even be done in such a way that the polynomial pieces blend smoothly, so that the resulting patched or composite function $s(x)$ that equals $P_j(x)$ for $x \in [\zeta_j, ..., \zeta_{j+1}]$, and all j, has several continuous derivatives. Any such smooth piecewise polynomial function is called a spline.



Source: own elaboration from data of IMF (2009), Chen et al. (2005) and Minondo and Ruber (2002).

Figure 1: Exports over GDP and domestic exports over GDP

in the series under both the null hypothesis of a unit root and the alternative hypothesis of stationarity. The outcomes are shown in Table 4, which reports the results of this analysis (column 3) in comparison with those obtained for the traditional series (column 1). In the first column, we can see that, for the traditional openness measure, three countries have a broken stationary trend (Australia, Denmark and the United States) while the second column shows the results of applying the analysis after removing the multi-accounting bias introduced by VS, where all the series, but Spain, have a stationary trend. Finally, if we consider the possibility of two breaks for the new openness measure, the Spanish series becomes stationary and the remainders barely change. We conclude that, when testing for the integration order of the variables studied, a stationary pattern clearly emerges if the VS bias is discounted from the openness measure while a first order integrated process characterizes the traditional openness measure.

TABLE IV

Unit root tests. Lee and Strazicich (2003, 2004)

Country Name	X/GDP $t\!-\!statistic$	no. breaks	X^*/GDP $t\!-\!statistic$	no. breaks
Australia	-6.763^a	1	-6.705^a	1
Canada	-3.658	1	-4.383^c	1
Denmark	-4.286^c	1	-4.307^a	1
France	-2.805	1	-5.635^a	1
Germany	-3.934	1	-4.729^b	1
Japan	-3.585	1	-4.629^b	1
Netherlands	-3.575	1	-3.266^c	1
Spain	-3.975	2	-3.702^c	2
United Kingdom	-3.614	1	-3.884^b	1
United States	-4.190^c	1	-3.704^b	1

[1] Lee and Strazicich (2003, 2004)unit root tests.
[2] We apply the general-to-specific procedure [Ng and Perron, 1995] to select the number of lags with a $kmax = T^{1/3}$.
[3] a, b, and c denote a statistic significant at the 1%, 5% and 10% respectively.

5 Conclusions

This paper shows that, in the group of DC, unit roots are the dominant feature for the traditional measure of openness calculated as the ratio of exports (as they appear in the official statistics) over GDP in 1948-2007. So, according to this outcome, trade openness is a variable that is temporally inconsistent with the stationarity of the growth series for the same group of DC in the second half of the twentieth century.

We posit that this stochastic inconsistency is something of a mirage. In recent decades, the progress of vertical specialized trade or, in other words, the increase in the percentage of imports embodied in domestic exports, has introduced an upward bias into the openness ratio since the numerator is gross valued (in the official export statistics) while the denominator is value-added (GDP). In this paper, we show how this bias, by exaggerating the contribution of international trade to the domestic economies, is responsible for the presence of unit roots in the traditional ratios of openness. We start from scattered data of vertical specialization in ten OECD countries and obtain new ratios free from the multi-accounting bias. Then, by interpolating data into these new ratios, we generate ten yearly series, which we assume are representative of the evolution of the export value actually added in each country between 1948 and 2007 and, consequently, more representative of the importance of foreign trade for those ten economies. By doing so, we find that, once the multiple-accounting effect of the vertical specialization is removed, the export share of output becomes stationary for the ten countries, in contrast to the results obtained for the original openness series, where only four countries exhibited a stationary trend. To sum up, in terms of stochastic properties, there is an essential change depending on whether the VS bias is removed or not, which, in turn, reconciles the lack of persistence of growth rate series in DC with their equally non-persistent series of openness.

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